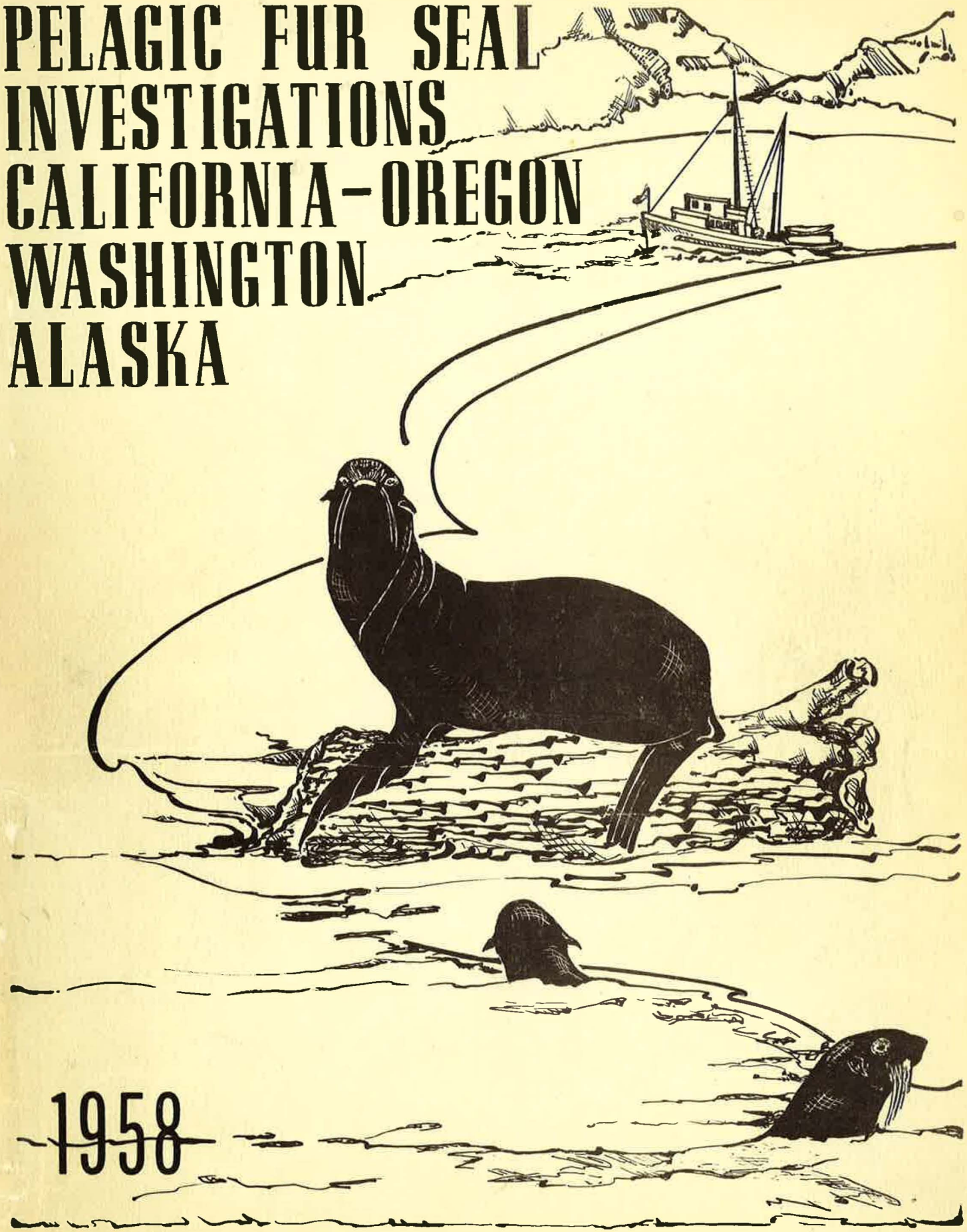
KAJIMURA

PELAGIC FUR SEAL INVESTIGATIONS CALIFORNIA-OREGON WASHINGTON ALASKA



1958

PELAGIC FUR SEAL INVESTIGATIONS

CALIFORNIA, OREGON, WASHINGTON, and ALASKA

1958

U. S. Fish and Wildlife Service
Bureau of Commercial Fisheries
Section of Marine Mammal Research
Seattle, Washington

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I. SUMMARY

In 1958, the first pelagic research was carried out under the terms of the Interim Convention on Conservation of North Pacific Fur Seals which is scheduled to last for six years.

The United States chartered three fishing vessels for the research. They were operated from the northern part of the Channel Islands off California to Bristol Bay in the Bering Sea. The total period in which one to three vessels, under charter, engaged in hunting was 1 February to 1 July.

Seals were hunted from the vessels and also, in calm weather, from small boats, powered with outboard motors, which were carried by the vessels. A total of 7,024 seals were seen; 1,503 were collected. Of these, 1,335 were females and 168 were males.

Seals were relatively concentrated at several points. Some of the outstanding were: the southernmost group found 10 miles west of San Miguel Island; the concentration located farthest offshore, at 90 miles southwest of Point Reyes, California; the largest California-to-Washington concentration, which was 10 to 15 miles off Santa Cruz to Pigeon Point, California; La Perouse Bank off Washington where yearling seals were most numerous; the large Gulf of Alaska concentration on Portlock Bank off Kodiak; and another large group between Sanak Island and Unimak Pass in Alaska.

Ages of seals were determined by counting both external growth ridges and internal growth lines in the longitudinal sections of the upper canine teeth. The latter method made possible age determinations up to 22 years. The sample of female seals suggests that the effective producing age is 5 to 18 years and that the number in existence drops off rapidly after 18 years.

An overall pregnancy rate of 74 percent was found for seals 4 to 22 years old. Pregnancy rates of about 79 percent or higher continued until the 16th year. The most productive years range from 6 to 16 years. Ten percent of the females had apparently aborted or absorbed their fetus. The combined number of pregnant and aborted or resorbing females indicates a high impregnation rate.

An 11-year-old female, carrying two well-developed, equal-sized, female fetuses, was taken on 9 May 1958, furnishing the first record known to the United States of twins in the northern fur seal.

The most numerous groups, 12-year-old females, made up 9 percent of the seals taken and females from 6 to 14 years old each furnished 5.5 percent or more of the collection. Seals in age classes 1 to 5 were inadequately represented. The best example of this is age class 2, of which only six were taken.

No direct correlation between seals and water temperature was found. The occasionally apparent correlation is a response to food availability.

Saury, squid, hake, and anchovy accounted for 73 percent of the food of seals taken off California and 81 percent of those taken off Oregon. Off Washington, about 52 percent of the food was herring and the combination of herring, saury, squid, and rockfish made up 89 percent of the total. Herring was also the leading food in Alaska, particularly in the southeastern portion, but capelin and sand lance were the principal food species from Kodiak to Unimak Pass. Herring, capelin, sand lance, and Alaska pollack composed 93 percent of the food volume recorded.

Salmon occurred once in a stomach from off Washington and 12 times in Alaska. The food volume represented by salmon was 0.7 percent.

At the present level of commercial utilization of the food species represented, the fur seal is not a menace to the economic welfare of fishermen in the United States.

II. INTRODUCTION

A. Purpose

1. Need for information

The place of the fur seal in the ecology of the North Pacific Ocean is not fully agreed upon by all the nations bordering that ocean. As a result, neither is the economic position of the fur seal nor are the methods for harvesting best suited to the population at its present level. Agreement on the controversial aspects of fur-seal management can be obtained only through research which will provide a better understanding of fur-seal biology, especially its pelagic phase. It cannot be expected that fully conclusive information on all points in question will be reached because some, such as the relation of fur seals to commercial fisheries, would require a vast knowledge of ecological relationships among many species at various stages in the food cycle or chain. It is possible to extend knowledge on this subject to the point where sound management decisions can be made.

It is believed that the combined results of the 1958 pelagic investigations by the North Pacific Fur Seal Commission will reveal substantial gains in knowledge of the northern fur seal, both in facts applicable to current operations and those which, for the present, are mostly of academic interest.

2. Authority to conduct investigations

This is a report of fur seals collected in accordance with

item 4 of the Schedule in the Interim Convention on Conservation of North Pacific Fur Seals, in which the United States agrees to the following: "The United States of America each year shall take at sea for research purposes in the Eastern Pacific Ocean between 1,250 and 1,750 seals."

The United States presented a proposed plan for pelagic research at the first meeting of the North Pacific Fur Seal Commission in Washington, D. C., in January, 1958. With certain modifications agreed on at the Conference, the plan was put into effect. The results are presented in the following pages.

B. Methods, equipment, and personnel

1. Methods and equipment

a. Vessels and boats

The three vessels chartered for the 1958 pelagic sealing operations were: two halibut schooners, M/S Lindy - length 72', M/S Trinity - length 65'2", and one purse seiner, M/V Tacoma - length 71'5". Four men made up the crew of each vessel. They included a captain, engineer, cook, and deckhand. A Fish and Wildlife Service biologist and three, or occasionally two, biological aides were attached to each vessel.

Each vessel carried two small boats (dories or surfboats, as shown in figure 1) for use in hunting during good weather. Ten-horsepower, outboard motors were used for propelling the small boats.

Figure 1. Dory being used for hunting fur seals in Sitka Sound, Alaska.

The purse seiner and one halibut schooner operated off the west coast of the United States from 1 February through 1 May, when the purse seiner was terminated. One halibut schooner operated in Alaskan waters from 1 February to 25 June and a second halibut schooner operated in Alaskan waters from 10 May to 1 July.

Radio contact between vessels was maintained, when possible, to coordinate vessel movements and assure adequate coverage of areas being surveyed. Loran bearings were taken periodically as an aid in plotting positions and navigation. Radar and radio direction signals were used as aids to navigation.

All vessels carried enough supplies, water, and fuel to enable them to spend at least two weeks at sea. Because of weather conditions at sea, the longest time any one vessel spent, without making port, was ten days but, for the greater part of the field season, four or five days at sea was about the average length of a trip. The hunting day at sea usually was from 6 A.M. until 6 P.M.; but in the earlier part of the season, particularly in Alaska, the hours were from dawn to dark. Late in the season, in Alaskan waters, hunting was sometimes carried out earlier as sunrise occurred about 4 A.M. When on the hunting grounds at night, the vessel shut down and drifted from 6 P.M. until 6 A.M. except when it was necessary for the vessel to make port or in traveling from one area to another.

Both the halibut schooner and the purse seiner have favorable and unfavorable characteristics in adapting them to fur-seal hunting. The schooner is a more stable boat at sea than the seiner but lacks its maneuverability. The helmsman on the seiner has much better visibility than the helmsman of the schooner. He is able to follow the seal being chased without directions from the bow as is frequently necessary on the schooner. If the seiner has a crow's nest, it is more convenient for the lookout. than standing in the rigging or on the pilot house of the schooner. It, also, usually has the advantage of being at a higher elevation above deck.

The success of either type vessel depends on the helmsman's

ability to follow the seal and, when a seal is killed, to put the vessel alongside in the least possible length of time.

b. Hunting methods

Seals were hunted from both the vessels and boats. In rough or stormy weather, the large vessels only were used; but during periods of good weather and relatively calm seas, both the large vessel and boats were operated. When hunting from the vessel, two lookouts were on duty at all times and two gunners were on standby at the bow, or went there when seals were sighted. When a seal was killed, the vessel ran up to it and it was brought aboard with a Japanese-type four-pronged gaff attached to a 12- or 14-foot bamboo pole. Various techniques were used in approaching seals, depending on whether the seal was asleep, awake but remaining in the same location, or awake and moving.

Several methods were used when hunting from the small boats. One method, used when seals were abundant, was for the vessel to remain stopped in one area while its boats hunted out from it in all directions, returning to the vessel when a load of seals was secured. Another method, used when seals were few, was for the vessel to continue on course with a small boat at each side, running abreast of the vessel at distances varying from several hundred yards to half a mile. The vessel would alter its speed accordingly, to maintain its relative position in relation to the small boats. Seals were taken by the small

boats more easily and with fewer losses than from the large vessel because of the boats' maneuverability and speed. Twelve-gauge shotguns and loads of 00-buckshot were used to kill the majority of seals. Rifles (.243-caliber) with telescopic sights were also used, with varying results.

When seals were brought aboard, they were tagged with aluminum specimen-tags. The seals were then examined for tags, check marks, and brands. The weight of the seal in kilograms and the length in centimeters, from tip of snout to end of tail, were taken and the seal was then skinned. After skinning, the snout was removed and placed in a cloth bag with a corresponding specimen-tag. The seal was then cut open, the stomach removed and tagged, and the reproductive condition of the seal was noted. If a fetus was present, its sex, length, and weight were taken. When a sufficient number of snouts had accumulated, they were boiled and the upper right canine was saved for processing in the laboratory. Stomachs were injected with 10-percent formalin for preservation of contents and barreled for later examination in the laboratory. Skins were salted and stored for later shipment to the processing plant. The skins of seals, taken from California to Alaska, were blubbered by a plant in San Francisco before being shipped to St. Louis. In Alaska, the skins were unloaded at St. Paul, Pribilof Islands.

Records were kept throughout the season by all vessels of numbers of seals sighted, collected, wounded and lost, and killed and lost.

The totals were:

7,024	seals	. . . . .	sighted
1,503	"	(21.4 percent)	collected
302	"	(4.3 percent)	wounded and lost
255	"	(3.6 percent)	killed and lost

It is sometimes difficult to determine whether a seal has been wounded or not and it is quite probable that the number of seals wounded and lost was higher than the figures indicate. In many cases, seals killed were lost through sinking because of the vessel's slow maneuverability.

c. Laboratory methods

(1) Aging canine teeth by use of longitudinal sections

A different technique was adopted for aging seals collected during the 1958 pelagic sealing research program. Longitudinal sections of the canine teeth were made and the age of the seal was determined by counting growth lines comparable to the external ridges on the tooth.

Previous work in this field, by American and Japanese biologists, was consulted and teeth from known-age seals were available for comparison. The previously proved methods of aging seal canines, from external growth rings, was also applied to these teeth. External and internal methods of aging teeth compared favorably up to about age 10, at which age the external ridges tend to become obscure. By using the internal, longitudinal-sections method, ages were obtained from teeth which previously had been placed in the 10 (years)-plus category of the external aging method.

(a) Method and equipment used to prepare longitudinal sections.

A Craftsman gem-making set (figure 2), made by the B. & I. Manufacturing Company, Burlington, Wisconsin, and marketed by Sears, Roebuck & Company, for cutting and polishing gems and minerals, was used. This consisted of a 1/3-horsepower, 1750 r.p.m. motor, housing unit and lubrication cup, several cutting, grinding and polishing wheels, grinding and polishing compounds, cement, and doweling. The motor and housing unit were secured to a section of 3/4-inch plywood, 24 inches wide by 46 inches long.

Figure 2. Machine used for grinding and polishing longitudinal sections of fur-seal canine teeth.

Preparing teeth for grinding. -- Each tooth had the tag number of the seal applied to it with India ink. A number of teeth, usually 100, were set out in numerical order. Duplicate numbers were made up on small pieces of masking tape. Four-inch lengths of 1/2-inch doweling, called "dop sticks", were laid out and the masking tape numbers corresponding to the tooth numbers were applied. This was a precautionary measure in case the original number on the tooth was ground off in processing.

A small alcohol lamp was used to melt cement, called "dop cement." A quantity of cement was built up on the tooth and on the "dop stick." Keeping both the "dopped" tooth and the "dop stick" soft over the lamp, the tooth was pressed onto the stick and then set aside to harden.

Grinding. -- An 8-inch silicon-carbide grinding wheel is set on the shaft (horizontal position) in the housing. Water, dripped from the lubricating cup, prevents the tooth from burning and helps keep the wheel clean. The tooth, cemented in place on the "dop stick", is then ground down exactly in half, as nearly as is possible. Care must be used in this operation and, as the halfway point is approached, the tooth should be examined frequently. The shape of the tooth sometimes necessitates grinding one area more than another in order to follow the mid-line of the tooth. If the tooth is not ground enough, all growth lines may not be readily visible and the same is true if it is ground too much.

Polishing. -- The felt polishing wheel is set on the shaft. Water-

flow from the lubricating cup dampens the wheel and polishing compound is brushed onto the face of the wheel. Polishing compound is reapplied when needed as the tooth polishing progresses. The teeth are polished until all dull areas disappear. It was found that polished teeth were more easily read than unpolished teeth.

(b) Aging teeth

A strong light is necessary to bring out the light and dark areas of the tooth. Two lamps were used in the present project, both of which proved satisfactory. One lamp is a standard 100-watt slide projector. The second was of the type used in the laboratory to provide light for microscope work (Universal Illuminator, Model 559, made by the American Optical Company).

Two spectacle-type magnifying glasses, Magni Focuser No. 5 and No. 7, were worn when reading teeth. Both the No. 5 and No. 7 were adequate for the work.

Before aging teeth by the longitudinal-section method, two men each read 500 teeth, including available known-age teeth, to familiarize themselves with the methods involved.

It was found that there was a marked difference in the individual teeth, caused by degree of grinding and variation in tooth structure, as described below:

Degree of grinding. -- Teeth not ground exactly in half may not show all growth lines clearly and it is possible that the same line may be counted twice.

Teeth ground past the mid-line may lose some growth lines and the apparent position of the growth line changes, which may lead to difficulties in counting.

Variation in tooth structure. -- In teeth up to about age five, the annual growth lines are widely separated, comparatively speaking, and care must be used in counting only the annual lines and not some intermediate shading or line. The annual external ridges are of value as a check on the younger teeth. The pulp chamber is usually still open in teeth up to about age 10, although there is much individual variation and the cementum layer is not very evident. The pulp chamber of older teeth, age 12 or more, may be entirely closed up. The cementum layer is usually plainly visible and can be confused with an annual line. Growth lines are laid down comparatively close to each other and are sometimes difficult to differentiate.

To read the age, the tooth is held in the light and, as the growth lines are counted, may be turned to give the angle of light that shows the lines to best advantage.

All teeth were read by two men. Teeth, about which there was a difference of opinion, were rechecked by four men. All teeth in the sample, with two exceptions, were successfully aged by making longitudinal sections and reading the annual growth lines. The two teeth not aged were teeth, of 10 years or older, whose internal structure was such that no accurate age could be determined. Although the preparation of

teeth for aging by longitudinal section is time consuming, it is believed that the results are well worth the extra effort and time involved.

(2) Stomach examinations

At the Fish and Wildlife Service laboratory in Seattle, Washington, the contents were removed from the stomachs and their weight and displacement volume was determined. The usual procedure of sorting, according to species, and counting the number of each species was followed as nearly as possible. From volume measurements, a calculation was made of the percentage of the total volume represented by each food item.

Although non-food materials, such as stones, are usually excluded from volume measurements, they were included in these data. The effect is trivial, however, because of the few stones found in seals from a pelagic habitat.

Additional information on stomach examinations is contained in the section on food habits.

d. Personnel

The following personnel took part in pelagic fur-seal investigations for the United States in 1958:

Permanent employees, Bureau of Commercial Fisheries:

1. Ford Wilke, Supervisory Biologist
2. Karl Niggol, Biologist
3. Clifford H. Fiscus, Jr., Biologist

Temporary employees, Bureau of Commercial Fisheries: (the following men are students from various colleges and universities)

1. William J. Barmore, Jr.
2. John R. George
3. Richard T. Holmes
4. Thomas C. Juelson
5. Warren W. Jones
6. Terence J. O'Brien
7. Alan J. Tolmsoff
8. Samuel G. Wright, Jr.

III. PREVIOUS RESEARCH

"Distribution and food habits of the fur seals of the North Pacific Ocean" contains an effective summary of research up to 1952, by V. B. Scheffer and James I. Manzer. As a function agreed on at the first meeting of the North Pacific Fur Seal Commission, the United States prepared a "selected bibliography on the northern fur seal", dated 1 August 1958. Papers and publications which were omitted, or have been prepared since, include:

Chapman, D. G. 1954. A further note on the Alaska fur seal population. Unpub. rept., U. S. Dept. Interior, Fish and Wildl. Serv., 43 pp.

Chapman, D. G. 1957. Estimate of escapement of fur seal bachelors from commercial harvest. U. S. Dept. Interior, Fish and Wildl. Serv., unpub. rept. Included in rept. "Alaska fur seal investigation, Pribilof Islands, Alaska, 1957", as appendix KK.

Chapman, D. G. 1958. Population estimates of Pribilof fur seal pups based on 1957 data. U. S. Dept. Interior, Fish and Wildl. Serv., unpub. rept., 18 pp.

Chapman, D. G. 1958. Estimate of escapement of fur seal bachelors from commercial harvest, 1957. U. S. Dept. Interior, Fish and Wildl. Serv., unpub. rept., 13 pp.

Scheffer, V. B. 1958. Seals, sea lions and walruses. Stanford Univ. Press. 10 + 179 pp., 32 pls.

Tanonaka, G. K. 1958. Japanese pelagic sealing research methods and techniques. U. S. Dept. Interior, Fish and Wildl. Serv., unpub. rept., 53 pp.

Wilke, F. 1959. Fat content of fur seal milk. To be published in The Murrelet.

Wilke, F., and K. W. Kenyon. 1957. The food of fur seals in the eastern Bering Sea. Jour. Wildl. Mgmt., 21(2):237-238.

IV. RESEARCH IN 1958

A. Distribution of seals

1. Distribution by time, place, and numbers

The distribution of seals observed is shown in figures 3 to 8 and tables 1 to 3. Each square, in the figures, represents an area of 10 square miles. The number in the upper half of the square represents the number of seals sighted in that area throughout the season. As some areas were visited more than once during the course of the season, the numbers shown in each square are a cumulative total in many cases and, except in a very general way, cannot be used as a measure of density but are useful to indicate distribution.

a. California

Two vessels operated off the California coast during most of February, all of March, and part of April. As is true in winter operations, poor weather conditions curtailed and, at times, brought sealing to a standstill.

The vessel operating out of Eureka on the northern California coast, from 15 February to 12 March, found seals most frequently 25 to 30 miles offshore. They were widely scattered and no large numbers of seals were located until the vessel arrived off Point Arena on 13 March.

The vessel operating in the central California area between Point Reyes and Point Sur, during the months of February and March, found seals generally distributed over the area covered. Seals were most

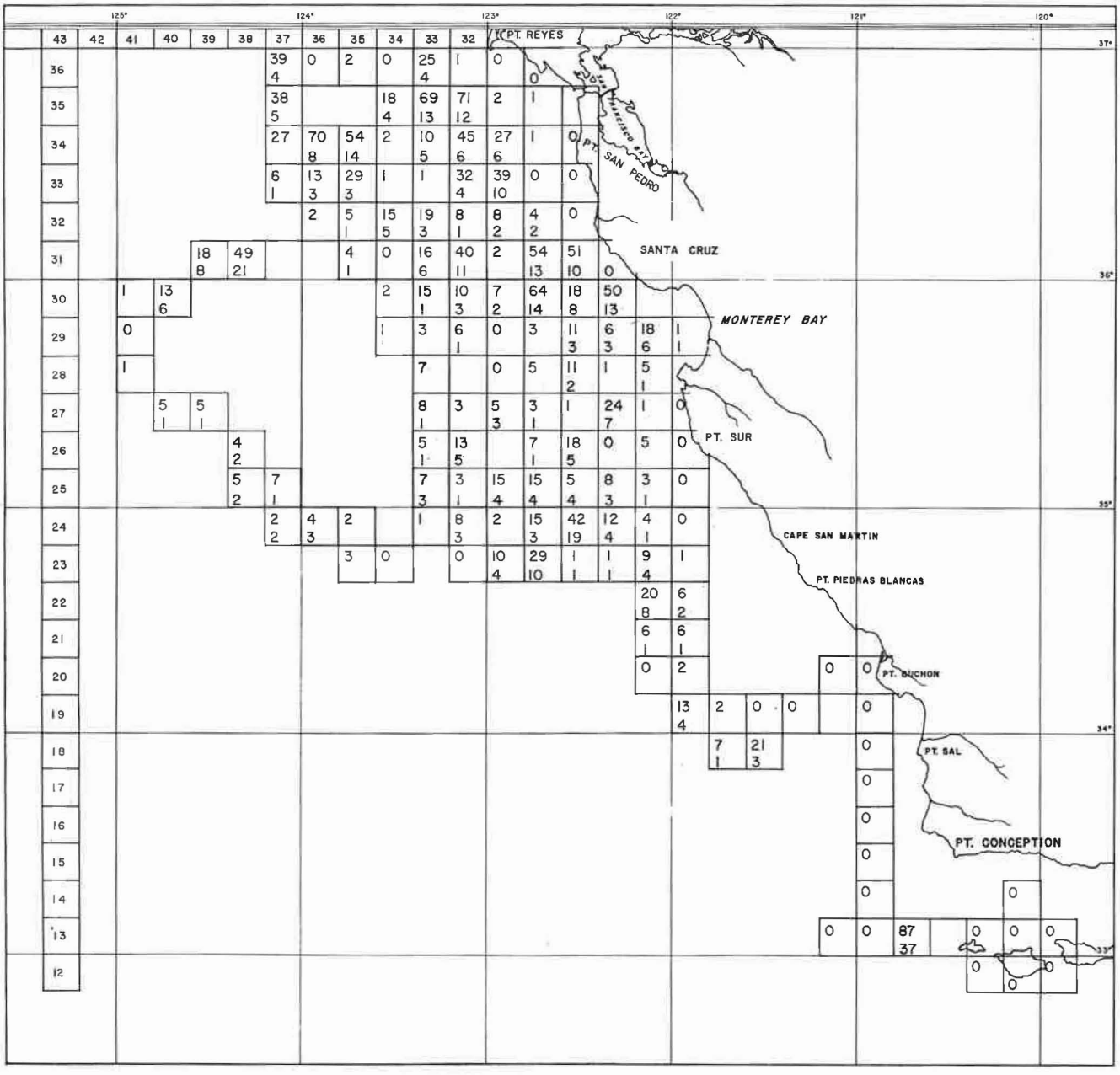

Figure 3. Distribution of seals observed (upper number) and collected (lower number) from 33° 50' north latitude to 38° 00' north latitude, from 6 February to 10 April 1958.

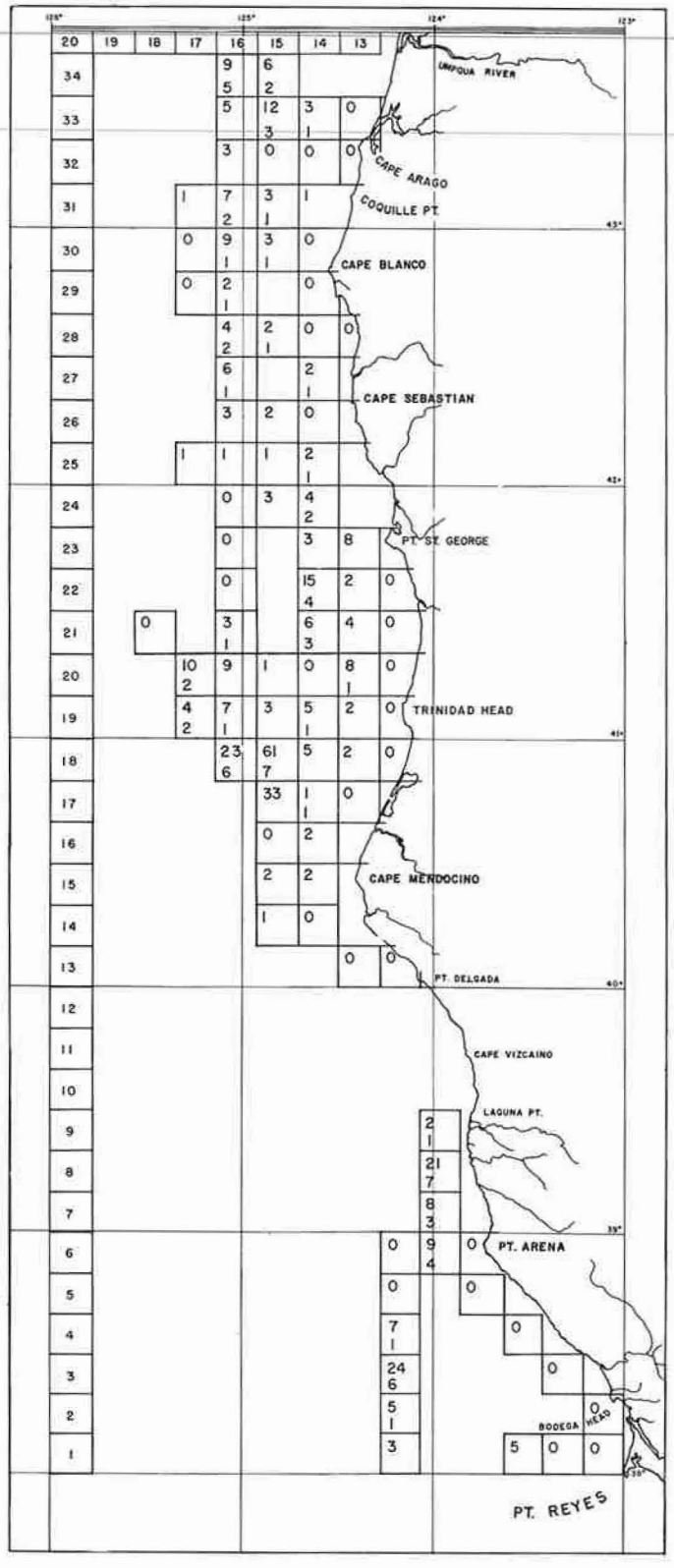

Figure 4. Distribution of seals observed (upper number) and collected (lower number from 38° 00' north latitude to 43° 40' north latitude from 13 February to 13 March and 11 to 16 April 1958

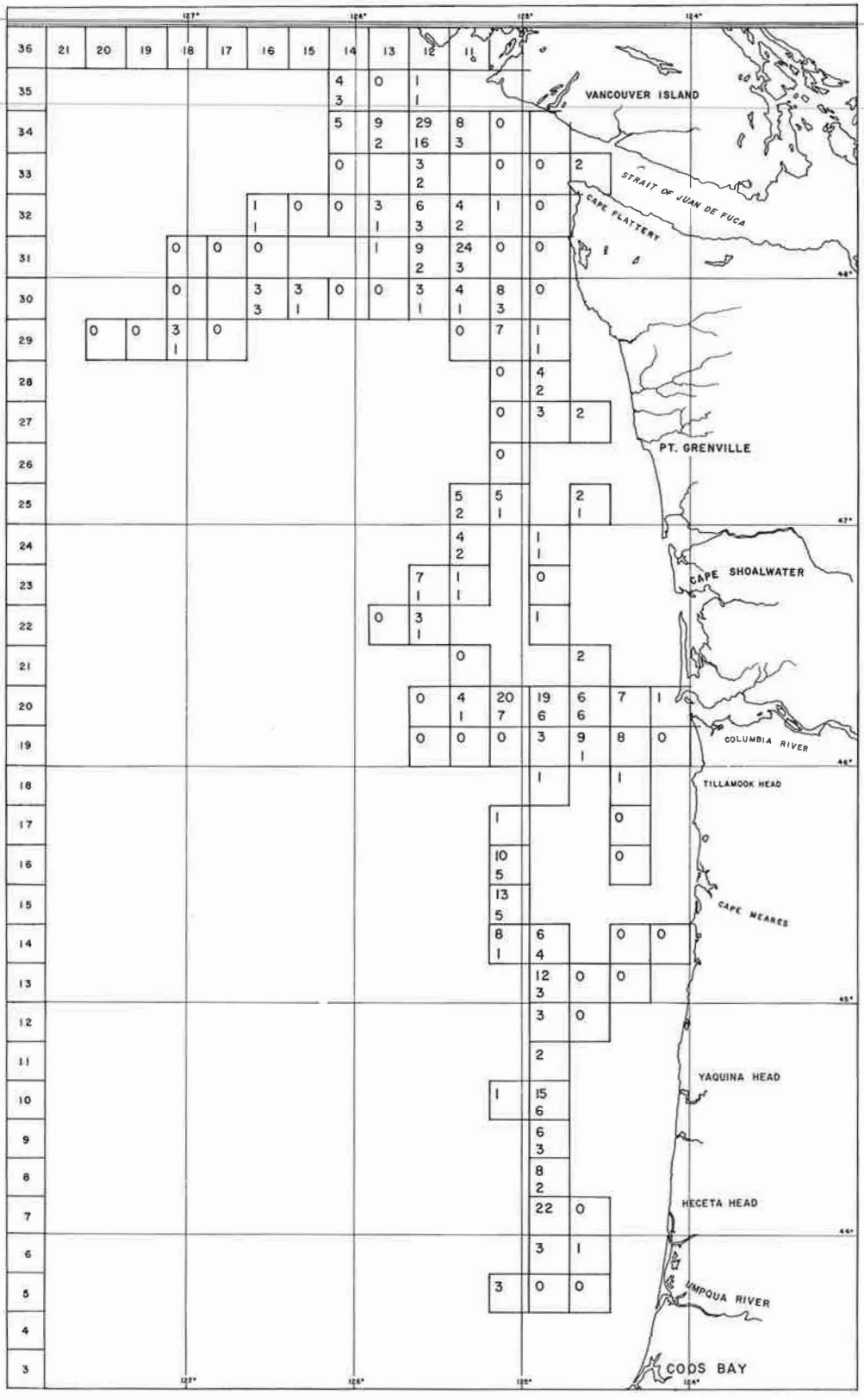

Figure 5. Distribution of seals observed (upper number) and collected (lower number) from 43° 40' north latitude to 48° 40' north latitude, from 5 to 12 February, and 16 to 29 April 1958.

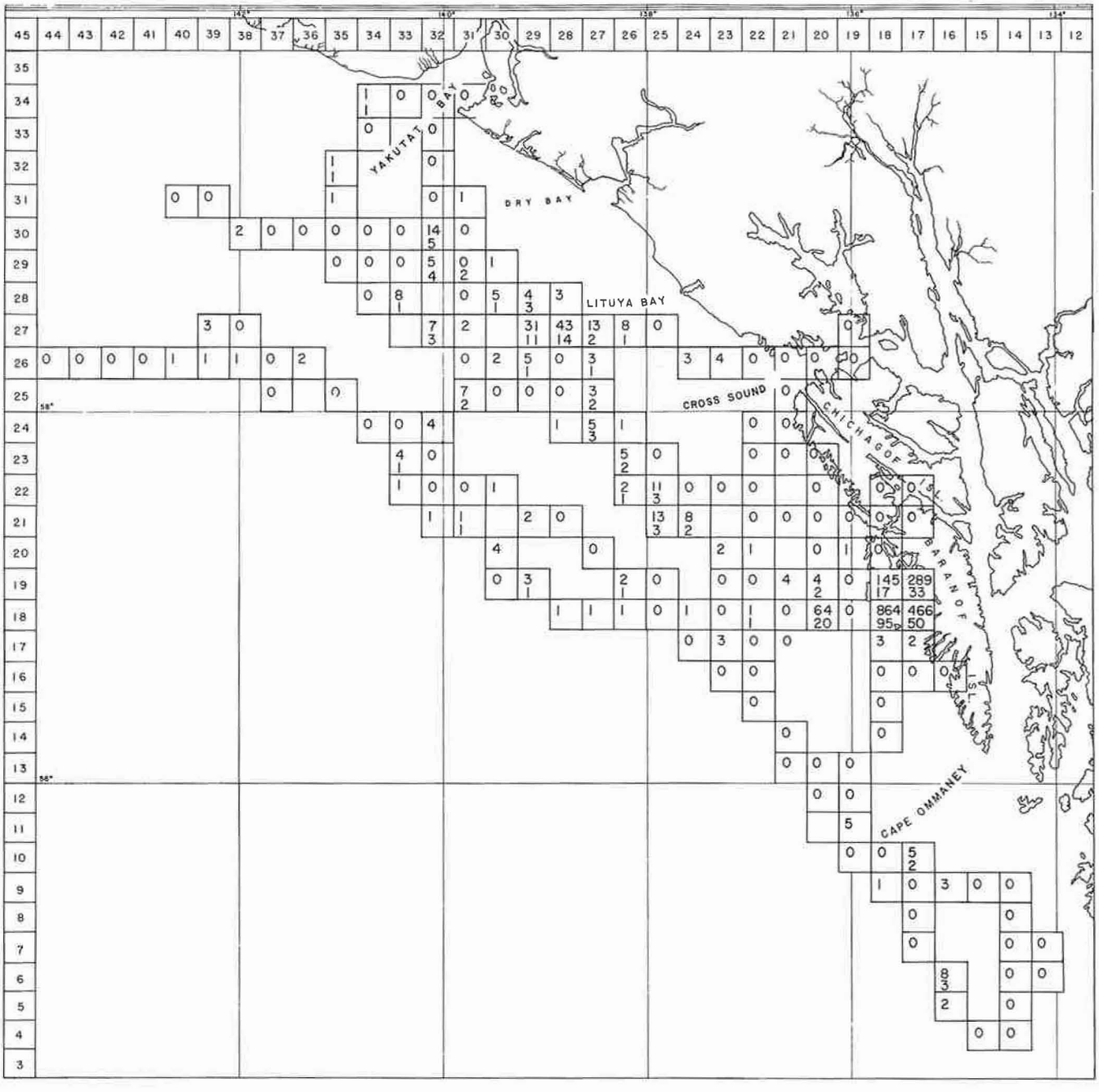

Figure 6. Distribution of seals observed (upper number) and collected (lower number) for area east of 144° 00' west longitude from Dixon Entrance to Cape St. Elias. Collecting began 13 February and ended 12 May 1958.

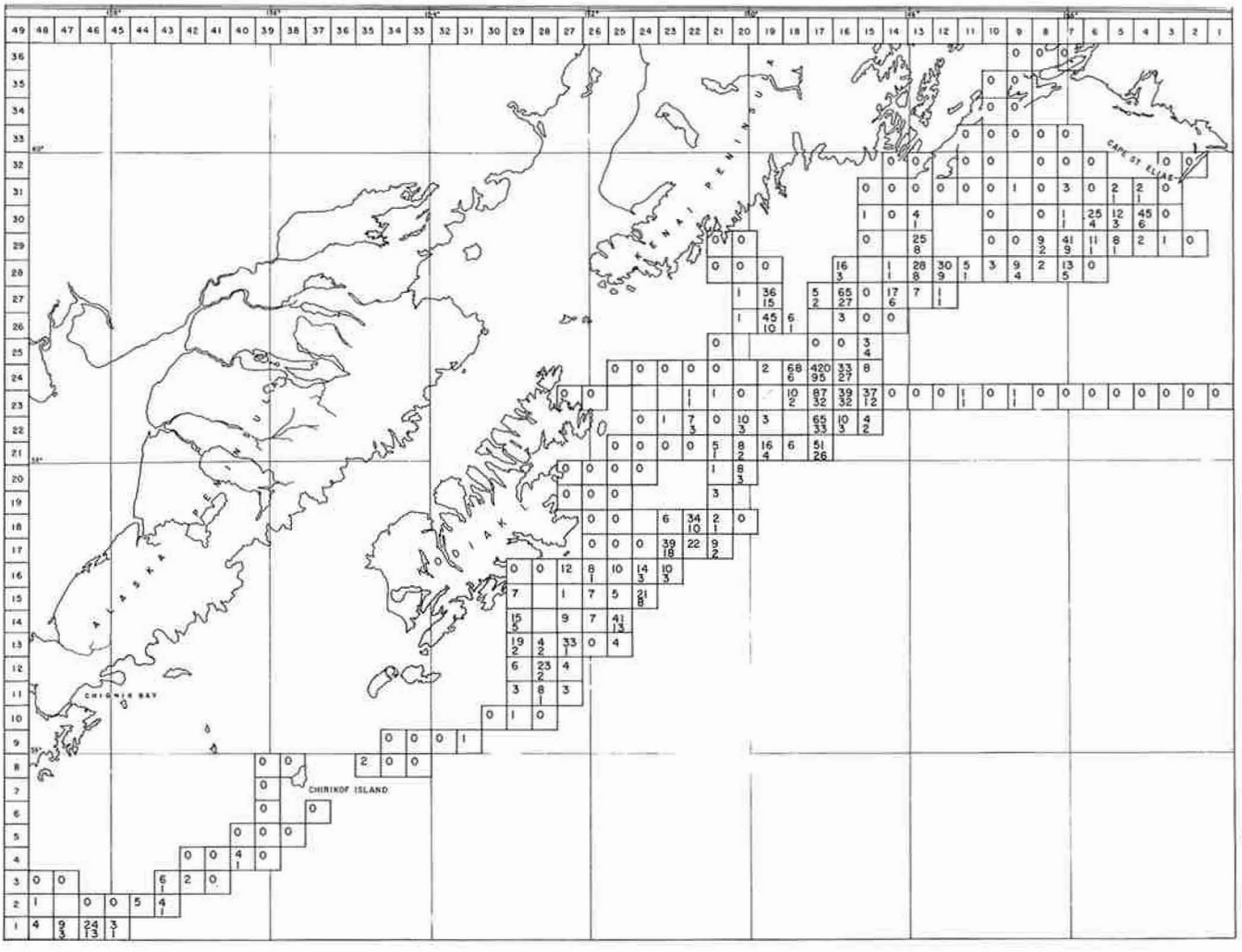

Figure 7. Distribution of seals observed (upper number) and collected (lower number) from Cape St. Elias to Shumagin Islands, from 30 April to 13 June 1958.

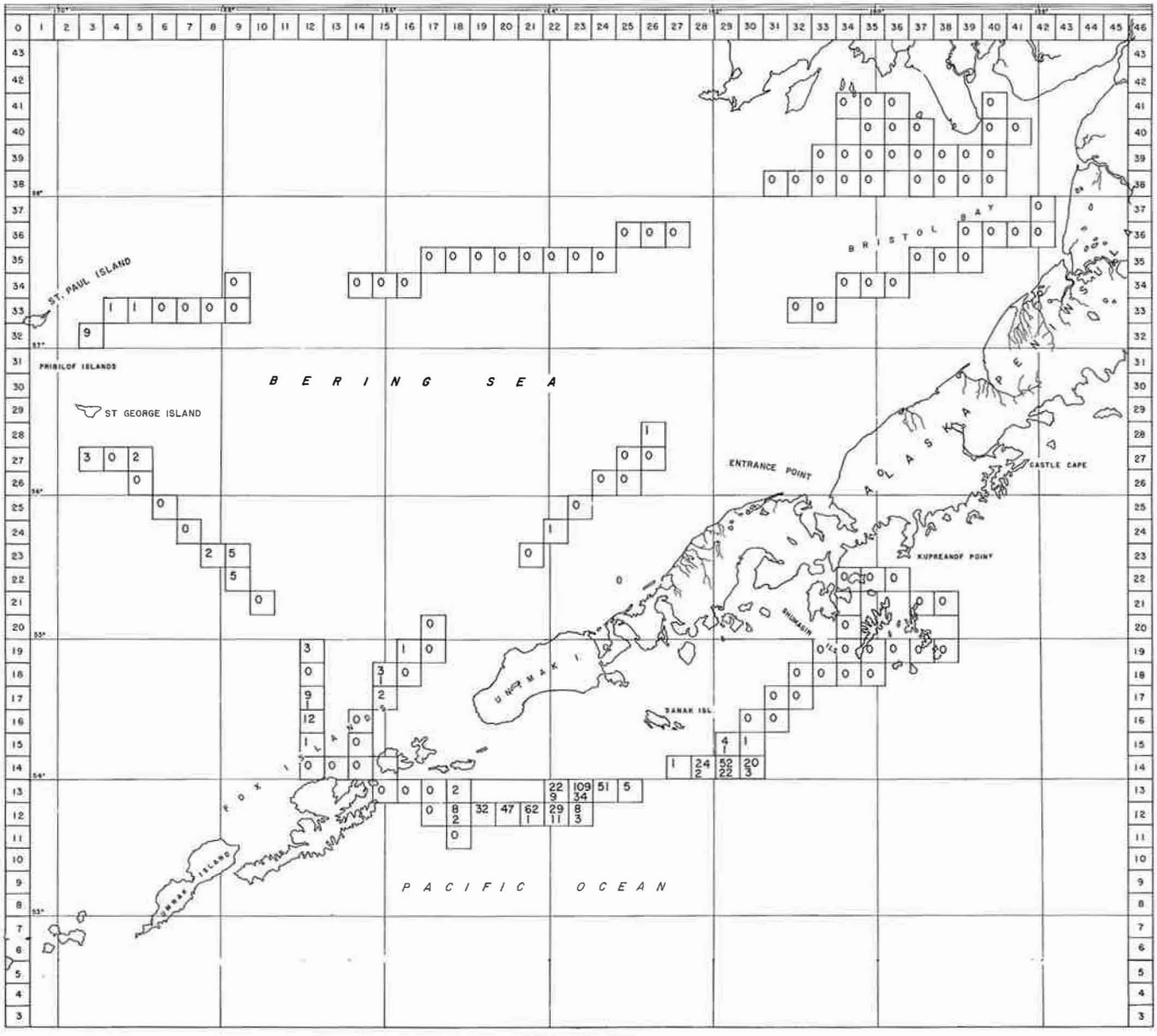

Figure 8. Distribution of seals observed (upper number) and collected (lower number) from Shumagin Islands to Pribilof Islands, from 11 June to 1 July 1958.

Table 1. Numbers and relative abundance of seals seen off California, Oregon, Washington, and Alaska, by 10-day periods, 1 February to 1 July 1958.

Period	Number of boat-hunting days	Total seals sighted	Total seals seen per boat-day	Percent seen in various periods
California				
1-10 February	2.75	171	62.2	8.6
11-20 February	8.00	274	34.2	13.7
21 February - 2 March	11.50	362	31.5	18.2
3-12 March	13.00	197	15.2	9.9
13-22 March	10.50	536	51.0	26.9
23 March - 1 April	13.50	334	24.7	16.8
2-11 April	3.50	45	12.8	2.3
12-21 April	1.50	71	47.3	3.6
Total	64.25	1990	30.0	100.0
Oregon				
1-10 February	1.00	3	3.0	1.6
11-20 February	2.00	2	1.0	1.0
12-21 April	7.25	188	25.9	96.9
22 April - 1 May	0.50	1	2.0	0.5
Total	10.75	194	18.0	100.0
Washington				
1-10 February	2.00	22	11.0	8.8
12-21 April	1.75	37	21.1	14.9
22 April - 1 May	13.00	190	14.6	76.3
Total	16.75	249	14.9	100.0
Alaska				
11-20 February	6.50	167	25.7	3.6
21 February - 2 March	7.25	621	85.7	13.5
3-12 March	7.75	538	69.4	11.7
13-22 March	8.50	462	54.4	10.1
23 March - 1 April	7.50	2	0.3	0.1
2-11 April	8.00	101	12.6	2.2
12-21 April	5.00	63	12.6	1.4
22 April - 1 May	9.00	117	13.0	2.5
2-11 May	10.00	671	67.1	14.6
12-21 May	12.25	357	29.1	7.9
22-31 May	16.50	585	35.5	12.7
1-10 June	11.00	287	26.1	6.3
11-20 June	14.00	566	47.6	12.3
21-30 June	6.00	43	7.2	0.9
1 July	1.00	11	11.0	0.2
Total	130.25	4591	35.2	100.0
Grand total	222.00	7024	31.6	100.0

Table 2. Numbers and relative abundance of seals collected off California, Oregon, Washington, and Alaska, by 10-day periods, 1 February to 1 July 1958.

Period	Number of boat-hunting days	♂ taken	♀ taken	Total seals taken	Percent total seals per boat-day	Percent taken in various periods
California						
1-10 Feb.	2.75	0	25	25	9.1	5.3
11-20 Feb.	8.00	0	57	57	7.1	12.1
21 Feb. - 2 Mar.	11.50	0	99	99	8.6	21.1
3-12 Mar.	13.00	0	42	42	3.2	9.0
13-22 Mar.	10.50	0	126	126	12.0	26.8
23 Mar. - 1 Apr.	13.50	0	85	85	6.3	18.1
2-11 Apr.	3.50	0	18	18	5.1	3.8
12-21 Apr.	1.50	0	18	18	12.0	3.8
Total	64.25	0	470	470	7.3	100.0
Oregon						
1-10 Feb.	1.00	0	0	0	0.0	0.0
11-20 Feb.	2.00	0	0	0	0.0	0.0
12-21 Apr.	7.25	1	52	53	7.3	100.0
22 Apr. - 1 May	0.50	0	0	0	0.0	0.0
Total	10.75	1	52	53	4.9	100.0
Washington						
1-10 Feb.	2.00	1	0	1	0.5	1.2
12-21 Apr.	1.75	1	9	10	5.7	12.0
22 Apr. - 1 May	13.00	8	64	72	5.5	86.8
Total	16.75	10	73	83	5.0	100.0
Alaska						
11-20 Feb.	6.50	6	17	23	3.5	2.6
21 Feb. - 2 Mar.	7.25	8	51	59	8.1	6.6
3-12 Mar.	7.75	0	67	67	8.6	7.5
13-22 Mar.	8.50	0	46	46	5.4	5.1
23 Mar. - 1 Apr.	7.50	0	0	0	0.0	0.0
2-11 Apr.	8.00	14	13	27	3.4	3.0
12-21 Apr.	5.00	12	4	16	3.2	1.8
22 Apr. - 1 May	9.00	12	18	30	3.3	3.3
2-11 May	10.00	20	137	157	15.7	17.4
12-21 May	12.25	28	76	104	8.5	11.6
22-31 May	16.50	35	189	224	13.6	25.0
1-10 June	11.00	8	41	49	4.4	5.5
11-20 June	14.00	14	80	94	6.7	10.5
21-30 June	6.00	0	1	1	0.2	0.1
1 July	1.00	0	0	0	0.0	0.0
Total	130.25	157	740	897	6.9	100.0
Grand total	222.00	168	1335	1503	6.8	

Table 3. Grouping of seals sighted off California, Oregon, Washington, and Alaska 1 February to 1 July 1958.

Area	Frequency of groups: Number of seals per group 1	2	3	4	5	6	7	8	9	10	Total groups	Total seals
California												
number	673	284	130	46	25	2	3	1	1		1165	1990
percent	33.8	28.5	19.6	9.2	6.3	0.6	1.1	0.4	0.5			100.0
Oregon												
number	68	33	15	1	1	1					119	194
percent	35.0	34.0	23.2	2.1	2.6	3.1						100.0
Washington												
number	130	35	5	2		1					173	229
percent	56.8	30.6	6.5	3.5		2.6						100.0
Alaska - Sitka area												
number	116	61	43	19	14	14	13	4	3		287	747
percent	15.5	16.3	17.3	10.2	9.4	11.2	12.2	4.3	3.6			100.0
Alaska (except Sitka)												
number	920	410	152	81	29	7	4	3	2	1	1609	2787
percent	33.0	29.4	16.4	11.6	5.2	1.5	1.0	0.9	0.6	0.4		100.0
Total: Alaska												
number	1036	471	195	100	43	21	17	7	5	1	1896	3534
percent	29.1	26.7	16.6	11.3	6.1	3.6	3.4	1.6	1.3	0.3		100.0
Grand total												
number	1907	823	345	149	69	25	20	8	6	1	3353	5947
percent	32.1	27.7	17.4	10.0	5.8	2.5	2.3	1.1	0.9	0.2		100.0

Seals sighted but grouping not recorded:		
	Washington	20
	Alaska, Sitka area	1042
	Alaska (except Sitka)	15
		1077

frequently found from 15 to 50 miles offshore. Most hunting was done within 60 miles of the coast but on one occasion the vessel, working two days (21-22 February) from 80 to 135 miles offshore, found numerous seals 90 miles southwest of Point Reyes. Seals were found as far offshore as the vessel cruised and, while there were fewer seals seen 95 to 135 miles offshore, the difference was not an appreciable one. On 2 and 3 March, a seal concentration was found 10 to 15 miles offshore between Santa Cruz and Pigeon Point. On 14 March, another seal concentration was found 45 miles west of Point Reyes, which extended south for about 30 miles. On 17 March, numerous seals were found about 50 miles southwest of Point Reyes. These were probably part of the concentration found on 14 March. Seal distribution was closely related to food abundance.

The Eureka vessel moved south and hunted the area from Point Sur to the northern Channel Islands between 15-24 March. A large concentration of seals was found west of San Miguel Island on 19 March. Aside from this concentration, seals did not appear as numerous in this area as in the central area.

On 26, 27, and 28 March, both vessels, cruising north from the vicinity of Point Sur towards the Farallon Islands, found that the majority of seals seen were from 40 to 60 miles offshore. There appeared to be a general northerly movement of seals at this time.

In the period of 9 -15 April, the vessels moved north from Point

Reyes to the Oregon border. The seals sighted were widely scattered, with one exception -- a small concentration was found west and north of Point Arena.

In general, it was observed that upon moving offshore, the first seals would be sighted in the vicinity of the 100-fathom, depth curve. Concentrations of seals were frequently found on or near fishing banks.

b. Oregon

One vessel hunted three days off the Oregon coast in early February. Poor weather conditions prevailed and only five seals were seen.

Between 13-22 April, two vessels working northward each hunted five days off the Oregon coast. Seals were found scattered over the area hunted, with two exceptions: one concentration was found on and near Heceta Bank and another concentration southwest off the Columbia River mouth. The seals were definitely moving north at this time.

c. Washington

In early February, one vessel hunted two days off the Washington coast under poor weather conditions. One seal was collected and 22 were seen. During the period of 21-29 April, two vessels operated eight days each off the Washington coast. Seals observed were well scattered except on and near La Perouse Bank, where seals were found in large numbers. A course was run offshore to a point 120 miles southwest of Cape Flattery and few seals were seen near the outer end of the run.

Yearling seals were seen in greater numbers on La Perouse Bank than at any other location off the west coast of the United States.

d. Alaska

One vessel operated in the area around Sitka during the months of February and March. Seals were quite numerous in Sitka Sound during this time. A noticeable concentration was observed in a two-mile wide strip between Biorka Island and Cape Edgecumbe. Seals were found in about the same numbers during these two months, with small fluctuations caused, probably, by herring-school movements.

Offshore trips of 40 and 70 miles were made and the few single seals found were not further than 20 miles offshore. Even less productive were trips along the coast, north to Cross Sound and south to West Crawfish Inlet. The absence of seals in West Crawfish Inlet was very remarkable as in earlier years a large number of seals was found there in winter.

Seals collected during February were in two distinctive age groups: 10-year-and-older females (66 percent) and the 1-year-old class (33 percent) of both sexes. Also, one 4- and one 5-year-old female were taken. This situation changed in April when only two yearling seals, from a total of 130 seals 10 years old and older, were taken.

In April, the vessels covered the area offshore between Dixon Entrance and Yakutat. Seals appeared to be well scattered over the area. A concentration was found on 27 April, 15 miles west of Cape Edgecumbe.

During the month of May, one vessel operated in the northern Gulf of Alaska between Kodiak Island and Cape St. Elias. A second vessel hunted from Cape Spencer across the Fairweather Grounds. Numerous seals were found in that vicinity on 11 May. The vessel moved northwest and spent the remainder of the month in the northern Gulf of Alaska. Seals were well distributed in the area, with the largest concentration being found on Portlock Bank. The vessels made four cruises across the bank during the month and found seals in large numbers on each cruise. Small concentrations of seals were found in the vicinity of Middleton Island, Cape St. Elias, and on Albatross Bank.

Both vessels moved from Kodiak Island west to Unalaska during June. Seals were found in small numbers throughout the area covered. They were concentrated on Albatross Bank southeast of Cape Barnabas, in the area east and southeast of Simeonof Island, and from Sanak Island west to Unimak Pass. On 17 June, one vessel ran eastward into Bristol Bay and, after hunting in the eastern part of it, moved west to St. Paul Island, arriving there on 1 July. No seals were seen east of Amak Island and no seals were sighted on the westward course until the vessel arrived within 50 miles of St. Paul Island. On 23 and 24 June, the second vessel ran the course from Unalaska north to St. George Island. Seals appeared widely scattered and no concentrations were seen.

Seal observations, during normal hunting operations in areas where seals were not concentrated, were infrequent and it was quite common

for the vessel to cruise for an hour or more between sightings and then usually only one or two seals or a small group could be seen. However, in a seal concentration such as was found on Portlock Bank, as many as five groups occasionally would be in sight at one time over long periods. The largest number sighted by one vessel, in one day, was 324 seals. On several occasions during February and March, 150 to 200 seals were seen per day in Sitka Sound. Other concentrations were observed as follows:

Date 1958	Locality	Number seals sighted
	California	
6-8 February	3-15 miles W. of Farallon Islands	110
21 February	90 miles S.W. of Pt. Reyes	85
2-3 March	10-15 miles off Santa Cruz to Pigeon Pt.	161
14 March	45 miles W. of Pt. Reyes, extending south 30 miles	87
17 March	50 miles S.W. of Pt. Reyes	110
19 March	10 miles W. of San Miguel Island	85
11 April	20 miles N.W. of Pt. Arena	40
	Oregon	
15 April	Heceta Bank	51
16 April	55 miles S.W. of Columbia River	51
	Washington	
26, 27, and 28 April	La Perouse Bank	51
	Alaska	
16 February	Sitka Sound	59
22 February	" "	78
28 February	" "	75
2 March	" "	261
8 March	" "	98
10 March	" "	231
21 March	" "	137
27 April	15 miles W. of Cape Edgecumbe	62
8-10 May	Portlock Bank	368
14-15 May	Vicinity around Middleton Island	60

Date 1958	Locality	Number seals sighted
	Alaska (continued)	
23, 25, and 26 May	20 miles S.W. of Cape St. Elias	61
28 May	Portlock Bank	198
7-8 June	Albatross Bank, 35 miles S.E. of Cape Barnabas	94
8 June	50 miles E. of Simeonof Island	49
14 June	100-fathom curve, Sanak Island W. to Unimak Pass	324
16-17 June	" " "	157

Of the seven seal concentrations noted off California, the first three are of particular interest. The San Miguel group was found 140 miles south of the nearest discovered area where seals were found in any considerable numbers. The group found 90 miles southwest of Point Reyes is of interest because of its location offshore. The Santa Cruz - Pigeon Point group is of interest because it was probably the largest single concentration located off California and because it was found relatively close inshore. Other concentrations listed off California are of no special interest except that they appeared to be in areas of abundant food, which is also normally true of seal concentrations.

Concentrations seen off Oregon and Washington point out the fact that relatively few seals were seen by the research vessels at this time of year.

Seals were found in Sitka Sound in about the same numbers in February and March. Unexplainable fluctuations in seal numbers occurred on some days, possibly a result of movements to and from offshore areas.

Of the seal concentrations listed for Alaska, the Portlock Bank concentrations are of interest in showing that there was a large population of seals on the Bank through the month of May. The large numbers of seals sighted between Sanak Island and Unimak Pass probably equal the Portlock Bank group. Other concentrations seen in Alaskan waters show the widespread distribution of relatively large numbers of seals at this time of year.

In 1958 pelagic sealing was carried out, in general, over the same area as was covered in 1952. The area south of the Channel Islands was omitted in 1958. Seals were found in the same general areas both years and operations were in progress in each area at about the same time. In 1952, work was carried out from Dixon Entrance to Kodiak during the month of June. In 1958, this area was covered in April and May and the month of June was spent working west of Kodiak to Unimak Pass and north to the Pribilof Islands.

2. Distribution by age and sex

a. Age and sex

All seals collected off California, Oregon, and Washington during February, March and the first half of April were females. In total 585 females were taken in the February-to-April period. Of 11 males taken in the last part of April, one came from Oregon, and 10 from off the Washington coast. These included one 3-year-old and two 4-year-old seals. The proportion of seals in each age class, between ages 3 and 16

years, is much the same for each region. Until the last week in April, when they appeared in numbers off the northern Washington coast, 1- and 2-year-old seals were almost absent.

An almost identical sample was made off Sitka, Alaska, during the same time period. The only difference was that 1-year-old seals were collected in February instead of April. This group of seals disappeared after a few weeks, perhaps still migrating south. Beginning in April, male fur seals were taken in the Gulf of Alaska. Since male fur seals of the older age classes are known to winter in the Gulf of Alaska, their absence in samples of February, March, and part of April is attributed to limited sampling offshore, due to stormy weather in the Gulf. Two groups were dominant in the samples: 3- and 4-year-old and 7- and 8-year-old males. Due to incomplete sampling or some other factor, the 6- and 7-year-old class is weakly represented.

Female seals collected off Alaska show a gradual increase in numbers, by age, until the peak is reached in the 12-year-old class and then almost as gradual a decrease (table 4).

The absence of 2-year-old seals is very unusual. Of a total of 1,321 seals collected, only six were in this age group. It is presumed that this group is spread over a wide area of the north Pacific Ocean.

b. Tag recoveries

Schedule Item 1 of the Convention requires the United States to tag 50,000 seal pups each year for the first five years. Although

460
532
123
35
38

Table 4. Age and sex of fur seals collected off California, Oregon, Washington and Alaska in 1958.

Age (years)	California 6 February to 12 April				Oregon 13 April to 16 April				Washington 21 April to 29 April				Alaska 12 February to 2 July				Combined areas			
	males		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	number	percent
1	-	-	-	-	-	-	2	3.8	7	8.5	14	17.0	21	2.4	14	1.6	28	1.9	30	2.0
2	-	-	2	0.4	-	-	-	-	1	1.2	1	1.2	1	0.1	1	0.1	2	0.1	4	0.1
3	-	-	17	3.7	1	1.9	6	11.3	-	-	6	7.0	56	6.3	10	1.1	57	3.8	39	2.6
4	-	-	18	3.9	-	-	5	9.3	2	2.4	3	3.6	20	2.3	16	1.8	22	1.5	42	2.8
5	-	-	38	8.3	-	-	5	9.3	-	-	1	1.2	2	0.2	26	2.9	2	0.1	70	4.7
6	-	-	40	8.7	-	-	7	13.2	-	-	3	3.6	6	0.7	49	5.5	6	0.4	99	6.7
7	-	-	43	9.3	-	-	4	7.6	-	-	7	8.5	18	2.0	49	5.5	18	1.2	103	7.0
8	-	-	38	8.3	-	-	3	5.7	-	-	4	4.8	14	1.6	57	6.4	14	0.9	102	6.9
9	-	-	28	6.1	-	-	6	11.3	-	-	9	10.9	7	0.8	38	4.3	7	0.5	81	5.5
10	-	-	39	8.5	-	-	2	3.8	-	-	5	6.1	3	0.3	51	5.8	3	0.2	97	6.7
11	-	-	44	9.6	-	-	3	5.7	-	-	4	4.8	3	0.3	62	7.0	3	0.2	113	7.6
12	-	-	46	10.0	-	-	2	3.8	-	-	4	4.8	-	-	82	9.3	-	-	134	9.0
13	-	-	31	6.7	-	-	1	1.9	-	-	6	7.2	1	0.1	72	8.1	1	0.1	110	7.4
14	-	-	26	5.6	-	-	2	3.8	-	-	2	2.4	1	0.1	62	7.0	1	0.1	92	6.2
15	-	-	21	4.6	-	-	3	5.7	-	-	3	3.6	-	-	44	5.0	-	-	71	4.8
16	-	-	13	2.8	-	-	-	-	-	-	1	1.2	-	-	42	4.8	-	-	56	3.8
17	-	-	8	1.7	-	-	-	-	-	-	-	-	-	-	27	3.0	-	-	35	2.4
18	-	-	5	1.1	-	-	1	1.9	-	-	-	-	-	-	16	1.8	-	-	22	1.5
19	-	-	3	0.7	-	-	-	-	-	-	-	-	-	-	11	1.3	-	-	14	0.9
20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	0.3	-	-	3	0.2
21	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	-	-	1	0.1
22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0.1	-	-	1	0.1
10+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0.1		-	2	0.1
Total	-	-	460	100.0	1	1.9	52	98.1	10	12.1	73	87.9	153	17.2	736	82.9	164	11.0	1321	89.0

Grand total (males and females in combined areas) 1485 1/

1/ A total of 1503 seals were collected but, because of lost or damaged teeth, the ages of 18 could not be determined.

1958 is the first year the Convention is in effect, the United States tagged 50,000 pups in 1956 and 1957 and from 1,000 to 20,000 in several earlier years (see Appendix). It is expected that recoveries of tagged seals will eventually make possible an estimate of the amount of intermingling between Asian and American fur seals. Because yearling seals are usually poorly represented in pelagic samples and only six 2-year-old seals were included in the United States collection in 1958, it is evident that a lag of at least two years must occur before tag-recovery data from a given year's tagging is available. Perhaps worthwhile information on intermingling will never be collected in the eastern Pacific. There should, however, develop the necessary comparative information on the proportion of tagged Pribilof seals. This has not come as smoothly as expected. Variable results are obtained from one tag series to another and an, as yet, unexplainable sex difference shows up. The early tag series are now undependable because of tag losses and the difficulty of identifying seals that have lost tags.

The following table gives the pelagic tag recoveries for 1958 by age and sex of seal and by location, and the succeeding table (table 5) makes a comparison of expected and actual tag recoveries.

Tag series	Year attached	Age of seal	California ♂	California ♀	Oregon ♂	Oregon ♀	Washington ♂	Washington ♀	Alaska ♂	Alaska ♀	Total ♂	Total ♀
A	1947	11	-	2	-	-	-	1	-	1	-	4
B	1948	10	-	-	-	-	-	-	-	1	-	1
CS	1949	9	-	-	-	-	-	-	1	-	1	-
No letter	1955	3	-	-	-	-	-	-	3	-	3	-
J	1957	1	-	-	-	1	1	2	1	-	2	3
Total			-	2	-	1	1	3	5	2	6	8
Total tagged seals taken												14

Table 5. Comparison of expected and actual numbers of Pribilof-tagged seals recovered off the North American coast, 1958.

Year pups were tagged	Tag series	Number tagged	Estimated percentage of tagged seals at time of recovery		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	19183	?	-	3	113	?	-	-	4
1948	B	19532	?	5.0	3	97	?	4.85	-	1
1949	CS	19960	?	3.25	7	81	?	2.63	1	-
1951	D	1000	0.22	0.32	18	103	-	-	-	-
1952	E	20000	3.46	4.68	6	99	0.18	4.53	-	-
1953	F	9888	1.38	2.10	2	70	-	1.45	-	-
1954	G	19950	1.27	3.39	22	42	0.28	1.43	-	-
1955	H	49800	11.35	11.35	57	39	6.46	4.43	3	-
1956	I	49850	10.0	10.0	2	4	0.20	0.40	-	-
1957	J	49900	10.0	10.0	28	30	2.80	3.00	2	3
Total		259063					9.92	22.72	6	8
Grand total							32 64		14	

No explanation is apparent for the discrepancy between actual and expected tag recoveries nor for why there should be a greater discrepancy in female than in male recoveries. The most likely possibility is that it is sampling error brought about by segregations of which the investigators are unaware. No tags at all were recovered from females of ages 3 to 7. The difference in tag yields for females is highly significant according to a χ^2 test made by Dr. D. G. Chapman and the difference for males is not significant, by a very slight margin.

Information on Pribilof Island tag recoveries for 1958 is contained in the report on Pribilof Islands investigations.

3. Distribution by water temperature

a. Water temperature and abundance of seals

Fur seals appear, in certain localities, to show a preference for water of a definite temperature range. However, these apparently preferred temperatures vary from locality to locality. It seems then reasonably evident that, as inferred by Taylor, et. al. (1955), seal distribution is regulated by the secondary characteristics of the water, such as food supply.

Seals were taken in 1958 in waters with a surface temperature from 4.5° to 15°C. In California (table 6), 77 percent of the seals were taken in water ranging in temperature from 13° to 14°C. Off Oregon and Washington, 84 percent were taken in water with a temperature range from 11° to 12°C. In Alaska, the seals were spread over a broader tempera-

Table 6. Distribution of seals collected, according to surface-water temperature, 1 February to 1 July 1958.

Period	Water temperature (number of seals collected)																				
	4.5°C	5°C	5.5°C	6°C	6.5°C	7°C	7.5°C	8°C	8.5°C	9°C	9.5°C	10°C	10.5°C	11°C	11.5°C	12°C	12.5°C	13°C	13.5°C	14°C	14.5°C	15°C	Mean
California																							
1-10 February	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	15	14.6
11-20 February	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	1	28	11	10	14.2
21 February - 2 March	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	8	-	33	31	12	14.2
3-12 March	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	12	20	10	13	-	13.7
13-22 March	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9	49	13	54	-	-	13.4
23 March - 1 April	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	55	24	-	-	13.6
2-11 April	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	3	-	-	-	13.1
12-21 April	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	2	-	7	3	-	-	-	12.5
Oregon																							
12-21 April	-	-	-	-	-	-	-	-	-	-	-	-	-	16	16	18	3	-	-	-	-	-	11.6
Washington																							
1-10 February	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	11.5
12-21 April	-	-	-	-	-	-	-	-	-	-	-	1	2	7	-	-	-	-	-	-	-	-	10.8
22 April - 1 May	-	-	-	-	-	-	-	-	-	-	-	2	7	6	16	30	6	5	-	-	-	-	11.7
Alaska																							
11-20 February	-	4	19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4
21 February - 2 March	-	4	49	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.5
3-12 March	2	65	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.0
13-22 March	-	28	-	18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5.4
2-11 April	-	-	-	-	1	13	3	8	-	1	1	-	-	-	-	-	-	-	-	-	-	-	7.5
12-21 April	-	-	-	-	1	4	1	5	2	3	-	-	-	-	-	-	-	-	-	-	-	-	7.9
22 April - 1 May	-	-	-	1	-	1	5	-	-	1	1	20	-	-	-	-	-	-	-	-	-	-	9.3
2-11 May	-	-	-	-	3	29	93	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.4
12-21 May	-	-	-	-	-	2	12	14	23	-	-	-	-	-	-	-	-	-	-	-	-	-	8.1
22-31 May	-	-	-	-	-	-	6	108	66	13	-	-	-	-	-	-	-	-	-	-	-	-	8.2
1-10 June	-	-	-	1	1	5	11	5	21	5	-	-	-	-	-	-	-	-	-	-	-	-	8.0
11-20 June	-	-	-	1	52	5	1	4	3	27	-	-	-	-	-	-	-	-	-	-	-	-	7.4
21-30 June	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7.0

ture range but 68 percent were collected in water with a temperature between 7° to 8.5°C. Nothing more is illustrated by these data than that surface-water temperatures are lower to the northward so, inevitably, most seals occur in colder water in Alaska than in California, Washington, or Oregon. An obvious conclusion is that fur seals will tolerate a wide range of surface-water temperature. The observed limits are: the freezing point of sea water to 15°C.

b. Correlation with food species

Fish are known to have definite limitations in adjusting to water temperature, although many can withstand such a range of temperature that their occurrence must also be determined by other factors. Probably, as in the seal, food supply is often a determining factor.

Throughout its migration, the fur seal shows a willingness to alter its food to what is available (table 7 and figure 9). In the 12° to 15°C. waters off California, the principal food taken were squid, saury, anchovy, jack mackerel, and hake; off Oregon and Washington where most water areas cooled to 10° to 12°C., herring and rockfish appeared, jack mackerel disappeared and saury and squid became less important. In the relatively warm waters in Alaska where temperatures ranged from 7° to 10°C., capelin and sand lance, supplemented by herring and squid, were predominant. During the winter collecting when water temperatures of 4.5° to 6°C. were the rule, herring and pollack were the common foods.

Table 7. Food of fur seals, according to surface-water temperature and depth, February to July 1958.

Food species	Percent of total food volume 1/	Number of occurrences	Range of collections	Depth 2/ fathoms	Surface temperature centigrade minimum	maximum	mean
Squid (Decapoda)	14.5	413	San Miguel Island, California to Unalaska Island, Alaska	40-2500	6.0	15.0	12.4
Herring *Clupea pallasi*	29.0	158	Farallon Islands, California to Gulf of Alaska	15-1100	4.5	15.0	6.7
Capelin *Mallotus villosus*	16.3	116	Sitka, Alaska to Bering Sea	30-100	5.0	9.0	7.6
Saury *Cololabis saira*	8.4	110	Point Arguello, California to Gray's Harbor, Washington	100-2500	10.5	15.0	13.5
Sand lance *Ammodytes tobianus*	5.6	72	Gulf of Alaska to Unalaska Island, Alaska	30-100	6.5	9.0	7.6
Hake *Merluccius productus*	6.4	59	San Miguel Island, California to Cape Blanco, California	100-2000	12.0	15.0	13.4
Jack mackerel *Trachurus symmetricus*	2.0	45	San Miguel Island, California to Crescent City, California	100-2500	12.0	15.0	13.7
Anchovy *Engraulis mordax*	5.1	44	Point Arguello, California to Point Arena, California	50-500	13.0	15.0	14.0
Pollack *Theragra chalcogramma*	5.6	42	Sitka, Alaska to Gulf of Alaska	50-1100	6.5	10.0	8.5
Rockfish *Sebastodes* sp.	2.8	25	Monterey Bay, California to Gulf of Alaska	50-1200	7.0	15.0	12.6
Flatfish (Heterosomata)	1.2	13	Monterey Bay, California to Unalaska Island, Alaska	50-200	5.0	15.0	11.0
Salmon *Oncorhynchus* sp.	0.7	13	Strait of Juan de Fuca, Washington to Unalaska Island, Alaska	40-100	6.5	12.0	8.3

1/ In all seals collected

2/ Range of depths at point of collection of seals containing food fishes listed in table.

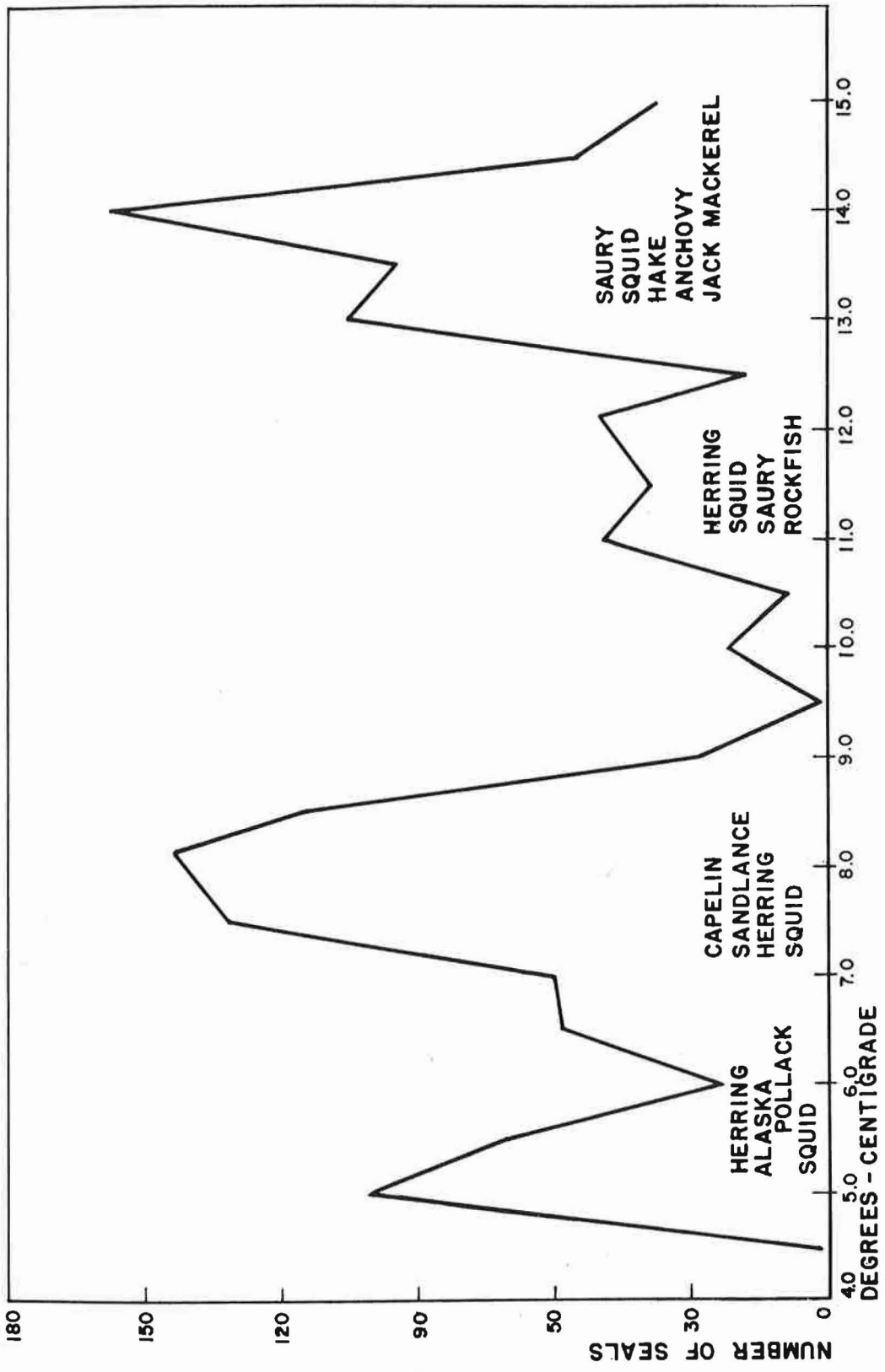

Figure 9. Food of seals collected according to water temperatures.

The summation of these data is that fur seals winter in waters of varying temperatures from California to Alaska where they feed on most of the commonly available forage fishes and squids; those from the south move northward through water that becomes cooler throughout most of the migration. During this time, some species disappear from the diet and others enter to become dominant.

B. Size and reproductive condition

1. Size

The mean lengths and weights for male, nonpregnant and pregnant female seals by age, collected during 1958 operations, are given in tables 8 and 9.

The length and weight of males ranged from 77 centimeters and 6.0 kilograms for a yearling to 195 centimeters and 169.0 kilograms for an 11-year-old bull. A marked, steady increase in length and weight continues from one to eleven years. The range in length and weight for any particular age class is of considerable magnitude.

For females, the range in length and weight is much more limited. The range for females was from 64 centimeters and 6 kilograms for a yearling, to 141 centimeters and 54 kilograms for a 14-year-old female. The heaviest female, however, was a 17-year-old, weighing 58.5 kilograms.

The growth rate of females differs radically from that of males.

Table 8. Length and weight of male and nonpregnant female seals collected off California, Oregon, Washington, and Alaska, by age and sex, 6 February to 23 June 1958.

Age (yrs)	Number measured	Length (centimeters) mean	range	standard deviation	Number weighed	Weight (kilograms) mean	range	standard deviation
Males								
1	28	77.4	69.0- 92.0	5.66	28	9.8	6.0- 14.0	1.76
2	2	97.0	92.0-102.0	-	2	16.5	16.0- 17.0	-
3	57	108.1	98.0-123.5	15.40	56	23.3	15.5- 33.0	4.69
4	22	115.4	101.0-122.0	5.18	22	28.6	23.5- 36.0	3.58
5	2	129.0	127.0-131.0	-	2	41.3	35.5- 45.0	-
6	6	148.0	142.5-155.0	4.25	6	62.9	51.0- 76.0	3.69
7	18	151.3	128.5-181.0	11.54	18	70.2	51.5-115.0	14.59
8	14	173.3	150.0-174.0	8.39	13	80.0	65.0- 99.5	11.80
9	7	168.1	148.0-196.0	17.96	7	101.4	67.5-160.0	31.78
10	3	175.3	166.0-186.0	10.07	3	99.2	85.0-115.0	4.74
11	3	192.2	190.0-195.0	2.25	3	145.2	126.0-169.0	6.92
12	-	-	-	-	-	-	-	-
13	1	170.0	-	-	1	106.0	-	-
14	1	192.0	-	-	1	120.0	-	-
Total	164				162			
Females								
1	30	73.5	64.0- 81.5	4.29	30	8.4	6.0- 10.5	1.15
2	4	84.6	79.0- 89.5	4.38	4	12.0	8.0- 15.0	3.34
3	38	99.2	91.0-109.5	5.22	38	17.1	10.0- 25.0	2.91
4	41	106.1	98.0-116.0	5.16	41	21.2	15.0- 27.5	2.77
5	39	112.9	100.0-123.0	5.20	39	24.8	18.0- 38.5	3.62
6	19	117.6	103.5-129.0	6.69	19	28.7	19.0- 39.0	4.42
7	11	123.6	116.0-128.0	3.85	11	31.8	24.5- 37.0	3.55
8	11	118.9	112.0-126.0	4.89	11	29.2	21.5- 34.0	4.22
9	3	125.0	119.0-135.0	8.72	3	34.5	27.0- 42.0	7.50
10	13	122.8	111.0-131.5	5.57	13	32.9	27.5- 42.5	4.46
11	9	130.7	123.5-138.0	6.28	9	35.6	26.0- 43.0	5.58
12	26	125.0	112.0-135.0	5.62	26	36.7	22.5- 58.5	6.97
13	19	126.5	116.0-139.0	6.71	19	36.6	25.5- 50.5	6.44
14	18	128.7	121.0-141.0	5.05	18	41.0	35.0- 54.0	5.41
15	15	128.3	121.0-137.5	4.60	14	39.0	30.5- 50.5	3.66
16	12	127.4	113.0-140.0	7.93	12	39.5	23.0- 53.0	7.62
17	15	128.6	117.0-136.0	6.31	15	41.7	31.0- 58.5	6.10
18	9	128.0	117.0-135.0	6.28	9	42.2	33.5- 54.0	6.87
19	10	126.1	117.0-135.0	5.47	9	42.0	34.0- 55.0	6.23
20	2	130.5	129.0-132.0	-	2	45.3	43.0- 47.5	-
21	-	-	-	-	-	-	-	-
22	1	127.0	-	-	1	43.0	-	-
Total	345				343			

Note: Totals differ because of missing data for some seals.

Table 9. Length and weight, by age, of pregnant seals collected off California, Oregon, Washington, and Alaska, 6 February to 23 June 1958.

Age (yrs)	Length (centimeters)				Weight (kilograms)			
	Number of seals	mean	range	standard deviation	Number of seals	mean	range	standard deviation
1	-	-	-	-	-	-	-	-
2	-	-	-	-	-	-	-	-
3	1	115.0	-	-	1	25.0	-	-
4	1	112.0	-	-	1	25.0	-	-
5	31	116.1	102-126	5.73	31	30.4	21.5-42.0	5.16
6	79	120.3	107-132	5.44	78	32.9	24.0-54.5	6.02
7	91	121.4	107-133.5	5.35	91	34.9	23.5-50.0	6.16
8	91	124.3	109-133	5.51	90	37.5	26.0-53.0	6.43
9	78	125.9	116-138.5	5.22	78	38.9	24.5-53.0	6.84
10	84	126.5	112-137	6.22	83	40.0	27.5-56.0	7.27
11	104	127.2	110-143	6.51	102	41.6	29.0-61.0	7.50
12	108	130.3	112-141	6.11	107	43.0	27.5-60.0	7.21
13	91	128.5	114-142	5.94	91	44.1	32.5-60.0	6.46
14	74	129.6	114-146	6.51	74	45.4	30.0-66.0	8.33
15	56	128.5	116-139.5	4.85	55	44.2	24.0-65.0	7.39
16	45	129.3	115-145	6.01	45	46.3	31.5-59.0	7.08
17	21	130.0	122-138	4.82	21	45.0	35.5-57.5	5.65
18	13	133.1	125-144	5.12	13	47.6	38.0-58.5	5.77
19	4	128.0	124-134	4.24	4	41.4	35.0-48.0	6.13
20	1	128.0	-	-	1	49.0	-	-
21	1	134.0	-	-	1	55.0	-	-
Total	974				967			

Note: Totals differ because of missing data for some seals.

Rapid gain in length and weight is noticeable up to the fifth or sixth year; the increase levels out during the next five years and remains fairly constant thereafter.

The seasonal increase in body weight for pregnant seals, shown in table 10, is affected by the increased weight of the fetus and surrounding membranes and fluid and the developing mammary glands. However, two variables must be considered: one is the time of egg implantation with related growth and increase in weight of the fetus (the seal pups are born over a period of six weeks); secondly, the variation in weight of pregnant seals may be affected by the relative abundance of food.

The rate of size increase of the fetus is also shown in table 10 and, as can be seen, is fairly regular. The increase in length during the 140-day period was 33.2 centimeters (130 percent), and in weight 5.27 kilograms (1424 percent).

The nonpregnant seals are slightly shorter and lighter than pregnant seals. At present, there is no reason to account for their being shorter, although they would be expected to weigh less.

2. Reproductive condition

a. Reproduction according to age

It is essential, for making population estimates to know what proportion of breeding-age, female seals give birth to young. It is also useful, management information to know the reasons for failure to produce young.

Table 10. Mean length and weight increase of fetuses and weight increase of pregnant females, by 10-day periods, from 1 February to 20 June 1958.

Date	Fetuses						Pregnant females		
	Number	Mean length centimeters	Cumulative percent increase	Number	Mean weight kilograms	Cumulative percent increase	Number	Mean weight kilograms	Cumulative percent increase
1-10 February	20	25.5	-	21	0.37	-	19	34.13	-
11-20 February	53	27.1	6	52	0.48	30	51	34.81	2
21 February - 2 March	107	30.2	18	107	0.70	89	101	36.65	7
3-12 March	87	34.2	34	87	1.05	184	88	39.14	15
13-22 March	125	36.6	44	124	1.26	241	123	36.49	7
23 March - 1 April	68	38.7	52	68	1.38	273	68	35.93	5
2-11 April	20	43.2	69	20	1.99	438	20	36.95	8
12-21 April	51	46.2	81	51	2.24	505	47	35.71	5
22 April - 1 May	180	50.6	98	48	2.76	646	38	38.60	13
2-11 May	119	52.9	108	118	3.64	884	99	43.83	28
12-21 May	52	54.5	114	52	4.10	1001	49	43.93	29
22-31 May	147	56.5	122	148	4.62	1149	142	45.13	32
1-10 June	31	56.2	120	31	5.03	1259	31	47.81	40
11-20 June	60	58.7	130	60	5.64	1424	57	47.73	40

wrong

Large numbers of female seals have been examined, especially from 1956 through 1958, for reproductive condition, on the Pribilof Islands. Because of segregation of seals on the breeding islands into those that join harems on rookeries and those that are found on hauling grounds and rookery fringes, it is difficult to obtain a sample that is fully representative of the breeding-age, female population. The antagonistic behavior of bull seals effectively prevents satisfactory sampling from the rookeries until about 10 August. Even when possible to sample rookery females, it is not known what proportion of rookery, rookery-fringe, and hauling-ground females would make up a representative sample.

A pelagic sample which, it is believed, would not be segretated by reproductive condition (although segregated by age and sex in some areas) would provide more accurate information about pregnancy rate than a land sample.

Tables 11 and 12 give, in several categories, the reproductive condition of female seals taken during the 1958 collecting. Some allowance must be made for a margin of error in interpreting the appearance of uterine horns and ovary sections. Because of the presence of a fetus, during the time of collecting, pregnancy is very clear cut. Abortions and resorptions present a problem in recognition which varies with the stage at which loss of the fetus occurs.

Table 11. Reproductive condition of female seals collected at sea off California, Oregon, Washington, and Alaska, 6 February to 23 June 1958.

Reproductive condition	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	10+	Group totals number	Group totals percent	Grand total number	Grand total percent
Nullipara																											
number	30	4	38	41	35	8	-	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-	-	161			
percent	18.6	2.5	23.6	25.5	21.7	5.0	-	1.9	-	-	-	1.2	-	-	-	-	-	-	-	-	-	-	-				12.2
Total																								161	100.0	161	12.2
Primipara																											
Pregnant																											
number	-	-	1	1	25	33	23	7	8	2	1	1	-	1	1	-	-	-	-	-	-	-	-	104			7.9
percent	-	-	0.8	0.8	20.9	27.6	19.2	5.8	6.7	1.7	0.8	0.8	-	0.8	0.8	-	-	-	-	-	-	-	-		86.7		
Nonpregnant																											
number	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
percent	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-				
Aborted or resorbed																											
number	-	-	-	-	3	6	3	-	-	-	-	-	1	1	-	-	-	2	-	-	-	-	-	16			1.2
percent	-	-	-	-	2.5	5.0	2.5	-	-	-	-	-	0.8	0.8	-	-	-	1.7	-	-	-	-	-		13.3		
Total																								120	100.0	120	9.1
Multipara																											
Pregnant																											
number	-	-	-	-	7	47	69	84	70	83	103	109	91	74	55	44	20	13	4	1	1	-	2	877			66.3
percent	-	-	-	-	0.7	4.5	6.6	8.0	6.7	8.0	9.9	10.4	8.7	7.1	5.3	4.2	1.9	1.3	0.4	0.1	0.1	-	0.2		84.3		
Nonpregnant																											
number	-	-	-	-	-	2	2	1	-	3	6	7	4	1	4	3	3	4	3	-	-	1	-	44			3.4
percent	-	-	-	-	-	0.2	0.2	0.1	-	0.3	0.6	0.7	0.4	0.1	0.4	0.3	0.3	0.4	0.2	-	-	0.1	-		4.2		
Aborted or resorbed																											
number	-	-	-	-	-	3	6	7	3	9	3	15	14	15	11	9	12	3	7	2	-	-	-	119			9.0
percent	-	-	-	-	-	0.3	0.6	0.7	0.3	0.8	0.3	1.4	1.3	1.4	1.1	0.9	1.2	0.3	0.7	0.2	-	-	-		11.5		
Total																								1040	100.0	1040	78.7
Grand total	30	4	39	42	70	99	103	102	81	97	113	134	110	92	71	56	35	22	14	3	1	1	2			1321	
Percent	2.3	0.3	3.0	3.2	5.3	7.5	7.8	7.7	6.1	7.3	8.4	10.2	8.3	7.0	5.4	4.1	2.7	1.7	1.1	0.2	0.1	0.1	0.2				100.0

Table 12. Proportion of pregnant and nonpregnant seals among 1,321 females taken off California, Oregon, Washington, and Alaska from 6 February to 23 June 1958.

Area	Number females	Number pregnant	Percent pregnant	Number nonpregnant	Percent nonpregnant
California	460	351	76.3	109	23.7
Oregon	52	30	57.7	22	42.3
Washington	73	38	52.1	35	48.0
Alaska	736	557	75.7	179	24.3
Total	1321	976	73.9	345	26.1

Nulliparous females (12.2 percent) were, as may be expected, largely among animals up to five years old. They have been found, however, at many ages, including in 1958 two 12-year-olds.

Primiparous females (9.1 percent) likewise were principally among younger seals, from 5 to 7 years old, but they are not uncommon up to age 9. Scattered examples appeared up to age 15.

Except in extremely rare instances, multiparous females (78.7 percent) must be at least five years old. This was true for the 1958 collection. Because the aging methods used before 1958 did not permit aging seals more than 10 years old, little information has been assembled about the age range at which the pregnancy rate began to decline. It can be seen in table 13 that a high level of productivity is maintained through age 16 and it remains at a reasonable level until age 18. Thereafter, the data

Table 13. Comparative pregnancy rate of seals collected off California, Oregon, Washington, and Alaska, by age, in 1952 and 1958.

Age (years)	Number females taken 1952	Number females taken 1958		Percent pregnant 1952	Percent pregnant 1958	
3	30	39		-	3	
4	80	42		1	2	
5	28	70		43	46	
6	49	99		82	81	
7	39	103		72	89	
8	55	102		77	89	
9	35	81		89	96	
10	31	97		74	87	
11	-	113		-	92	
12	-	134		-	82	
13	-	110		-	83	
14	-	92		-	80	
15	-	71		-	79	
16	-	56	655 1/	-	79	77 2/
17	-	36		-	57	
18	-	22		-	59	
19	-	14		-	29	
20	-	3		-	33	
21	-	1		-	0	
22	-	1		-	0	
10+	187	2		75	-	
Total	534	1288		63 3)	74 4)	

1/ Total of seals 11 to 22 years old and 2 of unknown age.

2/ Percent of pregnant seals more than 10 years old.

3) The overall pregnancy rate for 1952

4) The overall pregnancy rate for 1958

are scanty but it seems clear the pregnancy rate is dropping sharply. The most productive years, according to the 1958 age and pregnancy data, range from age 6 to age 16. Allowing for a pregnancy rate of about 50 percent, the productive life span extends to include the years 5 to 18. Little can be expected from animals younger or older than this.

In a preliminary manuscript for their population study of the fur seal, Kenyon, Scheffer, and Chapman (op. cit.) gave a postulated age distribution of female seals through age 25. This was not published because it was considered that there were too few data on which to base any figures. It has been a strongly felt need to have a working knowledge of the age distribution among female seals over 10 years old, to know the length of their productive life, and their life span. It is of interest to compare the postulated data with the data obtained in 1958 from aging this group of older females. Using the group of seals 11 to 25 years of age as 100 percent, the comparative percentage of seals at each age is given in table which follows (see, also, figure 10).

These data, including the surprisingly smooth curve resulting from them, suggest a more rapid disappearance of females from the population than had been postulated. In the observed distribution curve, a greater number of animals are included in ages 11 through 14, the curves cross at ages 15 to 16 and the steep slope of the observed distribution curve from ages 17 to 22 trims away many animals that were presumed to persist in drawing the postulated curve.

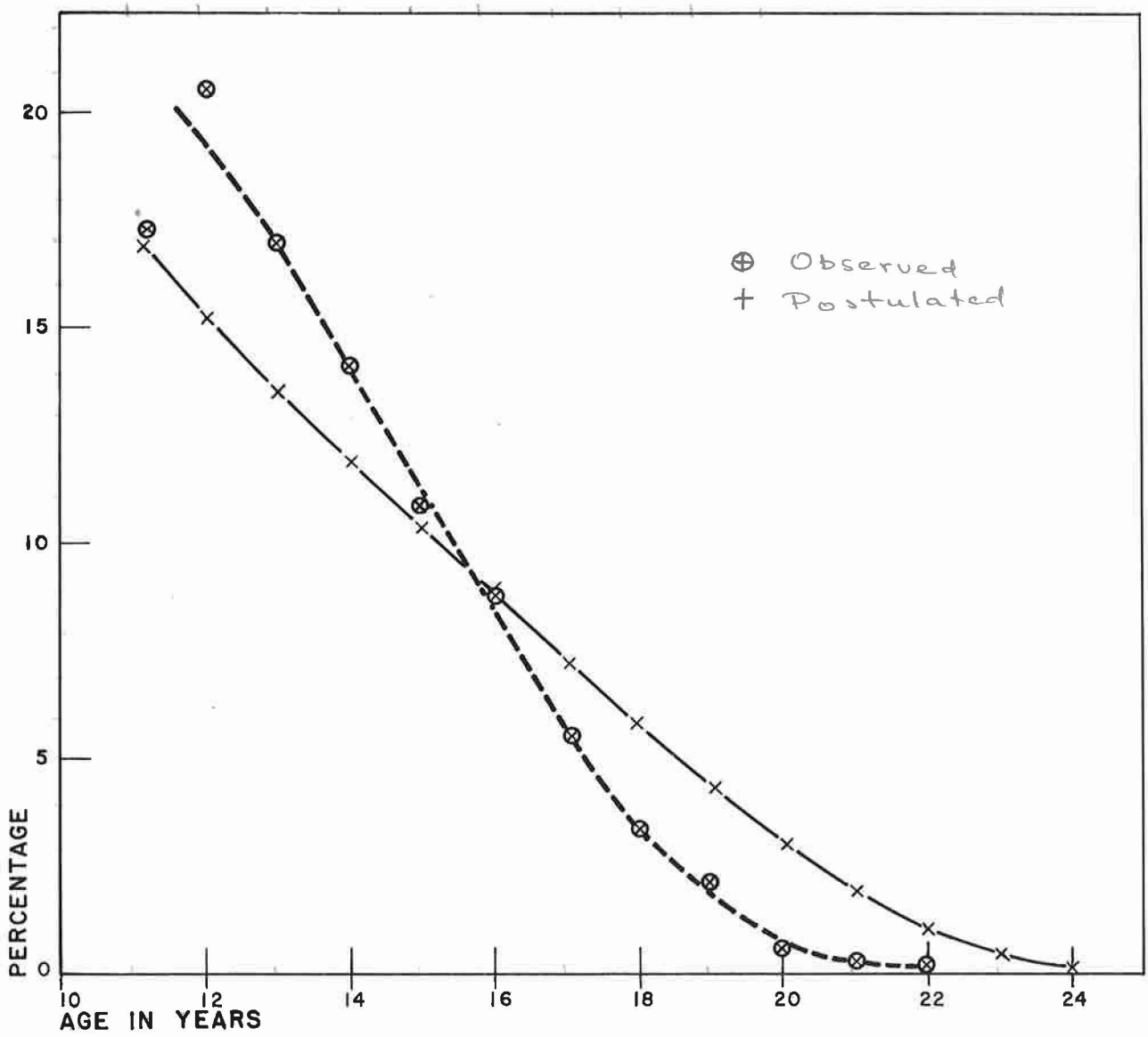

Figure 10. Comparison of postulated and observed age distribution among female fur seals 11 to 25 years of age.

Age	Postulated distribution of females in 10+ group	Observed distribution of females in 10+ group
	percent	percent
11	16.8	17.3
12	15.2	20.5
13	13.5	16.8
14	11.9	14.1
15	10.3	10.9
16	8.7	8.6
17	7.2	5.5
18	5.7	3.3
19	4.3	2.1
20	3.0	0.5
21	1.9	0.2
22	1.0	0.2
23	0.4	-
24	0.1	-
25	trace	-
Total	100.0	100.0

However reliable or unreliable this sample may be, it now seems that the rather laborious longitudinal tooth-section technique will open the way, in the future, to a better understanding of reproduction in the older age classes.

b. Uterine horn of pregnancy and fetal sex ratio

Table 14 shows the horn of pregnancy and sex of fetus for pregnant fur seals taken in 1958. Data on the uterine horn is missing for 112 seals and on sex of fetus for 11 seals. The sample shows some tendency for pregnancies to occur more frequently in the left horn and for a preponderance of male fetuses to develop. A sample of 119 first pregnancies examined in 1953, on St. Paul Island, occurred in the left uterus in 66 instances and in the right in 53 instances. The combined

1956 and 1957 records of all pregnancies examined on the Pribilof Islands are grouped as follows:

Right horn	-	3226
Left horn	-	3287

Table 14. Uterine horn of pregnancy for 869 seals and sex of fetus for 970 seals collected off California, Oregon, Washington, and Alaska in 1958.

Month	Uterine horn		Sex of fetus	
	left	right	male	female
February	68	57	78	70
March	113	113	157	145
April	57	53	53	59
May	181	136	174	144[1/]
June	46	45	46	44
	465	404	508	462
Totals	869		970	

[1/] Includes one pair female twins.

The tendency for more frequent pregnancies in the left horn of the uterus is shown only slightly by these data.

The 1952 pelagic investigation recorded 314 male and 276 female fetuses. A sample of 1,200 seal pups weighed on St. Paul Island in 1957 included 653 males and 547 females.

The sex ratio has been considered to be equal but these data create the suspicion that more males than females are being born under present herd conditions.

c. Abortions and resorptions

In previous pelagic collections, the fact that a female was pregnant was recorded without additional details. In 1958, information of interest regarding fetal abortions and absorptions has been obtained. If recognition of aborted or resorbed seals is reasonably accurate, the number of such seals is a large part of those not pregnant at the time of capture. A total of all animals pregnant, aborted or resorbed at that time reveals that 89.3 percent of all female seals, 5 years old or older in the sample, had been pregnant at some time since the latest breeding season. Assuming that the sample represents reasonably well what is true in the whole Pribilof Population, it seems evident that adequate opportunity for impregnation is provided by the present male escapement from the commercial kill.

d. Comparison of 1952 and 1958 collections

Comparison of the 1952 and 1958 female collections shows a higher pregnancy rate in the latter year for age group 5 and 7 through 10 and, also, for the composite 10+ group. The overall rates are 63 percent pregnant in 1952 and 74 percent in 1958. By weighting the two collections according to the life table (Kenyon, Scheffer, and Chapman, 1954) as was done by Taylor, et. al. (1955), the difference between 1952,

66 percent, and 1958, 70 percent, is reduced. Such manipulation, to increase the proportion of young animals in the sample, does not conceal the fact that a higher pregnancy rate existed among the productive age group in 1958. The problem is whether the difference is only apparent and is caused by inadequate samples or is the result of an actual improvement in pregnancy rates.

e. Anomalies

One 3-year-old female was found in a primiparous group. This is an unusual occurrence but checking the records did not disclose an error. Pregnancy at this age is not known to be impossible and is, perhaps to be expected in an occasional precocious individual.

An 11-year-old female was taken on 9 May 1958 in the Gulf of Alaska (58°35'N. -148°16'W.) carrying two well-formed, female fetuses. One (left) weighed 3.49 kilograms and the other (right) 3.43 kilograms. Their lengths, 53 and 54 centimeters, were also nearly equal. This is the first record of twinning in the northern fur seal, according to any records known to the Fish and Wildlife Service. Since it is seemingly a quite-possible situation in primiparous females or those that failed to produce for a year, it is rather surprising that twins have not been observed before, either in the uterus or after birth.

D. Predators

C. Food habits

1. Handling of materials

Usually the tagged stomachs, with openings tied off, were injected, depending on their size, with 50 to 300 cc. of 10 percent formalin solution. A few were merely punctured with a sharp knife to permit entrance of the preserving fluid. Occasionally, damaged stomachs were placed in a perforated polyethylene bag to prevent loss of the contents. The plastic bags interfered with satisfactory penetration of preserving fluid when the perforations were too small. Cotton bags would be more suitable. It was found that formalin injection will stop digestion in stomachs and speed up the preservative action of the formalin solution. For this reason, the injection method was found to be most satisfactory. All stomachs were then stored in barrels containing the same 10-percent solution. Material handled in this manner was stored for a six-month period and was still in good condition for examination.

2. Identification of food species

Fish were collected in fine mesh gill nets during pelagic sealing for later comparison with fragments of fish found in stomach contents. Specimens were also secured from fishermen and fish markets in the area. These supplemented the Fish and Wildlife Service skeleton and otolith collection. Some skeletal material was sent to Dr. Giles Mead, at the U. S. National Museum, for identification.

Since seal food consists mostly of schooling fish, the identification of one specimen often leads to easy recognition of the contents in a series of stomachs.

The most common food species were:

Squid (Decapoda), of which four species were identified. Squid identification was usually difficult because of advanced stage of digestion and, in many cases, only beaks were found in the stomach. Well preserved specimens were identified from Berry, S. S. (1912). Those identified were: Loligo opalescens, Docidicus gigas, Onychoteuthis sp., and Gonatus fabrici.

Pacific herring (Clupea pallasi), the most important food species by volume, was identified easily by well-preserved specimens or whole skeletons.

Capelin (Mallotus villosus), being a schooling fish, was found in stomachs containing it, in large numbers. The separation of osmerids in advanced stage of digestion was impossible. For that reason, final identification was deferred until other stomachs from the same area contained well-preserved fish for positive identification. The material was then compared and identified if possible.

Pacific saury (Cololabis saira) was readily identifiable by the small-toothed processes between the neural spines of the vertebrae and similar processes between the haemal spines.

Sand lance (Ammodytes tobianus personatus) was identified

by the external appearance of well-preserved specimens, the protruding lower jaw, and a number of characteristic vertebrae.

Pacific hake (Merluccius productus) was easily identified by expanded vertebral parapophyses, forming an almost solid, bony roof over the abdominal cavity.

Jack mackerel (Trachurus symmetricus) vertebrae are solid, elongated, and the last four neural and haemal spines lie flat against the vertebrae. It is also identifiable by two rows of scutes on the caudal peduncle of the partially digested fish.

Northern anchovy (Engraulis mordax) was identified by protruding, tapering snout, characteristically large mouth with maxillary reaching almost to gill openings, and small conical teeth.

Alaska pollack (Theragra chalcogramma) was recognized by the very characteristic subоperculum, and post-clavical bones. The haemal arch is large, oval, and prominent. The elliptical otoliths are concave.

Rockfishes (Sebastodes spp.) as a family are fairly easy to identify by the robust skeleton and by the spined preopercle.

Sebastodes jordani was identified from well-preserved specimens and otoliths.

Sebastodes alutus was recognized from otoliths and from the protruding symphysial knob on the lower jaw, with a matching notch on the upper jaw.

Salmon (Oncorhynchus spp.) were recognized by presence of pink or red flesh and characteristic vertebrae, in which the length equals the diameter. All vertebrae are very similar in size and shape. The surfaces of the vertebrae are smooth or very finely striated. Differentiation between species was not attempted because of missing skeletal parts and overlapping characteristics.

Sand dabs (Citharichthys spp.) were identified by the 36 vertebrae, the first haemal spine on the 12th vertebra, haemal arch begins at the 9th to 11th vertebrae, and the haemopophyses having very sharp-angled tips, characteristic for the genus.

Shad (Alosa sapidissima) found in seals' stomachs were only partly digested and could be recognized by sharp scutes along ventral edge, white peritoneum, and long, thin neural spines. The total vertebral count is 56.

Jack smelt (Atherinopsis californiensis) was recognizable by a bony structure called the haemal funnel which is formed by a sudden increase in length and flattening out of the haemopophyses beginning at the 33rd vertebra. The extended ends of the haemopophyses come together to form the funnel. The total count of vertebrae for this species is 51.

Northern midshipman (Porichthys notatus) was identified by the flat, depressed skull. The vomer has two fang-like teeth. The upper lobe of the urostyle is jointed.

Arrowtoothed halibut (Atheresthes stomias) was identified in

its four occurrences by the characteristically-shaped teeth.

Pacific lamprey (Entosphenus tridentatus) had, as the only clue to its identity, the remains of three horny cuspid front, and multi-cuspid posterior plates. The cartilaginous skeleton is easily digested.

Flatfishes (Heterosomata) remains were too incomplete to attempt identification more closely than to the order. The first few haemal spines made identification to order possible.

Smelt (Osmeridae) were recognizable, as belonging to smelt family, by the large mouth with maxillary reaching below the eye, teeth on both jaws and on tongue, and general exterior appearance.

Halfmoon (Medialuna californiensis) was recognized by the high supra-occipital crest extending back over the atlas, and a total vertebral count of 25.

Pacific tomcod (Microgadus proximus) has vertebrae with flattened transverse processes, and neural and haemal spines which taper to a point at posterior end. The vertebral count is 57. The otoliths are about one-third narrower than in true cod and the margins are very finely serrated.

Sablefish (Anoplopoma fimbria) appeared as a single half-digested specimen. The total number of vertebrae is 63, the first haemal spine is on vertebra 32, and the haemal arch is at vertebra 28. The opercula are black lined.

Pacific mackerel (Pneumatophorus diego) has a solidly-built

and well-interlocked vertebral column and the caudal vertebrae have toothed neural and haemal zygapophyses. The first haemal spine is long, curved backward, and then downward. On the beginning of the downward sweep, the spine is flattened, forming a sharp crest.

Lantern fish (Myctophidae) were recognizable from their exterior by the very large mouth, a few remaining photophores, and large scales.

Great pipefish (Syngnathus californiensis) has a vertebral column which is noticeably long and fragile for its length. It includes 74 vertebrae. The first two vertebrae are completely covered laterally and dorsally by bony modifications.

3. General account of stomach contents

Forty-eight percent of the 1503 stomachs collected contained food, although in some instances only trace amount remained. A larger proportion of the seals from California and Washington, 68 and 66 percent, contained food than did those from Oregon or Alaska. In these areas, 47 and 41 percent of the stomachs contained food. A higher proportion of stomachs contained food than in 1958, although the order of frequency of such stomachs for the various areas is similar.

The many variables make it difficult to know why these variations occur in the numbers of seals that have been recently feeding when collected. One cause of variation is the amount of food furnished by species that rise to the surface, where they are available to seals only at night.

At the time the seal is captured in daylight hours, much of the food has disappeared through digestion. Another closely related cause is the time of day when the seals are taken. As is demonstrated in figure 11 and previously, stomachs of seals collected early contain more food than those collected later in the day. Other conditions, such as fluctuations in the population of an important food species, the specific areas where the seals are collected, and the time spent collecting in an area, will influence the amount of food to be found in the stomachs of those collected.

Table 15 shows by area and in total the food items by species, the percentage of the total food volume represented by the species, and its frequency of occurrence. Another presentation of relative volume is shown in figure 12.

Several species were found that had not appeared in earlier North American collections. One, the jack mackerel, occurred 45 times in seals from California and Oregon. The northern midshipman appeared four times, the half moon twice, a trachipteran twice, and a pipefish once in California waters. From scattered locations in the Gulf of Alaska, arrowtoothed halibut was found in four stomachs. Lantern fish, which are a very important food of seals off Japan, were found once in a seal taken southeast of Yakutat in the Gulf of Alaska.

From California to Washington, the saury appeared 109 times in 323 stomachs, as compared with one occurrence in 125 stomachs in 1952. Jack smelt, which was found 17 times in the California-Oregon collection

Table 15. Analysis of stomach contents of 785 seals collected off California, Oregon, Washington, and Alaska, by percent of total volume and frequency of occurrence, 6 February to 23 June 1958.

Food items	California 6 February to 12 April		Oregon 13 April to 16 April		Washington 21 April to 29 April		Alaska 12 February to 2 July		Total combined areas	
	percent	frequency	percent	frequency	percent	frequency	percent	frequency	percent	frequency
Herring (Clupea pallasi)	0.6	5	-	-	51.8	21	45.7	132	29.0	158
Capelin (Mallotus villosus)	-	-	-	-	-	-	28.0	116	16.3	116
Squid, unidentified	20.6	263	50.7	34	10.6	29	3.1	67	10.6	393
" (Loligo opalescens)	7.9	9	4.5	1	-	-	0.5	2	3.2	12
" (Docidicus gigas)	0.5	3	-	-	2.4	1	-	-	0.3	4
" (Onychoteuthis sp.)	0.6	2	4.8	1	-	-	-	-	0.3	3
" (Gonatus fabrici)	0.4	1	-	-	-	-	-	-	0.1	1
Saury (Cololabis saira)	21.3	102	12.4	3	13.6	5	-	-	8.4	110
Pacific hake (Merluccius productus)	16.9	56	18.1	3	-	-	-	-	6.4	59
Sand lance (Ammodytes tobianus personatus)	-	-	-	-	-	-	9.7	72	5.6	72
Pollack (Theragra chalcogramma)	-	-	-	-	-	-	9.7	42	5.6	42
Anchovy (Engraulis mordax)	14.3	44	-	-	-	-	-	-	5.1	44
Rockfish (Sebastodes sp.), unidentified	1.6	8	2.3	1	12.9	5	0.2	2	1.3	16
" (Sebastodes jordani)	3.1	7	-	-	-	-	-	-	1.1	7
" (Sebastodes alutus)	-	-	-	-	-	-	0.7	2	0.4	2
Jack mackerel (Trachurus symmetricus)	5.1	44	7.1	1	-	-	-	-	2.0	45
Flatfish (Heterosomata)	-	-	-	-	-	-	0.2	1	0.1	1
Sand dab (Citharichthys sp.)	2.2	8	-	-	-	-	-	-	0.8	8
Arrowtoothed halibut (Atheresthes stomias)	-	-	-	-	-	-	0.5	4	0.3	4
Northern midshipman (Porichthys notatus)	2.3	4	-	-	-	-	-	-	0.8	4
Salmon (Oncorhynchus sp.)	-	-	-	-	1.5	1	1.1	12	0.7	13
Jack smelt (Atherinopsis californiensis)	1.5	3	-	-	-	-	-	-	0.6	3
Shad (Alosa sapidissima)	0.7	6	-	-	3.1	1	-	-	0.4	7
Unidentified fish	0.4	18	0.1	1	trace	7	0.4	15	0.4	41
Smelt (Osmeridae)	-	-	-	-	3.2	2	-	-	0.2	2
Tomcod (Microgadus proximus)	-	-	-	-	-	-	trace	2	trace	2
Halfmoon (Medialuna californiensis)	trace	2	-	-	-	-	-	-	trace	2
Sablefish (Anoplopoma fimbria)	-	-	-	-	0.9	1	-	-	trace	1
Mackerel (Pneumatophorus diego)	trace	1	-	-	-	-	-	-	trace	1
Lantern fish (Myctophidae)	-	-	-	-	-	-	0.1	2	trace	2
Lamprey (Entosphenus tridentatus)	-	-	trace	1	trace	1	-	-	trace	2
Pipefish (Syngnathus californiensis)	trace	1	-	-	-	-	-	-	trace	1
King-of-the-salmon (Trachipteridae)	trace	2	-	-	-	-	-	-	trace	2
Rocks	-	-	-	-	-	-	0.1	14	trace	14
Total	100.0		100.0		100.0		100.0		100.0	
Total stomachs containing food		323		36		55		372		786
Total empty stomachs		147		17		28		525		717
		470		53		83		897		1503

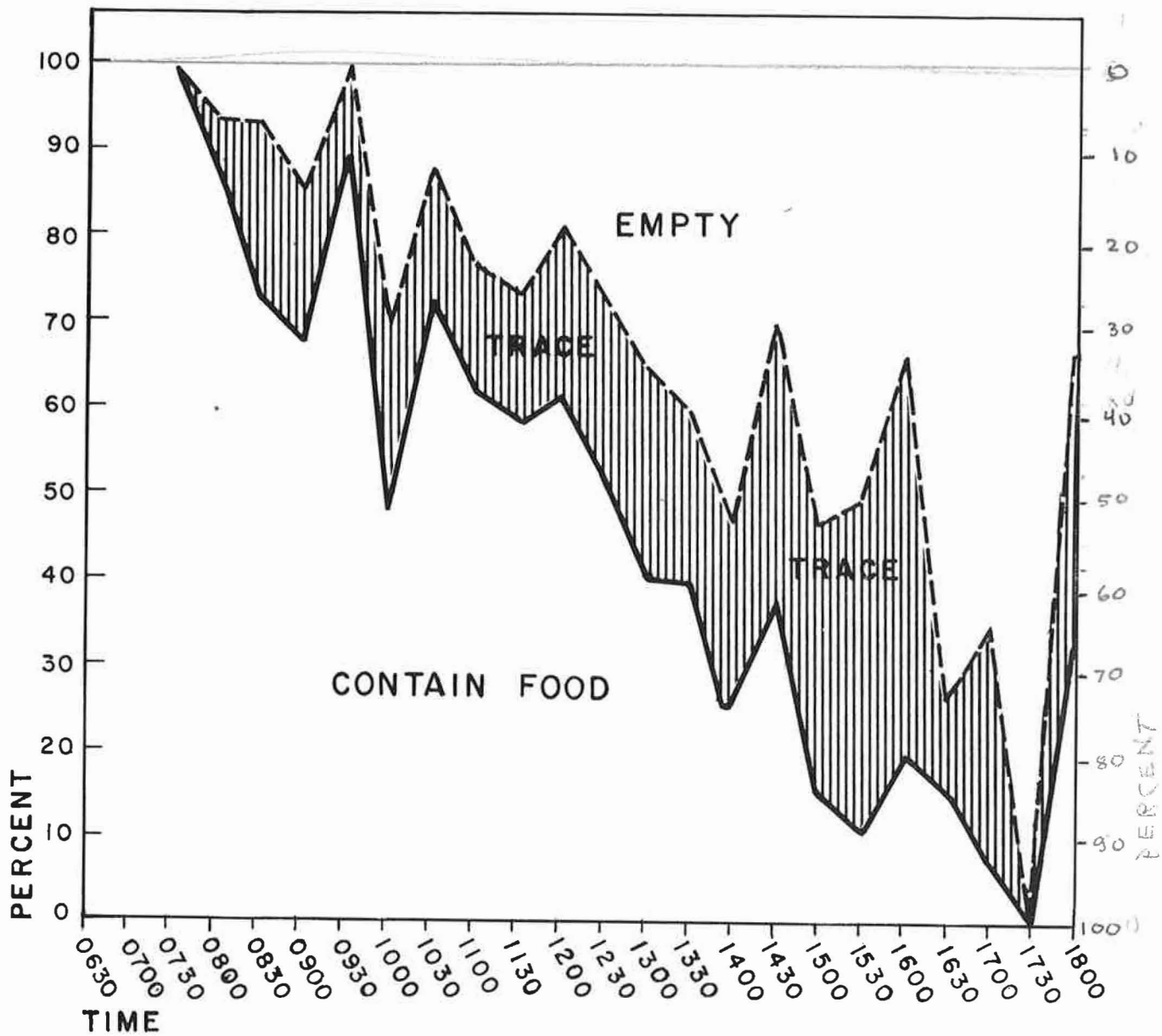

Figure 11. Proportion of seal stomachs, by time of day, collected off California, which contained a measurable amount of food, had only a trace of food, or were empty. Sunrise during period of collection, 6 February to 15 April, varied from 0723 to 0538.

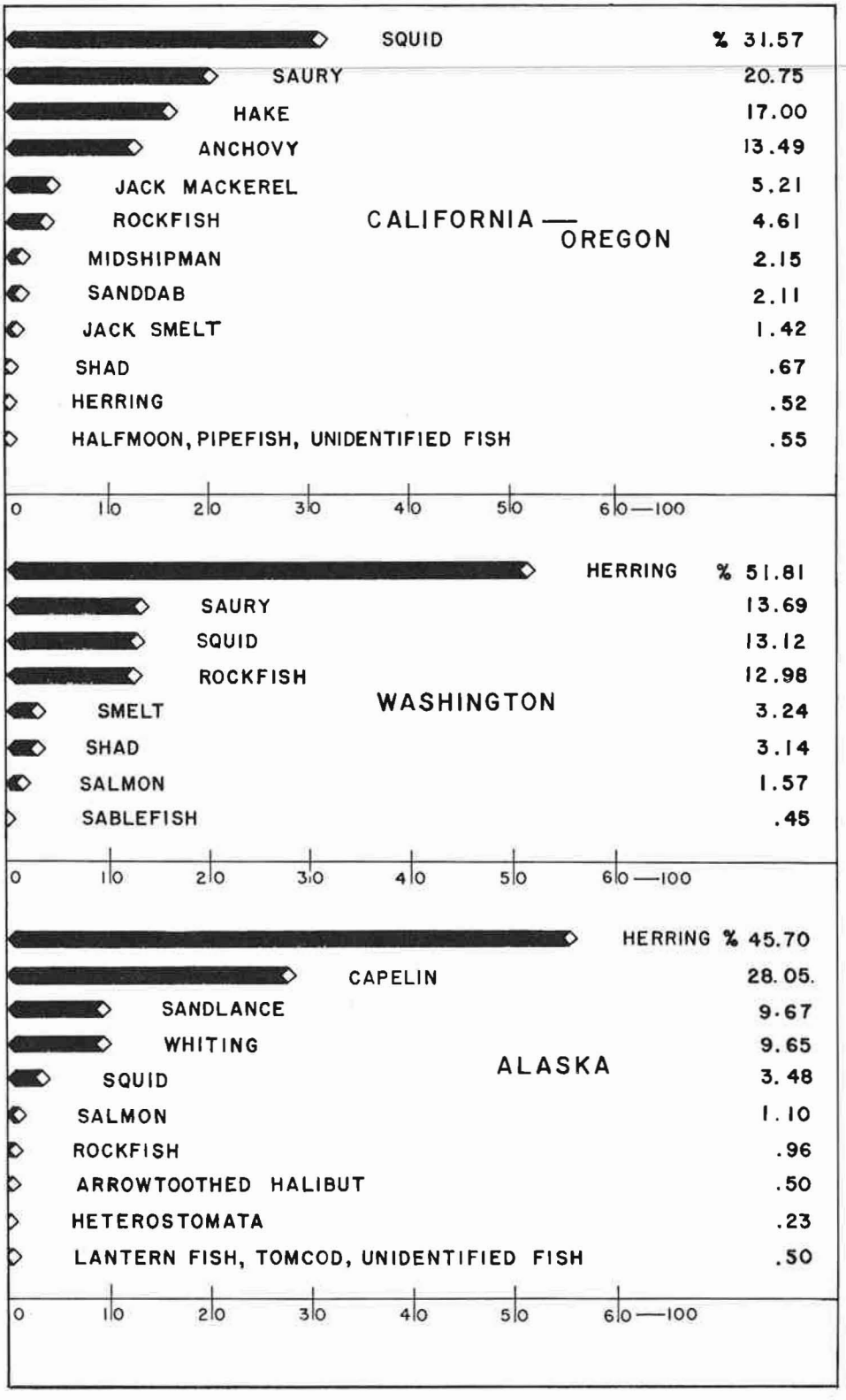

Figure 12. Principal food of fur seals collected off California, Oregon, Washington, and Alaska in 1958.

in 1952, appeared only once. A single occurrence of sand lance in 1953 (Alaska, 116 stomachs) increased to 72 in 1958 (525 stomachs).

At least part of the shift in importance of certain food species in the California-Oregon collection, between 1952 and 1958 and the appearance of others, can be traced to the fact that most of the 1958 collection was made further offshore than that in 1952. Pelagic species, such as jack mackerel, saury, and squids, become more abundant offshore and jack smelt and certain of the rockfishes appear less frequently.

4. Discussion of individual food items

a. Species of economic importance

The economic importance of fish taken by fur seals is determined by current utilization along the Pacific coast of North America. Their importance here will be different than it is in some other parts of the Pacific area.

(1) Squids

Squids (figure 13, 17) are taken by the fur seal over its entire ocean range, and, by frequency of occurrence, are its most important food. By percentage of volume, squids attain third place. As has been stated in earlier reports, it is difficult to accurately determine the importance of squids in the diet because: (a) squids are easily digestible and the parts resisting digestion are small in volume as compared with a fish skeleton; (b) eye lenses and beaks of squids are very resistant and are often found in folds of the near-empty stomachs where they may

tend to accumulate. It cannot be definitely stated whether frequency of occurrence or volume gives the best indication of the relative importance of squid as seal food. The authors believe frequency of occurrence is the best indicator.

Of the four species of squids identified, Loligo opalescens is the only one that enters a commercial fishery to any extent. Squids are used to a limited extent for human food and in an increasing amount for halibut bait. The squid fishery is a minor one and does not begin to fully utilize the resource.

Squids are taken by a wide range of marine species including many of the predatory fishes, the toothed whales, and many pinnipeds. Merkel (1957) found that the king salmon (Oncorhynchus tschawytscha) obtained over nine percent of its food off San Francisco from the squid, L. opalescens.

(2) Pacific herring

Herring (figures 14, 15) is a minor food item of seals off California and Oregon but becomes the principal food off Washington and southeastern Alaska. The seals in a collection made near Sitka, Alaska were predominantly herring feeders. Like squids, herring are preyed on by many forms. Merkel (op. cit.) and others have found the king salmon uses it extensively from San Francisco to Icy Strait in Alaska. Herring are not commonly found in seals taken far offshore.

(3) Shad

As a commercial species on the Pacific coast, the

shad ranges from minor to worthless although it is extensively used on the Atlantic. The supply in the Pacific far exceeds the demand at present. It occurred in stomachs from California and Washington a total of seven times. It is interesting to speculate why the shad is not taken more frequently.

(4) Northern anchovy

Anchovies (figure 16) were the fourth most important food of fur seals collected off California. Merkel (op. cit.) reported that the anchovy was one of the principal foods of the king salmon, and Hubbs and Wisner (1953) found it to be the second most important food species of the marlin off California. The commercial fishery for the species has increased in importance because of the scarcity of pilchards.

(5) Smelt

An unidentified smelt occurred in two stomachs collected off Washington. The eulachon (Thaleichthys pacificus) had been eaten by three seals collected in 1952. If the unidentified smelt found in 1958 were of this species, their economic importance was minor.

(6) Salmon

Salmon (figures 17, 18) appeared once in a seal taken off Washington and 12 times in Alaska where they occurred widely scattered around the Gulf of Alaska. Every study of fur seal stomach contents leads to the same conclusion -- that salmon are not immune to predation by fur seals but the amount of such predation is small and

apparently, by comparison with other hazards menacing salmon, not a cause for concern.

(7) Jack smelt

This is a commercial species in California. It made up only about 0.5 percent of the food volume in 1958 as compared with about 14 percent in 1952 when seals were collected closer inshore. Population fluctuations and oceanographic changes may also have helped bring about this change in their importance as a fur seal food.

(8) Jack mackerel

This species, new as a fur seal food, was found in 45 of the stomachs from California and Oregon (figure 16). According to Roedel (1953), it has become an important commercial species since about 1947 when sardines and Pacific mackerel became scarce off California. Hubbs and Wisner found that about three percent of the food of marlins off San Diego was jack mackerel. During North Pacific cruises of the U. S. Fish and Wildlife Service exploratory fishing vessel, John N. Cobb, and chartered vessels in July, August, and September, 1955 and 1956 (Powell, 1957; Powell and Peterson, 1957), jack mackerel were commonly taken in gill nets between 45°00' and 57°25' north latitude and offshore to 148°49' west longitude. It would appear that this species is widely available to pelagic feeders such as fur seals.

(9) Pacific mackerel

Mackerel occurred in only one stomach. Most

of the commercial catch is taken from Monterey Bay to the southward in California. Presumably, it should appear in seal stomachs much more frequently than it has been recorded. For reasons not readily apparent, it is a rare food species and another species often associated with it, the pilchard (Sardinops caerulea) is not known to be taken at all.

(10) Halfmoon

The halfmoon was found in only two seal stomachs, both from California, although young specimens were frequently taken in a fine-mesh gill net drifted at night from the sealing vessel. Hubbs and Wisner (op. cit.) recorded it in a marlin stomach and stated that young halfmoons long retain a surface-pelagic habitat. Halfmoons enter the commercial "perch" catch in the Los Angeles area which is south of the wintering grounds of any but a few scattered fur seals.

(11) Rockfishes

The only rockfish (figure 14) identified for the California-Oregon-Washington area was Sebastodes jordani, a small, noncommercial species, which appeared in stomachs seven times. Unidentified rockfish appeared eight times and made up 1.6 percent of the food volume. In Alaska a commercial species, Sebastodes alutus (figure 17), occurred twice as did unidentified rockfish. Together, they made up less than one percent of the food by volume.

S. jordani is an important food of the king salmon off San Francisco (Merkel, 1957).

(12) Sablefish

Found once in a stomach taken off Washington, this commercial species with its pelagic young is much less important as a seal food than might be suspected from its habitat and range.

b. Species of no economic importance

(1) Pacific lamprey

Lampreys were found in a stomach from a seal collected off Oregon and in one collected off Washington. Lampreys are apparently taken regularly by fur seals but make up only a trivial part of their diet.

(2) Capelin

Where it occurs, capelin (figure 19) is a major source of food for fur seals, harbor seals, marine birds, salmon, and probably many other forms. Except for the southeastern portion where herring predominate, it is the leading spring and summer food for fur seals in Alaska, by a wide margin. The 28 percent of food volume, which capelin furnished in the 1958 Alaska collection, was found in 116 stomachs. In 1952 when the seals were largely taken in the Gulf of Alaska, capelin composed more than 90 percent of the stomach contents. There is no commercial fishery for capelin in Alaska.

(3) Pacific saury

The saury (figure 18) is an important food of marlin (Hubbs and Wisner, op, cit.) and albacore (McHugh, 1952) but it has

appeared only rarely in fur seal stomachs in collections taken prior to 1958. In that year, it was identified in 110 stomachs collected from California to Washington and, although the overall percentage of food by volume it furnished was about 8.4 percent, it composed over 21 percent of the food volume off California. Probably the change is a result of more extensive offshore collections but the warmer waters in 1958 may have brought about a greater overlapping of the seasonal ranges of the fur seal and saury.

Saury have been observed, sometimes abundantly, over great expanses of the North Pacific and are one of the species that could provide food for fur seals during trans-Pacific migrations.

The saury is not a commercial fish in the eastern Pacific although intensively fished off Japan.

(4) Pacific hake

This species (figure 14) made up 17 to 18 percent of the fur seal's food off California and Oregon and a trace off Washington. An abundant fish of very poor commercial quality, it is known to be preyed on by fur seals, sea lions, harbor seals, and porpoises.

(5) Pacific tomcod

A small fish of no commercial value and apparently of little importance as a food of fur seals. Analysis of seal stomach-content collections have revealed it only occasionally.

(6) Alaska pollack

This important food species (figure 19) for many Alaskan pinnipeds was not found in stomachs from California, Oregon, or Washington. It was the fourth most freqently-taken fish in the 1958 Alaska collection and would probably rank higher in certain areas, among which would be the Bering Sea. There is no early prospect of the pollack becoming a commercial species except possibly as material for a factory-ship producing fishmeal.

(7) Flatfishes

These fish (figures 17, 18) do not constitute an important source of food for fur seals, as is true for most bottom-dwelling fish. A sand dab usually appears in California collections in small numbers. It was found in eight stomachs in 1958 and one in 1952. The arrowtoothed halibut was identified for the first time in four seal stomachs from the Gulf of Alaska. In addition, an unidentified flatfish was found in the Alaska collection.

(8) Great pipefish

The single occurrence of a pipefish in a seal from California is of interest mostly as a curiosity. There is nothing to suggest that pipefish are more than an insignificant source of food for fur seals.

(9) Sand lance

Sand lances (figure 15) appear rather erratically in the stomach contents of fur seals and other marine animals. In 1958,

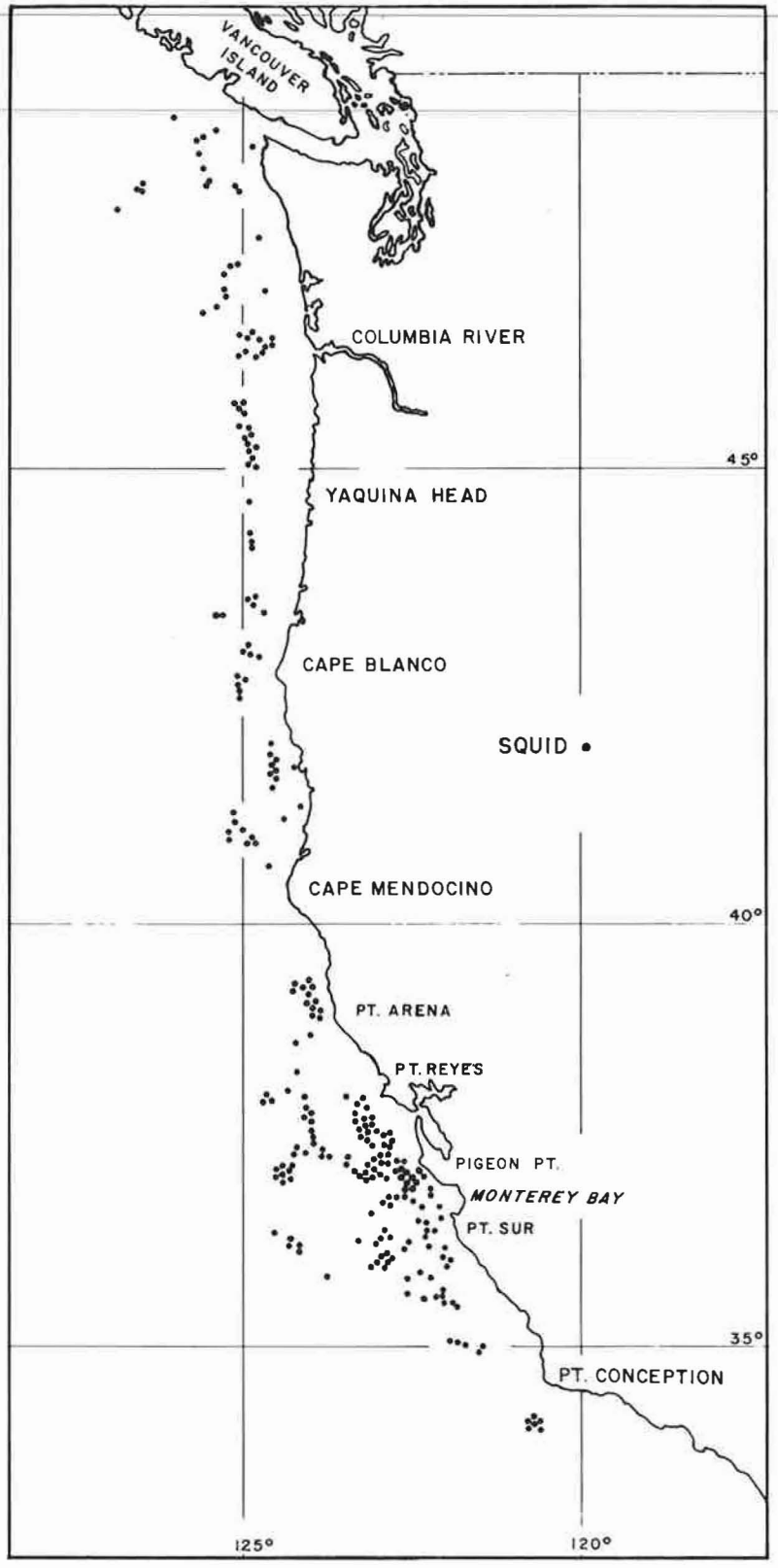

Figure 13. Locations from California to Washington where squid occurred in seal stomachs.

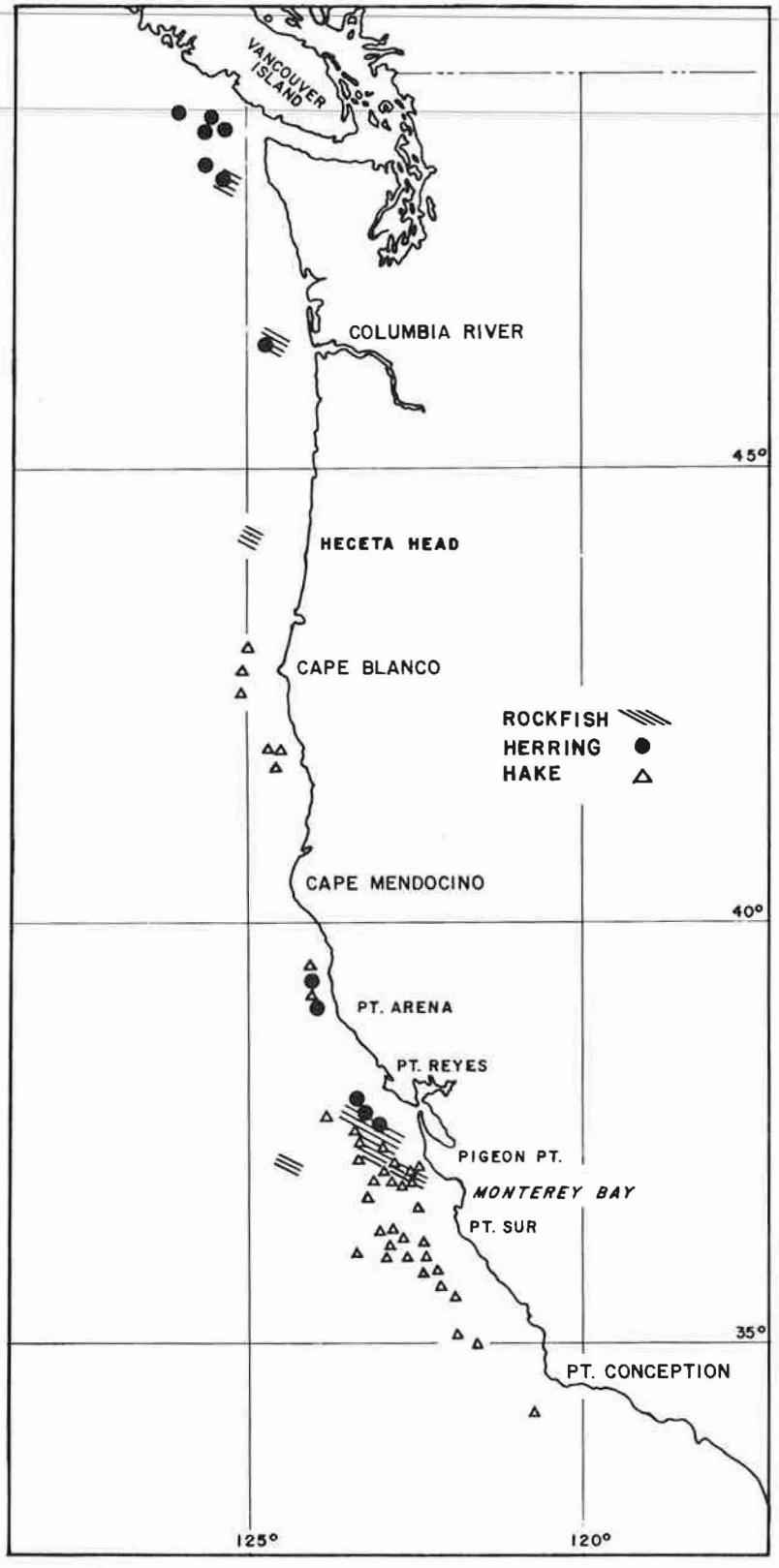

Figure 14. Locations from California to Washington where rockfish, herring, and hake occurred in seal stomachs.

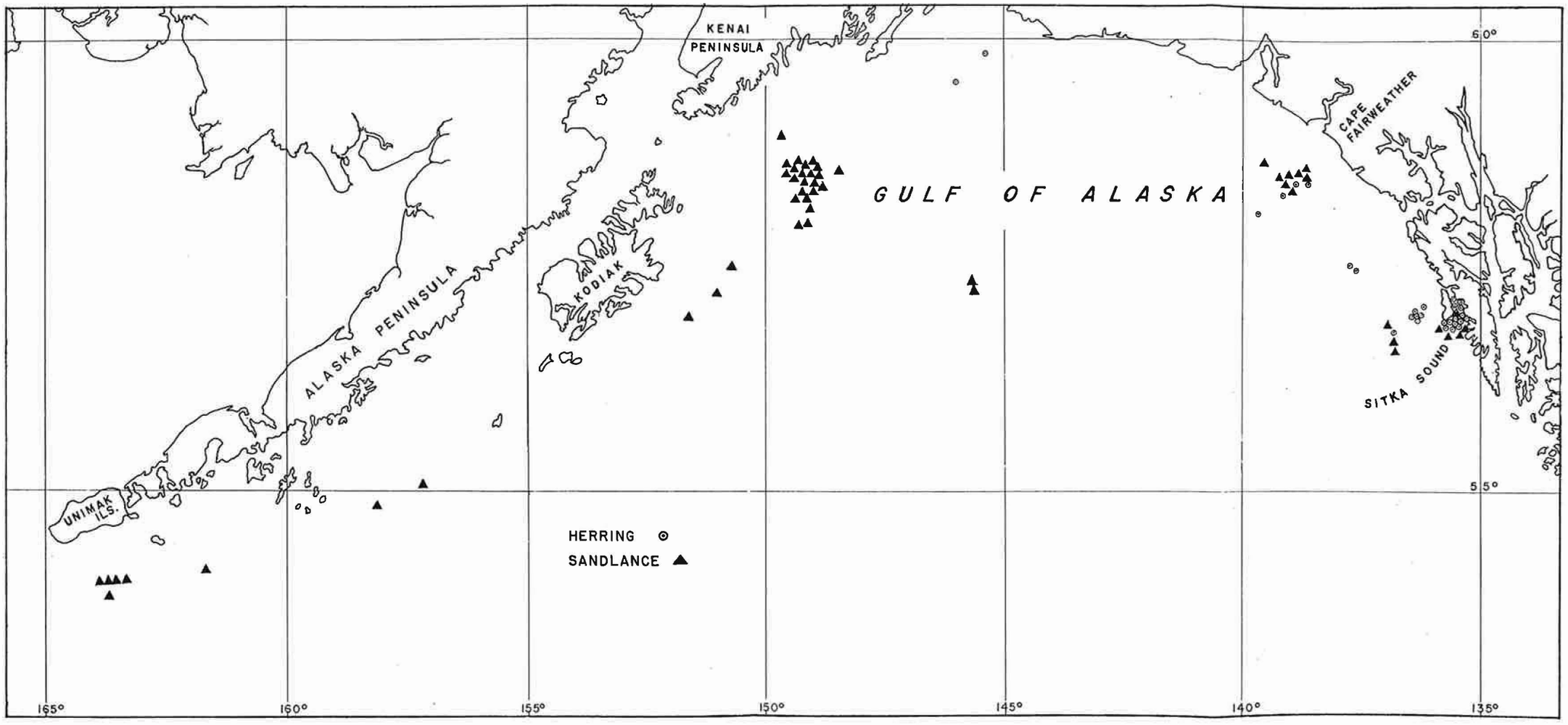

Figure 15. Locations in Alaska where herring and sand lance occurred in seal stomachs.

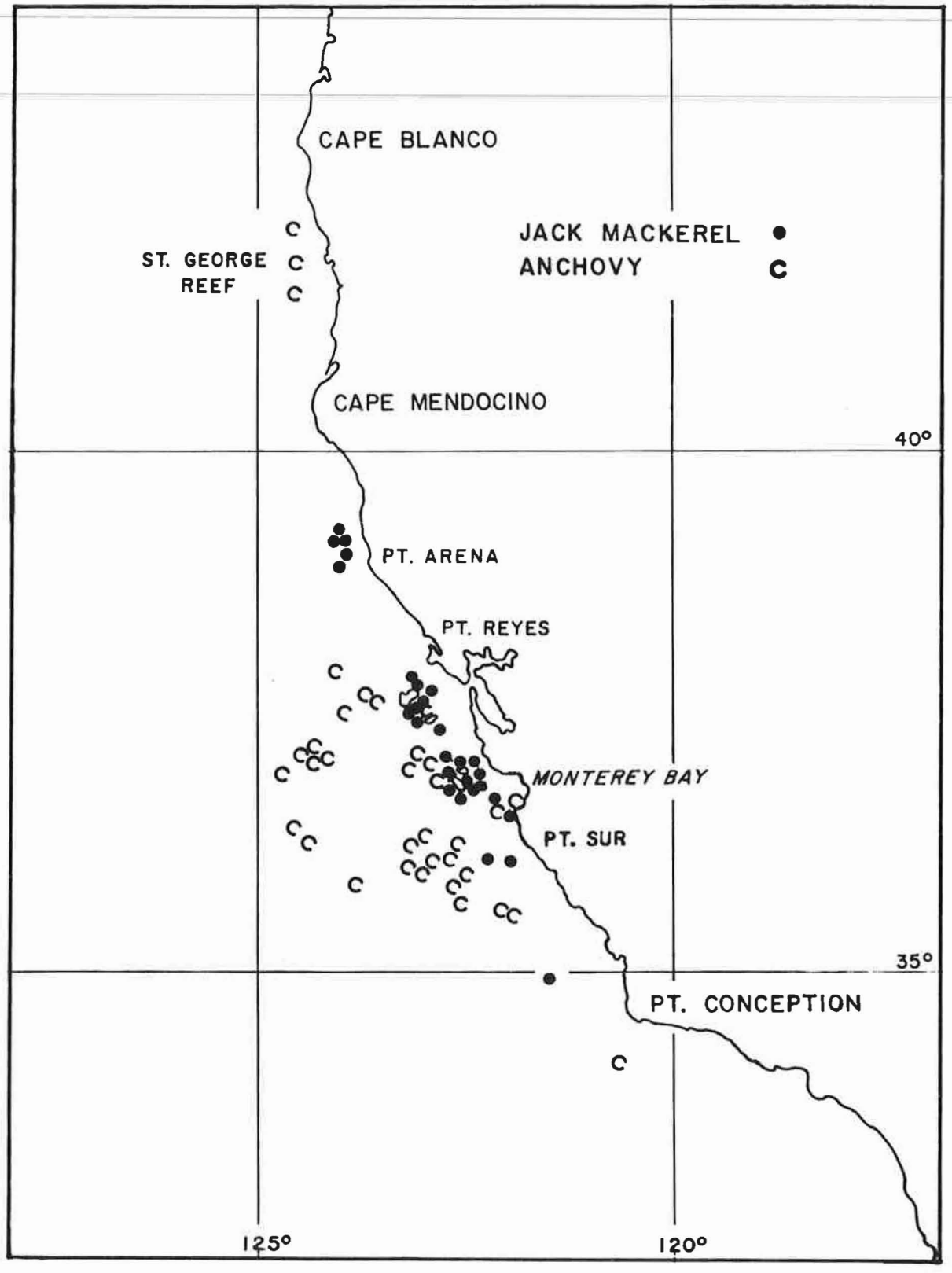

Figure 16. Locations from California to Washington where anchovy and jack mackerel occurred in seal stomachs.

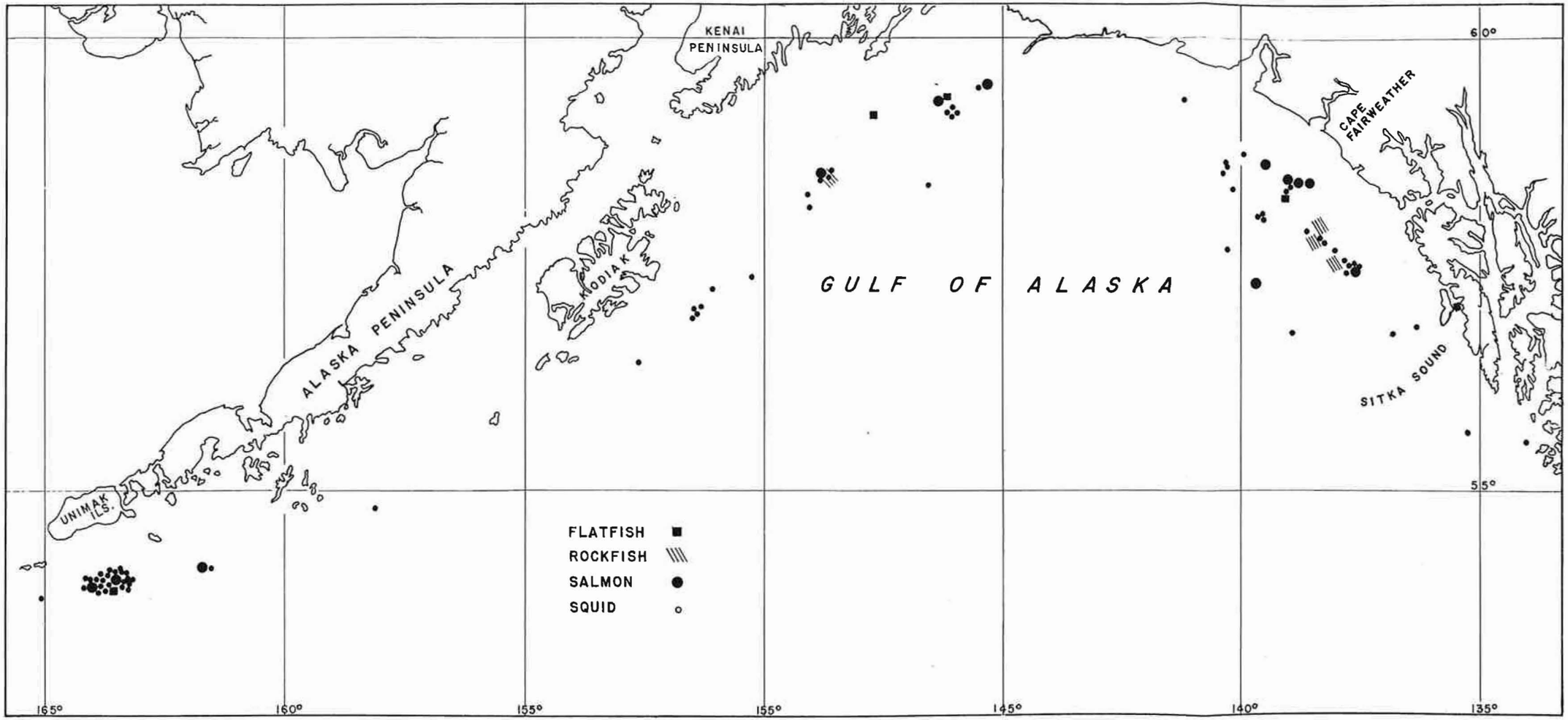

Figure 17. Locations in Alaska where flatfish, rockfish, salmon, and squid occurred in seal stomachs.

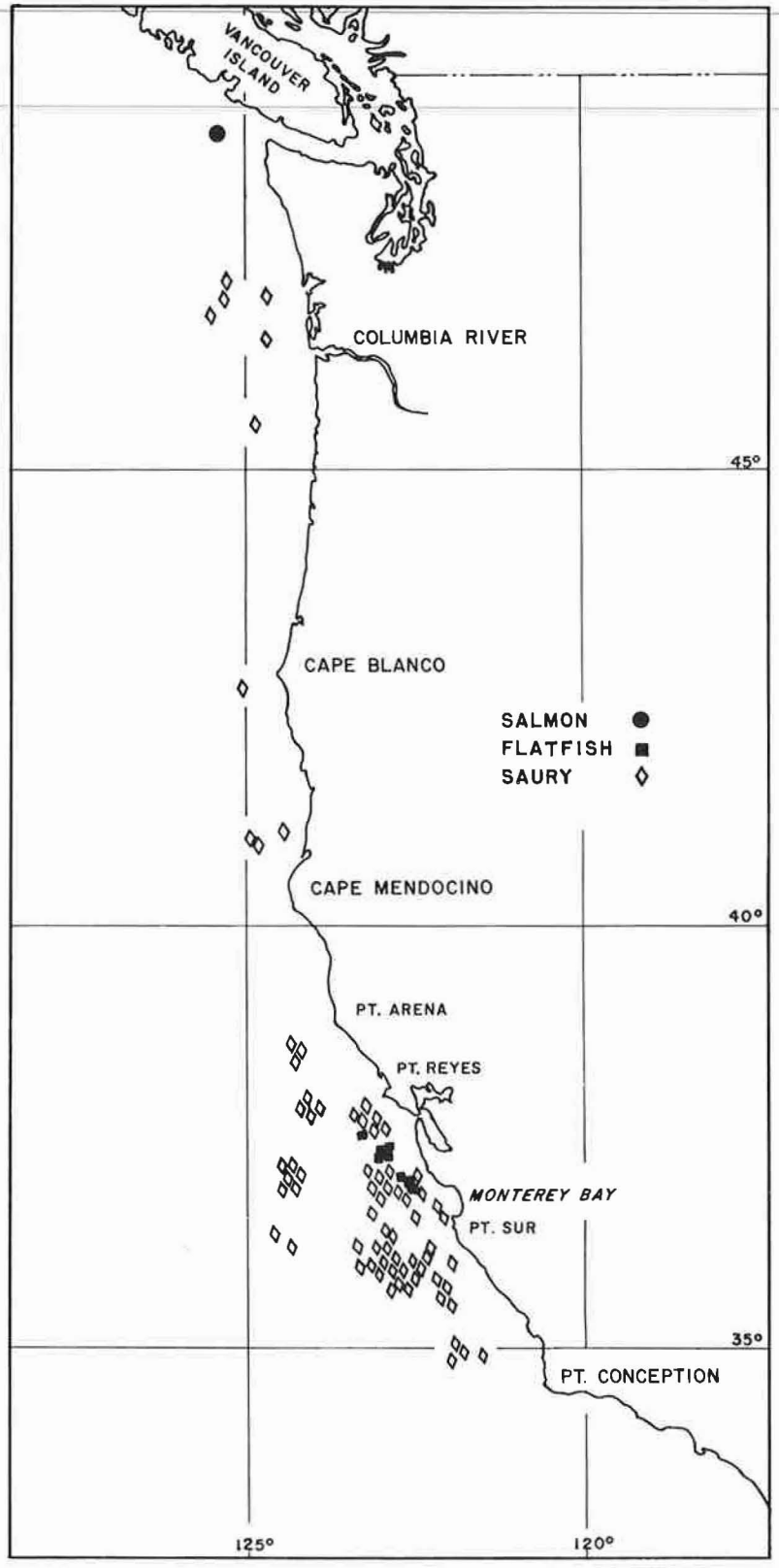

Figure 18. Locations from California to Washington where salmon, flatfish, and saury occurred in seal stomachs.

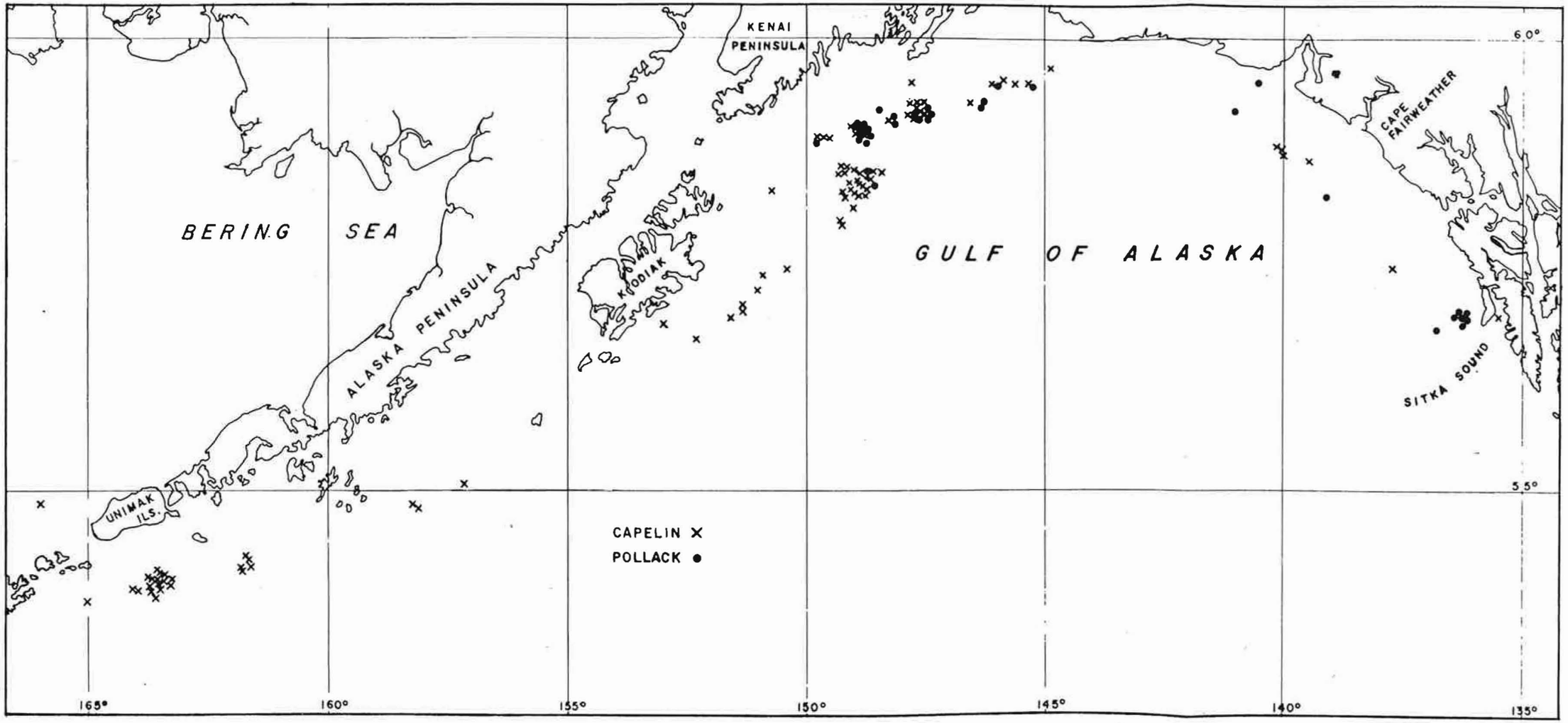

Figure 19. Locations in Alaska where capelin and pollack occurred in seal stomachs.

they were found in 116 of the 372 seal stomachs from Alaska that contained food but only once in 1952 in 116 stomachs and once in 1955 in 115 stomachs. Wilke and Kenyon (1952) reported it from a Steller sea lion stomach collected on St. Paul Island. Murres (Uria aalge californica) and cormorants (Phalacrocorux urile) were bringing sand lances into Walrus Island in the Pribilof group in July 1958.

5. Relation of fur seals to commercial fisheries

No attempt can be made at present to appraise the effect of fur seals on fisheries except in a direct way and that will be done only briefly. The indirect effects caused by feeding on the species utilized by commercially valuable fish or on predators of commercially valuable fish is too complex for analysis with our present knowledge of marine ecology.

In California where squid, saury, hake, and anchovy made up about 82 percent of the diet it can be said that the fur seal is not competing seriously with commercial fishermen. A squid, Loligo, and the anchovy are the subject of a limited fishery. Neither approaches full utilization. Jack mackerel is also a commercial fish but to an exceedingly minor extent considering its vast pelagic range.

Squids, saury, and hake accounted for nearly 91 percent of the food volume in seals from off Oregon. None of these are important commercially here. The jack mackerel, which made up about seven percent of the food in this area, is now only potentially a commercial species.

Herring entered the diet off Washington and was responsible for 52

percent of the food found in the stomachs. Herring is a managed commercial species. The damage done to the population by fur seals, porpoises, birds, predatory fishes of no value, and squid is impossible to know.

Off southeastern Alaska herring continued to be the predominant food. Seals and other herring predators are competing here with a restricted fishery. Capelin, sand lance, Alaska pollack and squid, all noncommercial species, made up practically all the seals' food from the Gulf of Alaska to the Bering Sea.

Salmon, which occurred once in 83 stomachs from Washington and 12 times in 897 stomachs from Alaska, is the most valuable commercial species taken. The rate of consumption and the range over which the seal stomachs were collected do not suggest that fur seals are an important hazard to salmon populations.

D. Predators

The potential predators of fur seals are the killer whale (Grampus retipinna) and sharks, particularly the great white shark (Carcharodon carcharias).

Killer whales were observed at the following places during the 1958 ocean work:

Date	Number	Place
9 March	5	Sitka Sound
13 March	3	Sitka Sound
19 March	1	Near rocks, which had many sea lions on them, on San Miguel Island
9 April	4-6	56°31' N. latitude, 135°50' W. longitude
10 May	1	58°15' N. latitude, 137°15' W. longitude
14 May	1	59°32' N. latitude, 145°00' W. longitude
18 May	10	58°58' N. latitude, 135°50' W. longitude
20 May	1	Near Montague Island
17 June	6+	Near Unalaska Island

On the evening of 19 March, near San Miguel Island, a great white shark (figure 20) was attracted by, and quickly swallowed, a sea lion carcass hanging from the chartered research vessel, M/S Trinity. It became tangled in a drifting fine-mesh gill net used to collect small fish specimens. The shark was too large (3,000 pounds) to bring aboard and, unfortunately, in the process of cutting it up to weigh, the stomach was lost through sinking. Obviously, the predation possibilities of large sharks of this type are very great. Almost nothing, however, is known about their relationship to fur seals.

Figure 20. This great white shark (Carcharodon carcharias) was attracted to a sea lion carcass near San Miguel Island, California. Sharks of this species may prey on fur seals.

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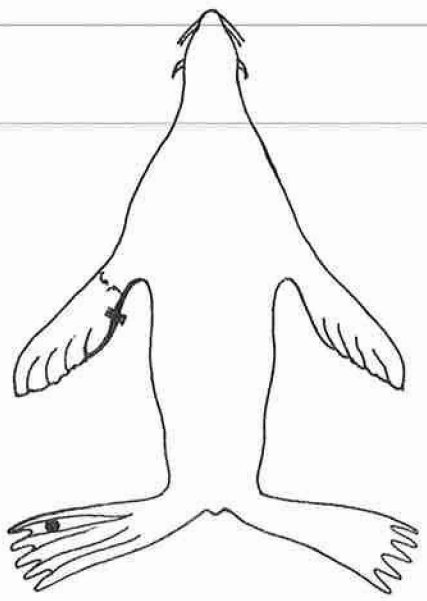

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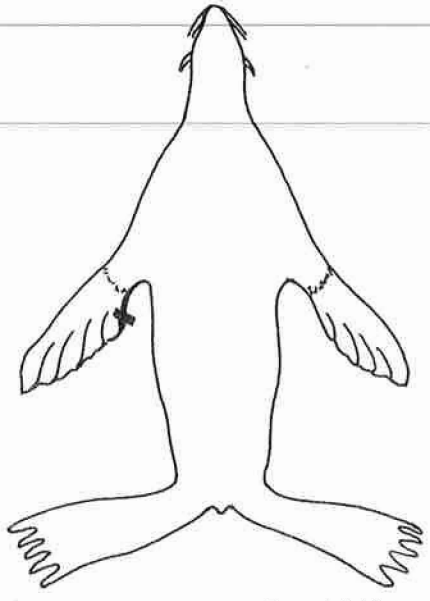

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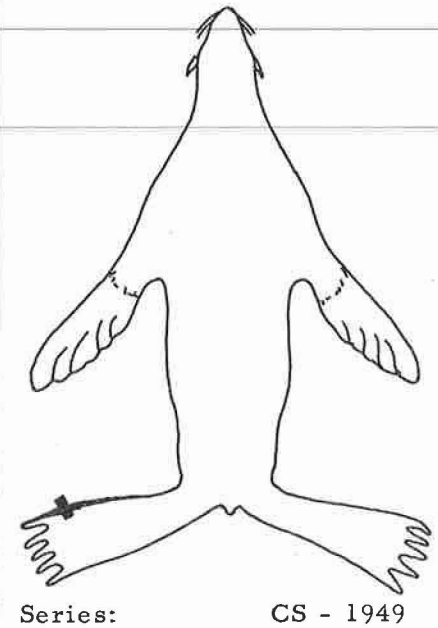

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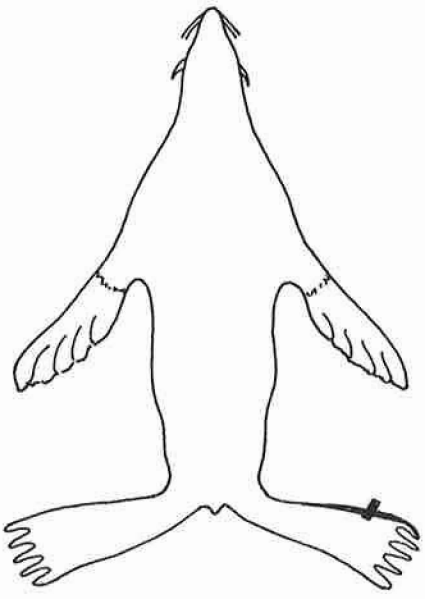

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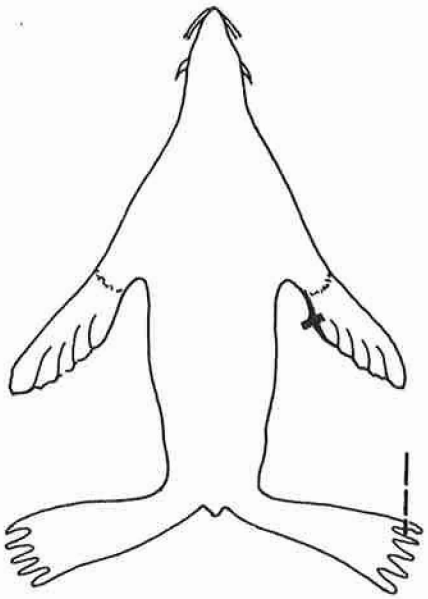

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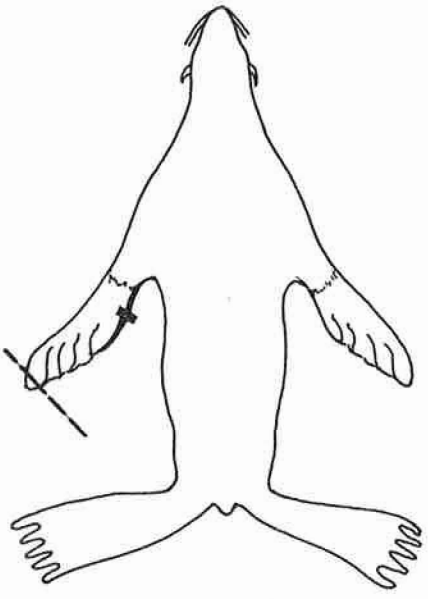

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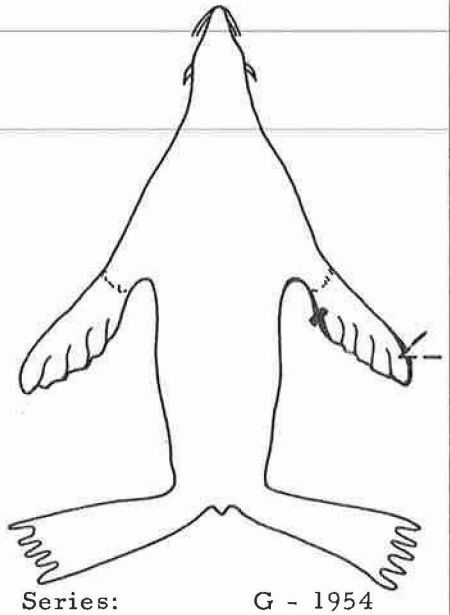

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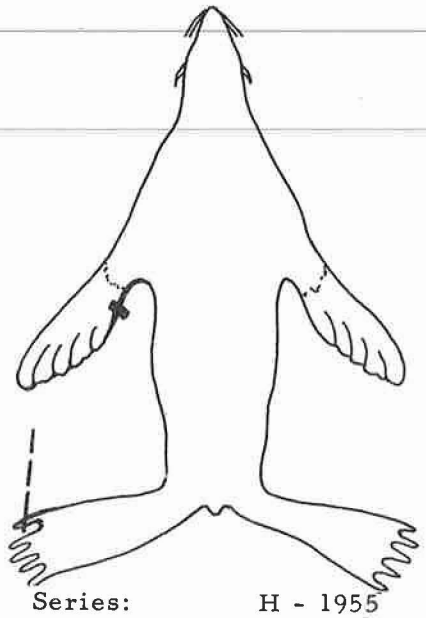

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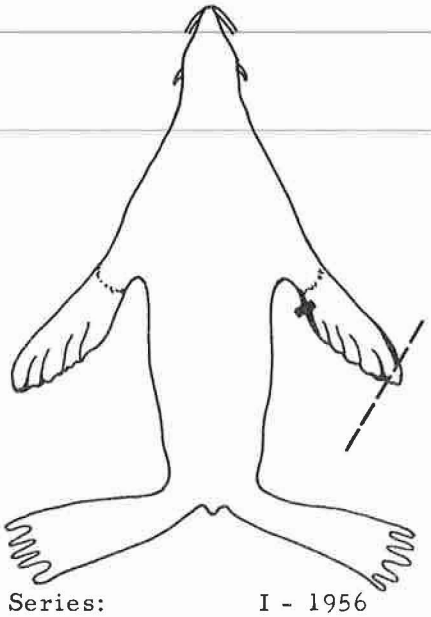

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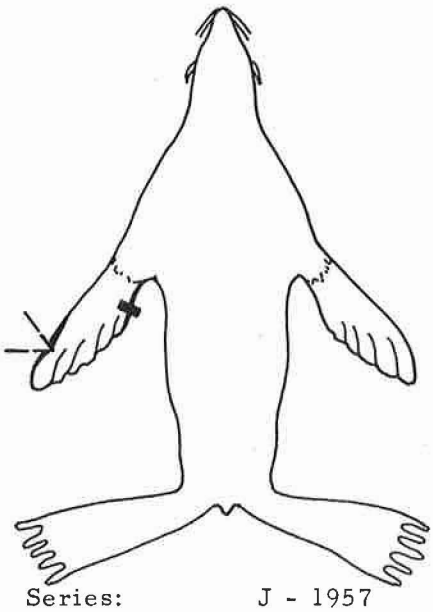

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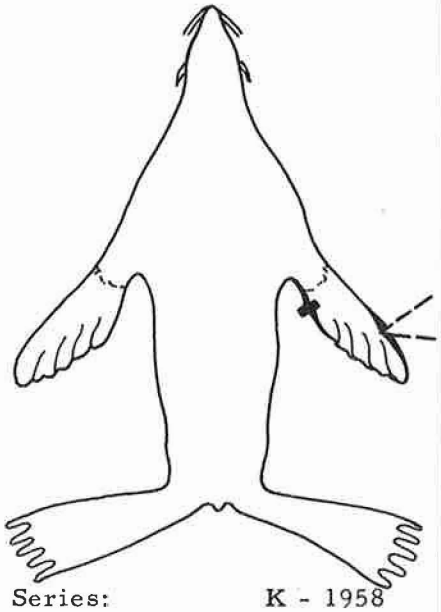

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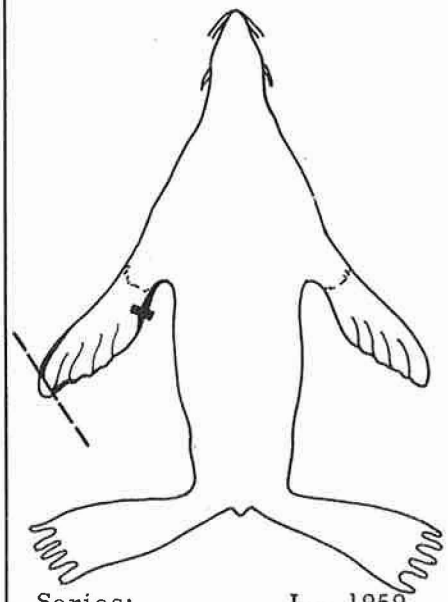

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Figure 21. Dory returning to charter vessel, the purse seiner M/V Tacoma, hunting off the Farallon Islands, California.

Figure 22. Lifting dory aboard purse seiner, M/V Tacoma, off Farallon Islands, California.

Appendix B.

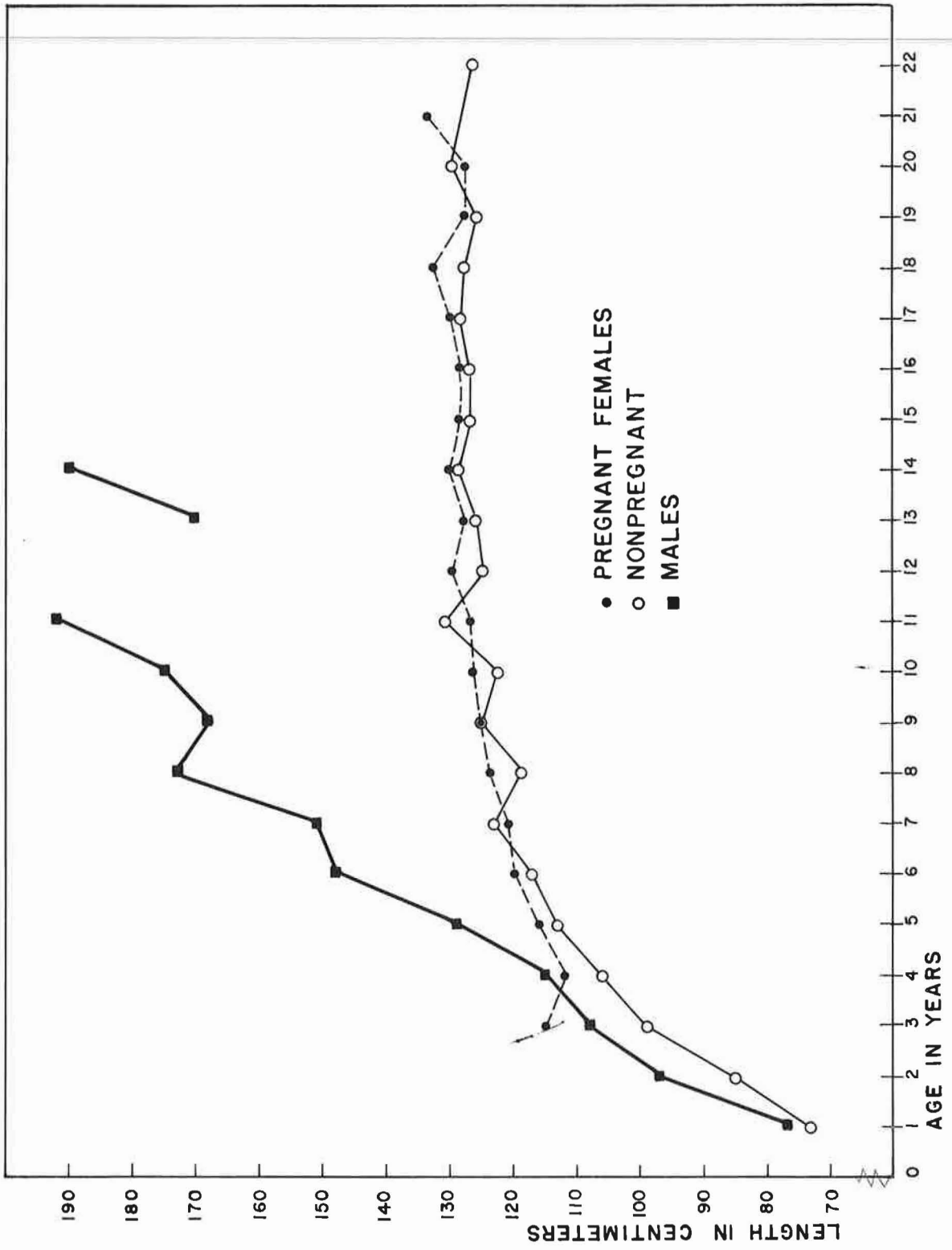

Figure 23. Length of seals collected off California, Oregon, Washington, and Alaska in 1958.

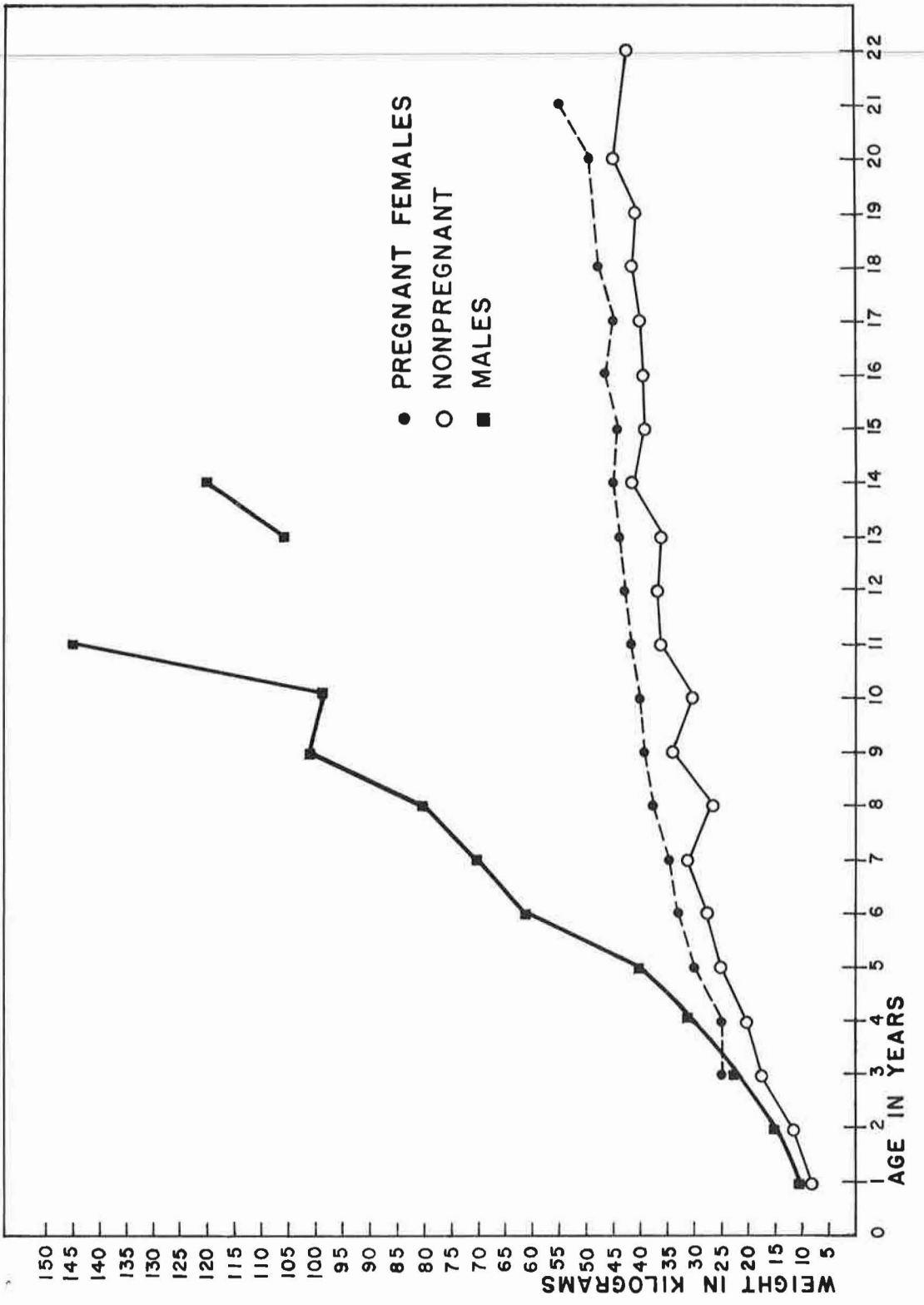

Figure 24. Weight of seals collected off California, Oregon, Washington, and Alaska in 1958.