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Alaska Fur Seal Investigations
Pribilof Islands, Alaska

1955

Ford Wilke

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After his stay on St. Paul Island, Mr. Nagasaki wrote a summary of his opinions of fur seal research on the Pribilof Islands and a study of homing tendency among three-year-old bachelors. The first is given in the following pages and the study of homing tendency in the section on tag recoveries.

MY PRIVATE OPINION OF FUR SEAL RESEARCH ON THE PRIBILOF ISLANDS

by

F. Nagasaki

In spite of the fact that the modern survey of the fur seal did not begin earlier than 1943, such biological knowledge has been brought to light in a rather short period. It goes without saying, I think, that this is due not to the characteristics and habits of the fur seal

I. COOPERATION.

Mr. Fukuzo Nagasaki, an employee of the Fisheries Agency, Ministry of Agriculture and Forestry in the Japanese Government, spent the period from 22 July to 1 September on St. Paul Island. He cooperated in the collection of data from the commercial seal kill until it ended on 31 July. He also participated actively in the dead pup counts and carefully observed the pup tagging. We believe that this experience coupled with his other observations on the islands will make it possible for him and other members of the Japanese Fisheries Agency to understand much more clearly the problems of fur seal research on the Pribilof Islands. It is natural for the statistically trained person without background experience with a species to insist on a more ideal approach than practical considerations allow.

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MY PRIVATE OPINION OF FUR SEAL RESEARCH ON THE PRIBILOFS

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In spite of the fact that the modern survey of the fur seal did not begin earlier than 1940, much biological knowledge has been brought to light in a rather short period. It goes without saying, I think, that it is due not to the characteristic habit and habitat of the fur seal

which apparently makes biological research easy to a certain extent but also to the contribution of the able scientists and to funds available to them. However, there are many important aspects which remain unknown.

Apart from the biological interest there would be no particular urgency in the research program if the commercial kill in the North Pacific Ocean would be continued the same as it now is because the annual catch has been stabilized both in quality and quantity. However, there seem to be several bits of evidence which support the possibility of increasing the catch on the Pribilof Islands without any harmful effect on the population. Therefore, if it is expected to increase the annual kill further biological investigation is very essential to determine a reasonable amount of availability. I think such a prospective biological approach may be divided into two parts:

The first part is the study of the population dynamics of the fur seal and the second part is the study of hookworm which would probably result in some measures to lessen the pup mortality. For the study of population dynamics the fundamental subjects are to make clear the population composition and its abundance. For these purposes tagging experiments are very effective and essential besides the statistics of the kill and the number of harem bulls because from the technical viewpoint the tagging technique is very well established. Also, plenty of tags which would be sufficient for population analysis were put on pups in several years on St. Paul Island, particularly nearly 50,000 tags put on in 1955. However, in spite of the large number of tags the sampling or the tag recovery is not satisfactory. There are some difficulties, I understand, in obtaining a satisfactory tag recovery. These difficulties are largely

caused by the segregative tendency of fur seals by age and sex. Though I have no idea whether it is possible or not it certainly would be very helpful as a further step in the population study to collect female samples at random. As it is already known that older females arrive earlier at the breeding islands, it might be a possibility to kill several thousand females after the breeding season when the harems are broken up. Such female sampling is, I think, much more efficient for learning the natural mortality and other factors than the pelagic sample which is more or less influenced by segregation.

As I pointed out roughly, the homing tendency (to their rookery of birth) of the three-year-old male is fairly strong. Therefore, an estimation of the number of pups should be calculated for each rookery separately. It means that the tagging should be done not only on every rookery on St. Paul Island but also on St. George Island because there is a certain amount of intermixture between St. Paul and St. George.

Another point I would like to recommend is to put double tags on seals in order to check the tag lost ratio. The present tagging method is to put on a tag and cut off the tip of a flipper. But, if another tag is put on the other side instead of cutting the flipper it might be very useful to determine the tag lost ratio. I think it is not necessary to carry on such a double tagging system more than once.

One of the current routine field operations is the census of the total number of harem bulls. Actually, the total number of bull seals might be an indicator of total abundance but considering the limitations of rookery space available to harem bulls and the replacement by new bulls

give some explanations of the high mortality.

the number of harem bulls at a certain moment does not necessarily represent the number of bull seals which actually participate in reproductive activity. Therefore, besides the census investigation the change of harem masters should be followed by some method. Also, the counting of the number of idle bulls is very important for determining the surplus potential of males.

Broadly speaking, the catch might indicate the comparative strength of the recruitment of three years but there is a little doubt on this assumption. The killing season is almost settled but the arrival of seals to the breeding islands is not necessarily constant. For example, the kill in 1955 is almost the same as in preceding years but the arrival of four-year-old males is estimated to be about two weeks later than usual. If the killing season had been continued two weeks more the catch should be considerably higher than that of last year. This is also pointed out by Chapman et al who figured the through-season escapement which fluctuates largely from year to year. Counting of rejected animals and the tracing of these seals using paint marks will bring new knowledge to us.

If the high mortality of pups is mostly caused by the hookworm, parasitological survey may find out some effective measures to prevent hookworm infection of pups. Such measures, such as spraying the rookery soil will be very expensive. Besides the parasitological study it would be very interesting to examine the dead pups in order to find out the cause of death. I think, even though it is theoretically possible, it might be practically impossible to lessen the mortality of pups. However, the census investigation of dead pups and some further study in the laboratory will give some explanations of the high mortality.

II. FOOD HABITS.

Needless to say, there are many international aspects in the fur seal population study. Exchange of information from each breeding island will promote and improve the research activity of fur seals in the North Pacific Ocean. It should be expected in the near future. Particularly the catching of sealion in the Bering Sea drifting gill nets has stimulated interest in the food of the Pribilof seal herd in the Bering Sea. No pelagic investigation of the food of fur seals while in the Bering Sea has been made since the 1890's. In 1896-97 Lucas wrote, in referring to a study made by A. B. Alexander, that, "In Bering Sea during August and September the pollack (*Theragra chalcogramma*) forms the staple article of food, a squid (*Gonatus argenteus*) coming next in importance, while some salmon and a few species of small fish are also eaten." Lucas quotes Alexander in stating that, "material which has been found in the stomachs of seals taken in different parts of Bering Sea indicates that only a small percentage is composed of fish which inhabit deep water. It is only reasonable to suppose that when seals are in shallow water they feed on both bottom fish and those near the surface." Lucas footnoted the latter part of this statement, saying "There is, however, no evidence of this except in the rare presence of cottoids. . . .^{1/} Stomachs collected from the killing fields in 1954 (Kenyon, MS)^{2/} verify Alexander's statement. Most of the content of these stomachs (94 percent) was composed of sand fish (*Trichodon trichodon*) which burrow in sand in relatively shallow water. The sturgeon-like sea poacher (*Agonus anopomus*), which was second in importance, is also a bottom dweller.

^{1/} Jordan, D. S., and others. 1898-99. The fur seals and fur-seal islands of the North Pacific Ocean. U. S. Treas. Dept., Doc. 2017, Part III, pp. 59-68.

^{2/} Kenyon, K. W. 1954. Food of fur seals taken on St. Paul Island, Alaska, 1954. MS.

II. FOOD HABITS.

A. Recent information about the food of fur seals in the Bering Sea.

The development of commercial fisheries in the Aleutian area, particularly the catching of salmon in the open sea with drifting gill nets has stimulated interest in the food of the Pribilof seal herd in the Bering Sea. No pelagic investigation of the food of fur seals while in the Bering Sea has been made since the 1890's. In 1896-97 Lucas wrote, in referring to a study made by A. B. Alexander, that, "In Bering Sea during August and September the pollack (Theragra chalcogramma) forms the staple article of food, a squid (Gonatus amoenus) coming next in importance, while some salmon and a few species of small fish are also eaten." Lucas quotes Alexander in stating that, "material which has been found in the stomachs of seals taken in different parts of Bering Sea indicates that only a small percentage is composed of fish which inhabit deep water. It is only reasonable to suppose that when seals are in shallow water they feed on both bottom fish and those near the surface." Lucas footnoted the latter part of this statement, saying "There is, however, no evidence of this except in the rare presence of cottoids. . . ."^{1/} Stomachs collected from the killing fields in 1954 (Kenyon, MS)^{2/} verify Alexander's statement. Most of the content of these stomachs (94 percent) was composed of sand fish (Trichodon trichodon) which burrow in sand in relatively shallow water. The sturgeon-like sea poacher (Agonus acipenserinus), which was second in importance, is also a bottom dweller.

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^{2/} Kenyon, K. W. 1954. Food of fur seals taken on St. Paul Island, Alaska, 1954. MS.

From 17 to 20 July 1955, 204 fur seals were collected pelagically in the Bering Sea from Unimak Pass and Unalaska to the Pribilof Islands. Throughout this period they were most abundant in or near Unimak Pass. Most of the seals were collected by shooting from the deck of a halibut schooner, the MS Paragon, with shotguns loaded with buckshot. On the rare calm days two men worked from a dory powered with a 10 horsepower outboard. In good weather this was as effective as the larger vessel and crew. Fewer animals were lost when hunting with the dory than from the larger vessel.

The seals did not build up into a high concentration between the Aleutians and Pribilofs but gave the impression they were part of a thin and steady stream of variable density moving on to the islands. Seal migration to the Pribilofs was late in 1955; the arrival of 3-year-old males did not reach its peak for nearly two weeks after the usual date. In Unimak Pass where fur seals could be found in relative abundance there were also sea lions, numerous hump-back whales, and vast numbers of shearwaters. It is reasonable to presume that the rich food supply attracted all these forms.

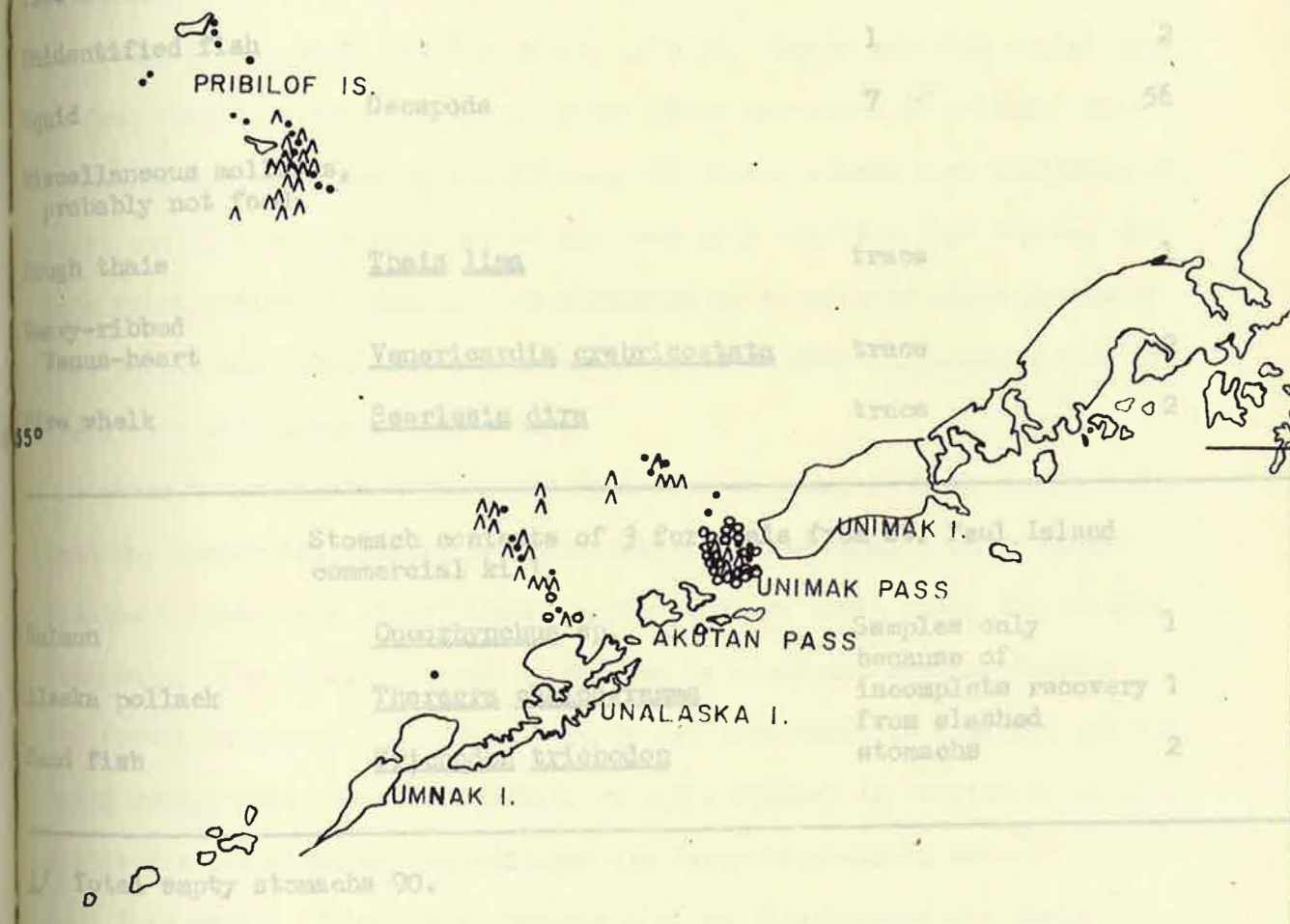
Pregnant females predominated among the seals collected, making up 71 percent of the total. Non-pregnant females composed 16 percent and males 13 percent of the remainder. This class distribution is almost exactly what might be expected from existing knowledge of the migration timing for different ages and sexes.

Table 1 gives the food contained in the stomachs of the seals collected pelagically and also three stomachs with food found among the thousands of empty stomachs of the seals taken in the commercial kill.

In general capelin was the predominant food item in Unimak Pass and near the Aleutian Islands. Well offshore in the Bering Sea, including

Table 1. Stomach contents of 307 fur seals collected in the Bering Sea between the Aleutian and Pribilof Islands from 17 June to 20 July 1953.

Scientific	Percentage of seals by volume	Percentage of seals by number
<i>Choristothorax</i> sp.	0.5	1
<i>Gadus macrocephalus</i>	52	45
<i>Theragra chalcogramma</i>	40	36
<i>Ammodytes americanus</i>	traces	1
Unidentified fish	1	2
Cephalopoda	7	56
<i>Thais linea</i>	traces	2
<i>Venerupis alveolata</i>	traces	2
<i>Scapharca</i> sp.	traces	2
<i>Quoyia</i> sp.	traces	1
<i>Theragra chalcogramma</i>	traces	1
<i>Gadus macrocephalus</i>	traces	2



○ CAPELIN
 • ALASKA POLLACK
 ▲ SQUID

Figure 1. Localities where seals feeding on capelin, squid, and Alaska pollack were collected.

Table 1.--Stomach contents of 205^{1/2} fur seals collected in the Bering Sea between the Aleutian and Pribilof Islands from 17 June to 20 July 1955.

Name of food item Common	Scientific	Percentage of food by volume	Frequency of item
Salmon	<u>Oncorhynchus</u> sp.	0.5	1
Capelin	<u>Mallotus catervarius</u>	52 ✓	45
Alaska pollack	<u>Theragra chalcogramma</u>	40 ✓	36
Sand-lance	<u>Ammodytes tobianus personatus</u>	trace	1
Unidentified fish		1	2
Squid	Decapoda	7 ✓	56
Miscellaneous mollusks, probably not food:			
Rough thais	<u>Thais lima</u>	trace	1
Heavy-ribbed Venus-heart	<u>Venericardia crebricostata</u>	trace	2
Dire whelk	<u>Searlesia dira</u>	trace	2

Stomach contents of 3 fur seals from St. Paul Island commercial kill.

Salmon	<u>Oncorhynchus</u> sp.	Samples only because of incomplete recovery from slashed stomachs	1
Alaska pollack	<u>Theragra chalcogramma</u>		1
Sand fish	<u>Trichodon trichodon</u>		2

✓ Total empty stomachs 90.

This sample illustrates once again quite clearly that the seal's food depends on availability. If capelin are the abundant fish it feeds on capelin. If pollack are the available form it feeds on pollack or if

✓ Edited, 1955. Distribution and food habits of fur seals of the North Pacific Ocean. Joint report by Canada, Japan, and the United States.

the area around the Pribilof Islands, Alaska pollack and squid were the most important food items (Fig. 1). Because of the scale of the figure the occurrences of capelin are not fully represented. It appears that concentration of capelin are available for the seals during extensive portions of their northern migration. This species made up over 90 percent of the food of seals taken in the western part of the Gulf of Alaska from the Kenai Peninsula to Afognak Island in June 1952 (Distribution and food habits of fur seals of the North Pacific Ocean, 1955).^{1/} Squid occupies a high rank in frequency of occurrence but a lesser place according to volume. This is caused by the following conditions: 1) squid become more available at night and 2) they are soft bodied and have only the beak, eye lenses, and pens which resist digestion. The abundance of these hard parts indicates that squids are a staple food but whole squid or even large quantities of flesh were only occasionally found.

Except for salmon none of the food species found in this sample enter into any commercial fishery in North America. The capelin is an arctic species (Clemens and Wilby) reaching its southern limit along the Olympic Peninsula. The Alaska pollack or whiting is abundant, ranging from California to Alaska. At present it is not acceptable as a market species, being rather thin and soft fleshed. A squid fishery is carried on in California for a limited market but none are taken in northern waters.

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^{1/} Edited. 1955. Distribution and food habits of fur seals of the North Pacific Ocean. Joint report by Canada, Japan, and the United States.

both are to be had it accepts both as well as other fish species and squid. Near the coasts of Southeastern Alaska and British Columbia herring is a staple food. In deep water off the Japanese coast seals feed most extensively on lantern fish and squid. Salmon doubtless would be readily taken if they were available since they are a highly acceptable food. From their infrequent occurrence in seal stomachs it appears that as a general thing salmon are not available prey species for fur seals. As stated by Wilke (1951)^{1/} the principal relationship of fur seals and salmon appears to be that of co-predators rather than predator and prey. Examination of the available evidence on salmon predation by fur seals in Alaskan waters leads to the conclusion that they prey to a very minor extent on free swimming salmon. In a favorable situation, such as where salmon are trapped in a gill net, seals may cause considerable damage.

The total volume of the contents found in the 169 stomachs which contained more than 1 cc. food was 21,522 cc. (Note), whose classification by species of fish is shown on Table VI. In the 80 stomachs containing less than 1 cc. of food, large or medium sized squid were found seventy-six times, lantern squid four times, medium or small lantern fish twice, large lantern fish once, rocks once and pebbles once.

(Note) The stomach containing the largest volume of contents (1673 cc.) belonged to the male, four years old which was caught at 9 a.m., April 3 about 35 miles east of Tokogusaki, 93% of the contents being large squid.

Table

Table VI indicates that in the stomachs large lantern fish and large or medium sized squid were found in the largest quantity, and other species of lantern fish, anchovies and lantern squid followed them.

B. Japanese Investigations in 1953.

In 1953 the Japanese Government made additional pelagic investigations of fur seals off northern Japan. The results of the stomach analyses are quoted below:

"Study was made of the contents of stomachs of the 414 seals caught by investigation boats off the coast of Sanriku (Miyagi, Iwate, and Aomori Prefectures in northern Honshu) during January through June 1953, applying almost the same methods as used in the 1952 investigation. (Of the 414 stomachs, complete records were kept about age, weight, place of catch, time of catch, etc., for 334.)

"(1) General Explanation of Stomach Contents

Of the 414 stomachs, 165 (40%) were empty; 169 (41%) contained more than 1 cc. of food; and 80 (19%) contained less than 1 cc. food. The total volume of the contents found in the 169 stomachs which contained more than 1 cc. food was 21,522 cc. (Note), whose classification by species of fish is shown on Table VI. In the 80 stomachs containing less than 1 cc. of food, large or medium sized squids were found seventy-six times, lantern squids four times, medium or small lantern fish twice, large lantern fish once, coke once and pebble once.

"(Note) The stomach containing the largest volume of contents (1675 cc.) belonged to the male four years old which was caught at 9 a.m., April 3 about 35 miles east of Todogasaki, 95% of the contents being large squids.

Table

"Table VI indicates that in the stomachs large lantern fish and large or medium sized squids were found in the largest quantity, and other species of lantern fish, anchovies and lantern squids followed them.

Table VII shows that large anchovies and medium sized squids formed the largest part of the contents each month. (Table VII omitted from quotation.)"

Table VI. Contents of 169 stomachs containing more than 1 cc. of food.

Species of fish	Volume (in cubic centimeter)	Percentage of the total volume	Frequency of appearances
o Large sized lantern fish	9806	45.563	47 (+) 1
x Large and medium* sized squid	5381	25.002	125 (+) 13
o Unidentified lantern fish	2936	13.642	39 (+) 3
Anchovy	1442	6.700	3
x Lantern squid	1378	6.403	25 (+) 5
o Small sized lantern fish	216	1.004	8
<u>Alepocephalus</u> ?	150	0.697	1
o Medium sized lantern fish	105	0.483	3
Unidentified fish	45	0.209	4 (+) 1
<u>Promethichthys</u> ?	25	0.116	1
Horse mackerel	8	0.037	2
<u>Chlorophthalmus</u> ?	7	0.033	3
<u>Lestidium</u> ?	5	0.022	1
Sand eel	5	0.022	1
<u>Anotopterus</u>	4	0.019	1
<u>Laemonema</u>	4	0.019	1
Unidentified	4	0.019	1 (+) 1
Pebble	1	0.005	1
Gadidae ?	Trace		(+) 1
Horsetail tang	Trace		(+) 1

- (Note) 1. The total of contents in such stomachs was 21,522 cc.
 2. Squids marked * include cuttle-fish, Onychoteuthis and two species of Loligo.
 3. Lantern fish marked o include various species of lantern fish.
 4. Squids marked x include various species of squids.

(Note by FW)

5. Alepocephalus, herring-like fish, Alepocephalidae
6. Promethichthys, (snake mackerel)
7. Chlorophthalmus, Family Sudidae
8. Lestidium, family Sudidae
9. Anotopterus ?
10. Laemonema, hake-like fish, near Gadidae

(2) Feeding Time in Feeding Habit of Seals Observed

As ascertained by the joint investigation in 1952, seals take food by night rather than by daytime. This year's investigation confirmed this tendency. Table VIII shows the condition of stomachs for every two hours from 6 a.m. to 4 p.m. and about one hour after 4 p.m. (No hunting was made at night.) In the stomachs of the seals hunted in the afternoon, large and medium sized squids were found in the largest quantity. Lantern fish was found in the largest amount in the stomachs hunted between 6 and 8 o'clock, and 10 and 12 o'clock. Large and medium sized squids represented the largest part of the contents of the stomachs in the division of 8-10 o'clock. Lantern squids were found in the stomachs of seals taken between 6 and 8 o'clock, 8 and 10 o'clock, and 12 and 14 o'clock. It is to be noted that medium and small sized lantern fish were found in the stomachs taken between 14 and 16 o'clock.

Table VIII Stomach Contents by Time of Catch

Time of Catch	Empty Stomachs	Stomachs Containing less than 1 cc. of Food	Stomachs Containing more than 1 cc. of Food	Total No. of Stomachs	Total of Stomach Contents (cc.)
6-8 o'clock	6	4	38	48	7450
8-10 "	21	5	40	66	6138
10-12 "	30	15	35	80	2690
12-14 "	32	13	11	56	192
14-16 "	34	22	6	62	450
After 6 o'clock	14	6	2	22	4

(3) Comparison With Feeding Habit of Seals Observed

in the Past Investigations

The publications issued in the past as regards the feeding habit of seals passing winter off the Pacific Coast of Japan are the report by Austin and Wilke, 1950, the report by Wilke, 1951 and the interim report of the joint investigation by Japan, the United States and Canada in 1952. The results of this year's investigation on this subject generally correspond with those stated in these reports. This time again several species of lantern fish constituted 60.7% of the total of the contents of the stomachs checked, and next came several species of squids representing 31.4%. Fishes found in the stomachs of seals and important for the fishing industry were, besides large squids, anchovies, which appeared three times and covered 6.7% of the contents of the stomachs where they appear. Other commercial fishes such as mackerels, sauries and salmons which were found in the 1952 investigation could not be found at all this time."

in improving population estimates based on tag recoveries.

B. Age classification.

Although the standard for tooth samples used in age classification of the commercial kill requires only a two percent sample for kills over 1,250, the overall sample size taken in 1955 was about 3.9 percent. Since the seals are laid out in rows of 10, it is a simple matter to get samples of any desired size. For example, taking one seal from each row gives a 10 percent sample and one from each 10 rows gives a one percent sample. Table 5 lists the usual data needed for population estimates. Table 6 and Figure 2 combine the kill records and age classification into cumulative form. It is suggested that the biologist keep

III. POPULATION.

A. Tag recoveries.

Each seal in the commercial kill was examined for a tag or tag scar on the right foreflipper and for a clipped outer digit on the right hindflipper. This work was done by Calvin J. Lensink, biological aid, and an assistant from St. Paul village. As in past years, the tags were removed and its number together with the field length of the seal was recorded. In the laboratory, the number was checked and recorded on a Keysort punch card. Other data punched on the cards were the field length, date, age, rookery of tagging, and rookery of recovery. Tables 2, 3 and 4 give the rookery of recovery of tagged seals taken in the commercial kill, the field length of tagged three-year-old seals by rookery of recovery, and by time of recovery.

A special effort was made to find all seals having a clipped rear digit since an accurate record of tag-lost seals is very important in improving population estimates based on tag recoveries.

B. Age classification.

Although the standard for tooth samples used in age classification of the commercial kill requires only a two percent sample for kills over 1,250, the overall sample size taken in 1955 was about 3.9 percent. Since the seals are laid out in rows of 10, it is a simple matter to get samples of any desired size. For example, taking one seal from each row gives a 10 percent sample and one from each 10 rows gives a one percent sample. Table 5 lists the usual data needed for population estimates. Table 6 and Figure 2 combine the kill records and age classification into cumulative form. It is suggested that the biologist keep

the tooth ridge counts current throughout the sealing season and provide the General Manager with a daily record of the cumulative percent of three- and four-year-old males in the kill. This information will give the General Manager a supplemental aid in making his decision as to the proper time to terminate the sealing season.

It is also strongly recommended that the tradition of calling 41-45 inch males three-year-olds be ignored. It has been suggested in the past that these animals be called group three males. There has been ample opportunity during the last several years to become adjusted to the idea that the so-called three-year-olds are actually 30 to 45 percent four-year-old animals. Being conservative in the direction of exactness can hardly be criticized but resisting change which would correct an error is a different matter. Canadian and Japanese biologists have both been somewhat bewildered by our explanation that these seals which are labelled three-year-olds are really a mixture of three- and four-year-old animals. We believe the appropriate entries in the annual statistical digest, "Alaska Fishery and Fur-seal Industries" should be corrected.

C. Homing tendency.

The following study of the homing tendency of three-year-old male seals was made by Mr. F. Nagasaki in 1955. It is based on data obtained from tag recoveries and tooth ridge counts during the commercial seal kill on St. Paul Island.

Homing Tendency of Three-Year-Old Male Seals

In 1952, 20,000 E-series tags were placed on seal pups at four rookeries on St. Paul Island. The tags were attached without regard for the sex of the seals.

1/ Ikaunin and Kitovi rookeries are included with Tolstoi, hereafter.

Survival rate from 1952 to 1955.

<u>Rookery</u>	<u>Number of pups tagged</u>
Northeast Point	4,000
Zapadni	800
Reef	6,000
Polovina	9,200
Tolstoi ^{1/}	0

Commercial kill in 1955.--Three years later, in 1955, the seals of the age class tagged in 1952 made up a large part of the commercial kill. On St. Paul Island an estimated 30,733 three-year-old males, mostly from 41-45 inches in total length, were taken throughout the killing season. The estimated number of three-year-old males killed at each rookery is

given below:	Polovina	Reef	Zapadni	Northeast Point	Tolstoi
	137	40	5	288	27
Northeast Point	55	20	10,213	47	10
Zapadni	348	186	9,355	364	112
Reef			1,721		
Polovina			4,811		
Tolstoi			4,633		
<u>Rookery of origin</u>	<u>Total</u>		30,733	<u>Recovery</u>	

Since all seals on the hauling grounds were driven and all males from 41-45 inches in length were supposedly killed (though there were some exceptions) the total kill at each rookery well represents the relative abundance of three-year-old males that have landed at each rookery (hauling grounds of the rookery). Then the total number of three-year-old males Sr in 1955 would be represented as:

$Sr = 30,733t$, if there is no dispersion of seals to other islands, where S is the total number of male pups in 1952 and r is the

^{1/} Lukanin and Kitovi rookeries are included with Tolstoi, hereafter.

Table 2.--Recovery location of tagged seals in commercial kill, survival rate from 1952 to 1955.

Tag recoveries in 1955.--A total of 1,057 tagged seals and 140 seals that had lost their tags were recovered on St. Paul Island. Eighty-two tags of the same series were recovered on St. George Island, but these are not considered in the present study. The E-series tag recovery at each rookery on St. Paul Island is given below:

	<u>Rookery where tagged</u>				<u>Rookery where recovered</u>				
	NEP	ZAP	REEF	POL	NEP	ZAP	REEF	POL	TOLSTOI
Northeast Point	1				144	16	1	28	19
Zapadni		3			5	28	1	5	5
Reef					62	102	40	43	61
Polovina					137	40	5	288	27
Tag-lost					<u>56</u>	<u>20</u>	<u>7</u>	<u>47</u>	<u>10</u>
Total					348	186	47	364	112

The recovery rate of tags at each rookery according to origin is calculated as shown in the following table:

<u>Rookery of origin</u>	<u>Rookery of recovery</u>				
	NEP	ZAP	REEF	POL	TOLSTOI
Northeast Point	1/70.9	1/584.7	1/1,721.0	1/171.8	1/243.8
Zapadni	1/2,042.6	1/334.1	1/1,721.0	1/962.2	1/926.6
Reef	1/164.7	1/91.7	1/43.0	1/111.9	1/76.0
Polovina	1/74.5	1/233.9	1/344.2	1/16.7	1/171.6

Estimate of the total number of male pups when tagged in 1952.--A more accurate method of estimating the total number of pups by tag recovery than the simple Peterson method might be possible if tagging had also been done on

Table 2.--Recovery location of tagged seals in commercial kill.

Time of recovery, St. Paul Island, Alaska

Recovery location	Rookery of recovery							Total	Percent recovery	St. George
	NEP	TOL	L-K	ZAP	REEF	POL	ST. G.			
<u>F-Series - 2-year-old seals, males</u>										
Coast Point	1	---	---	1	---	1	---	3	6	---
Kitovi	---	---	---	1	---	---	---	1	---	---
Kitovi	1	---	---	---	---	---	---	1	2	---
Kitovi	---	---	2	---	---	---	---	2	---	---
Kitovi	2	---	1	---	---	---	---	3	---	---
Kitovi	<u>1</u>	<u>---</u>	<u>---</u>	<u>1</u>	<u>---</u>	<u>1</u>	<u>2</u>	<u>5</u>	11	<u>2</u>
Total	5	---	3	3	---	2	2	15	---	2
Total	---	2	1	3	5	4	2	---	19	---
<u>E-Series - 3-year-old seals, males</u>										
Coast Point	144	10	9	16	1	28	---	208	2	22
Kitovi	5	3	2	28	1	5	---	44	8	2
Kitovi	62	41	20	102	40	43	---	308	3	26
Kitovi	<u>137</u>	<u>14</u>	<u>13</u>	<u>40</u>	<u>5</u>	<u>288</u>	<u>---</u>	<u>497</u>	13	<u>32</u>
Total	348	68	44	186	47	364	---	1057	23	82
g-lost	56	5	5	20	7	47	---	140	1197	---
<u>D-Series - 4-year-old seals, males</u>										
Kitovi	12	1	---	2	---	22	3	40	11	3
Total	---	---	---	5	7	1	1	---	21	---
Total	---	---	3	20	18	14	6	---	63	---

Includes 139 seals of E series with tags lost.

Table 3.--Field length^{1/} of tagged 3-year-old seals by time of recovery, St. Paul Island, Alaska

	Length in inches									Total recovery	No. length recorded
	39	40	41	42	43	44	45	46	47		
June	--	1	--	3	1	--	1	--	--	6	
"	--	--	--	7	8	5	--	--	--	20	
"	--	--	--	--	1	--	--	1	--	2	
"	--	--	--	--	1	1	--	--	--	2	
"	--	2	6	7	13	4	5	2	--	39	
"	--	--	--	--	--	--	--	--	--	--	
"	--	--	2	4	16	9	6	3	--	42	
"	--	1	1	3	1	3	1	1	--	11	
total	--	2	8	20	40	19	13	8	--	110	
"	--	1	--	--	3	1	1	--	--	6	
grand total	--	2	1	3	5	4	2	2	--	19	
June	--	--	1	11	11	16	6	--	1	46	
"	--	--	--	--	2	--	--	--	--	2	
"	--	--	--	1	3	1	--	--	--	5	
"	--	--	1	1	2	3	1	--	--	8	
"	--	--	--	9	20	27	19	1	--	79	1
"	--	--	--	--	1	--	2	--	--	3	
July	--	1	6	11	15	13	6	2	--	54	
total	--	1	11	39	56	60	32	3	1	203	
"	--	3	3	4	7	4	1	1	--	23	
grand total	--	4	3	10	13	11	5	1	1	49	
July	--	1	2	7	13	11	6	1	--	41	
"	--	--	--	1	--	1	--	--	--	2	
"	--	--	1	3	7	4	2	1	--	18	
"	--	--	2	3	2	1	3	--	--	11	
"	--	1	4	14	25	15	6	1	--	67	1
"	--	--	--	3	2	1	--	--	--	6	
"	--	1	2	9	20	18	2	1	--	53	
total	--	3	9	37	79	58	18	4	1	209	
"	--	--	--	8	7	4	1	1	--	21	
grand total	--	--	3	20	18	14	6	2	--	63	
	--	--	1	4	13	11	4	1	1	35	1

Includes 139 seals of E series with tags lost.

	--	1	6	22	30	31	15	--	--	105	2
	--	2	10	34	34	30	12	4	--	126	3
total	--	6	26	78	97	79	39	7	1	333	

Table 3.--Field length of tagged 3-year-old seals by time of recovery, St. Paul Island, Alaska (continued)

Date	Length in inches									Total recovery	No length recorded
	39	40	41	42	43	44	45	46	47		
July	--	--	--	2	2	--	2	1	--	7	
"	--	--	--	7	8	5	--	--	--	20	
"	--	--	--	--	1	1	--	--	--	2	
"	--	2	6	7	13	4	5	2	--	39	
" total	--	--	2	4	16	9	6	5	--	42	
Grand total	--	2	8	20	40	19	13	8	--	110	
July	--	--	1	7	7	3	1	--	--	19	
"	--	--	1	11	11	16	6	--	1	46	
"	--	--	--	1	3	1	--	--	--	5	
"	--	--	3	9	20	27	19	1	--	79	1
"	--	1	6	11	15	13	6	2	--	54	
Grand total	--	1	11	39	56	60	32	3	1	203	
July	--	--	--	4	4	9	2	--	1	20	
"	--	1	2	7	13	11	6	1	--	41	
"	--	--	1	3	7	4	2	1	--	18	
"	--	1	4	14	25	16	6	1	--	67	1
"	--	1	2	9	30	18	2	1	--	63	
Grand total	--	3	9	37	79	58	18	4	1	209	
July	--	3	8	9	14	4	6	--	--	44	
"	--	--	1	4	13	11	4	1	1	35	1
"	--	--	1	9	6	3	2	2	--	23	
"	--	1	6	22	30	31	15	--	--	105	2
"	--	2	10	34	34	30	12	4	--	126	3
Grand total	--	6	26	78	97	79	39	7	1	333	

Table 3.--Field length of tagged 3-year-old seals by time of recovery, St. Paul Island, Alaska (continued)

Date	Rookery	Length in inches								Total recovery	No length recorded	
		39	40	41	42	43	44	45	46			47
28 July	NEP	--	--	1	6	8	9	4	--	--	28	
29 "	NEP	--	1	3	10	17	8	6	--	1	46	
30 "	TRK	--	2	2	14	15	21	10	3	--	67	
31 "	ZAP	<u>1</u>	<u>1</u>	<u>7</u>	<u>19</u>	<u>12</u>	<u>11</u>	<u>5</u>	<u>--</u>	<u>--</u>	<u>56</u>	
Round total		1	3	13	49	52	49	25	3	1	197	
Totals		1	23	75	259	361	294	141	30	5	1189	8

4-day season extension: incomplete round.

Table 4.--Length classes of tagged 3-year seals by rookery of recovery, St. Paul Island, Alaska

Rookery of recovery	Length in inches								Total recovery	No length recorded	
	39	40	41	42	43	44	45	46			47
Polstoi	--	2	7	21	23	13	5	2	--	73	---
Ankanin-Kitovi	--	1	4	8	16	13	6	--	1	49	---
Capadni	--	2	10	43	66	55	24	2	3	205	1
Seef	--	--	2	16	20	9	4	3	1	55	---
Polovina	--	8	22	79	112	114	63	9	--	407	4
Northeast Point	<u>1</u>	<u>10</u>	<u>30</u>	<u>92</u>	<u>124</u>	<u>90</u>	<u>39</u>	<u>14</u>	<u>--</u>	<u>400</u>	<u>3</u>
Totals	1	23	75	259	361	294	141	30	5	1189	8
St. George	1	7	20	27	14	8	5	--	--	82	--

Table 5--Age classification of commercial kill males: St. Paul Island, Alaska.

Month	Rookery	Males killed	Tooth sample size	Percent in each age class				Estimated number killed from age class			
				2	3	4	5	2	3	4	5
June	NEP	297	26	--	41	59	--	--	122	175	--
	TLK	163	25	--	52	44	4	--	85	72	6
	ZAP	267	37	--	56	41	3	--	151	110	8
	REEF	233	31	--	42	55	3	--	98	128	7
	POL	338	29	--	28	72	--	--	95	243	--
	NEP	<u>411</u>	<u>31</u>	--	<u>45</u>	<u>55</u>	--	--	<u>135</u>	<u>226</u>	--
Total		1412	--	--	43	55	2	--	614	779	21
June	TOL	349	39	--	49	51	--	--	171	178	--
	ZAP	810	38	--	55	45	--	--	450	368	--
	REEF	342	31	--	23	65	13	--	79	218	45
July	POL	406	32	--	34	60	6	--	138	244	24
	NEP	<u>863</u>	<u>43</u>	--	<u>56</u>	<u>42</u>	<u>2</u>	--	<u>483</u>	<u>362</u>	<u>17</u>
	Total	2770	--	--	48	49	3	--	1321	1370	86
July	TLK	365	40	--	45	50	5	--	164	183	18
	ZAP	1088	43	--	61	37	2	--	664	402	22
	REEF	385	30	--	30	63	7	--	115	243	27
	POL	832	29	--	41	59	--	--	341	491	--
	NEP	<u>1283</u>	<u>27</u>	--	<u>59</u>	<u>41</u>	--	--	<u>757</u>	<u>526</u>	--
Total	3953	--	--	52	47	2	--	2041	1845	67	
July	TLK	614	30	--	57	43	--	--	350	264	39
	ZAP	1601	49	--	57	43	--	--	913	688	45
Total		15,074	--	--	53	48	1	--	8009	7066	158

RD1

Table 5--Age classification of commercial kill males: St. Paul Island, Alaska (Cont'd)

	Rookery	Males Killed	Tooth sample size	Percent in each age class				Estimated number killed from age class			
				2	3	4	5	2	3	4	5
July	REEF	532	48	2	33	65	--	11	177	344	--
"	POL	1223	25	4	32	64	--	49	391	783	--
"	NEP	1867	40	--	62	38	--	--	1158	709	--
Grand Total		5837		1	51	48	--	60	2989	2788	--
July	TLK	657	27	--	63	37	--	--	414	243	--
"	ZAP	2728	65	--	68	32	--	--	1856	873	--
"	REEF	361	28	--	43	57	--	--	155	206	--
"	POL	1674	39	--	54	46	--	--	904	720	--
"	NEP	2030	41	2	66	32	--	40	1340	650	--
Grand Total		7450		1	63	36		40	4669	2692	
July	TLK	946	37	3	65	32	--	28	615	303	--
"	ZAP	2517	59	--	66	34	--	--	1661	856	--
"	REEF	999	36	3	44	53	--	29	440	530	--
"	POL	1285	36	--	69	28	3	--	886	360	39
"	NEP	2480	132	3	58	39	--	75	1438	967	--
Grand Total		8227		2	61	37 (.5)		132	5040	3016	39
July	TLK	2141	95	2	69	27	2	43	1478	578	43
"	ZAP	2557	62	--	64	34	2	--	1637	869	51
"	REEF	1027	68	4	64	32	--	41	657	329	--
"	POL	1884	95	1	61	37	1	19	1149	697	19
"	NEP	4465	148	4	75	20	1	179	3348	893	45
Grand total		12,074		2	68	28	1	282	8269	3366	158

Table 5--Age classification of commercial kill males: St. Paul Island, Alaska (Cont'd)

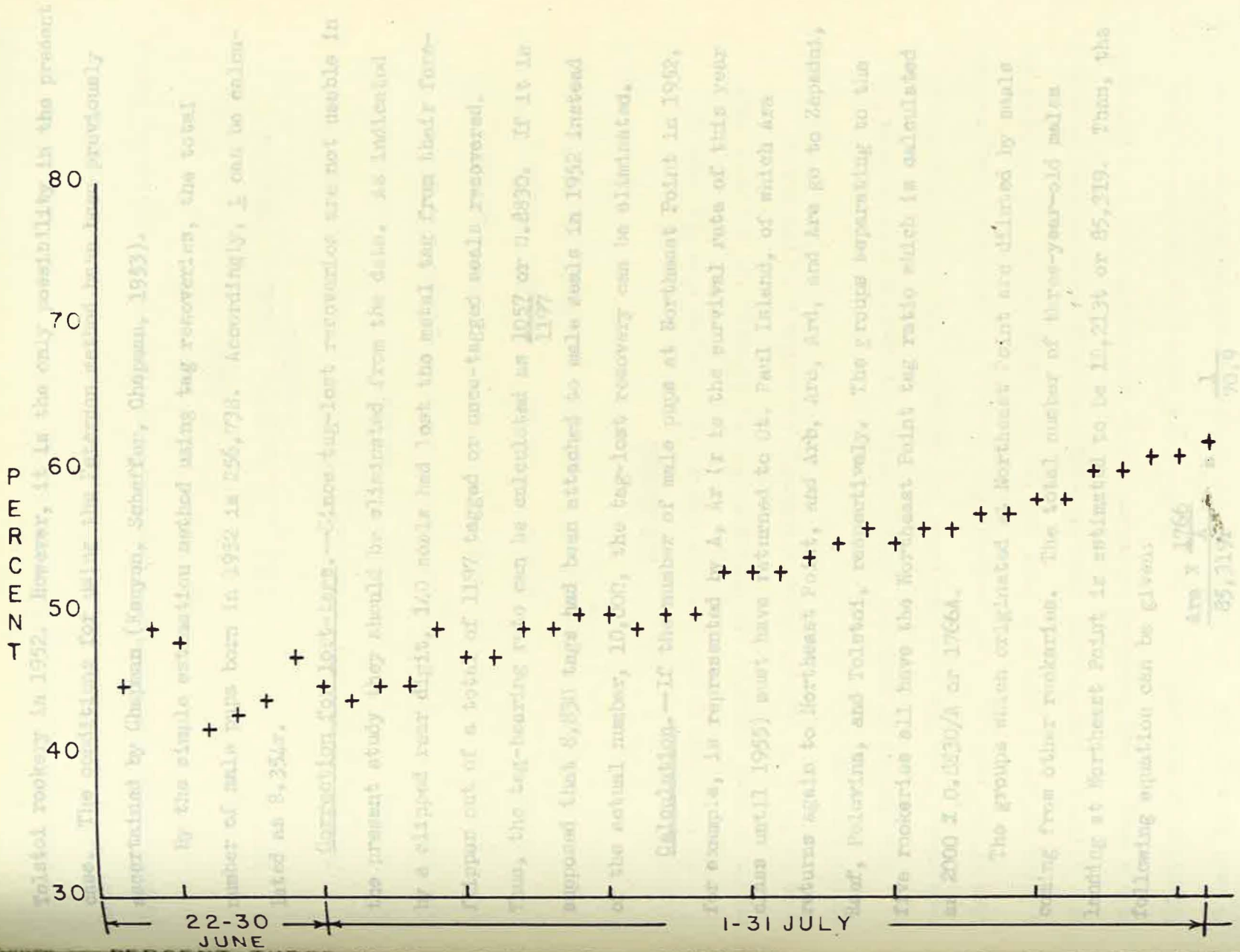
Date	Rookery	Males killed	Tooth sample size	Percent in each age class				Estimated number killed from age class			
				2	3	4	5	2	3	4	5
July	TK	1884	64	2	72	26	--	38	1356	490	--
"	ZAP	2683	69	1	73	26	--	28	2023	720	--
"	TLK	217	4	--	100	--	--	--	217	--	--
"	POL	1296	44	7	70	23	--	91	907	298	--
"	ZAP	358	3	--	100	--	--	--	358	--	--
"	NEP	<u>2094</u>	<u>92</u>	<u>8</u>	<u>66</u>	<u>26</u>	<u>--</u>	<u>168</u>	<u>1382</u>	<u>544</u>	<u>--</u>
"	REF	150	4	--	100	--	--	150	--	--	--
and total		7957		4	71	26		325	5668	2052	--
July	TK	55	1	--	100	--	--	55	--	--	--
July	TK	49,977	954	2	61	36	1	839	30733	18083	332
July	+ Cows	<u>641</u>									
July	TK	907	113	--	100	--	--	907	--	--	--
July	ZAP	1197	150	--	100	--	--	1197	--	--	--
July	Total St. Paul kill	50,618									
July	SELY	1,340	13	--	100	--	--	1,340	--	--	--
July	TK	1,374	2	--	100	--	--	1,374	--	--	--
July	NEP	1,057	1	--	100	--	--	1,057	--	--	--
July	TK	1,224	5	--	100	--	--	1,224	--	--	--
July	ZAP	1,825	4	--	100	--	--	1,825	--	--	--
July	JGTY	3,000	7	--	100	--	--	3,000	--	--	--
July	POL	3,521	1	--	100	--	--	3,521	--	--	--
July	NEP	1,190	1	--	100	--	--	1,190	--	--	--
July	TK	1,278	1	--	100	--	--	1,278	--	--	--
July	ZAP	5,762	1	--	100	--	--	5,762	--	--	--
July	REFY	5,938	1	--	100	--	--	5,938	--	--	--
July	POL	5,423	1	--	100	--	--	5,423	--	--	--
July	REF	7,217	1	--	100	--	--	7,217	--	--	--

Table 6--Cumulative age classification of commercial kill males, St. Paul Island, Alaska

Month	Rockery	Estimated number males killed from age				Cumulative total males killed	Cumulative percent males killed from age			
		2	3	4	5		2	3	4	5
June	NEP	--	122	175	--	297	--	41	59	--
	TLK	--	761	700	--	1461	--	92	49	--
"	TLK	--	207	247	4	458	--	45	54	1
"	ZAP	--	358	357	3	718	--	49	49	2
"	REEF	--	456	485	3	944	--	48	51	1
"	POL	--	551	728	--	1279	--	42	56	--
"	NEP	--	736	954	--	1709	--	43	56	--
"	TLK	--	1,370	754	--	2,124	--	78	44	--
"	TOL	--	907	1132	--	2039	--	44	55	--
"	ZAP	--	1357	1500	--	2857	--	47	52	--
"	REEF	--	1436	1718	13	3167	--	45	54	--
July	POL	--	1574	1962	6	3542	--	44	54	--
"	NEP	--	2057	2324	2	4383	--	46	54	--
"	TLK	--	1872	1547	--	3419	--	57	51	--
July	TLK	--	2221	2507	5	4733	--	46	52	--
"	ZAP	--	2885	2909	2	5796	--	49	49	--
"	REEF	--	3000	3152	7	6159	--	47	50	--
"	POL	--	3341	3623	--	6964	--	47	51	--
"	NEP	--	4098	4169	--	8267	--	49	49	--
"	TLK	--	2821	1651	--	4472	--	60	38	--
"	TLK	--	4448	4433	--	8881	--	49	49	--
"	ZAP	--	5361	5121	--	10,482	--	50	48	--
"	REEF	2	5538	5465	--	11,179	--	50	47	--
"	POL	4	5929	6248	--	12,402	--	49	50	--
"	NEP	--	7087	6958	--	14,045	--	50	49	--

Table 6---Cumulative age classification of commercial kill males,
St. Paul Island (Continued)

Rookery	Estimated number males killed from age			Cumulative total males killed	Cumulative percent males killed from age				
	2	3	4		2	3	4	5	
TLK	--	7501	7200	--	14,926	--	50	48	--
ZAP	--	9357	8073	--	17,654	--	53	46	--
REEF	--	9512	8279	--	18,015	--	53	46	--
POL	--	10416	8999	--	19,689	--	53	46	--
NEP	2	11756	9649	--	21,719	--	54	44	--
TLK	3	12371	9952	--	22,665	--	55	44	--
ZAP	--	14032	10808	--	25,182	--	56	43	--
REEF	3	14472	11338	--	26,181	--	55	43	--
POL	--	15358	11648	3	27,466	--	56	43	--
NEP	3	16796	12665	--	29,946	--	56	42	--
TLK	2	18274	13243	2	32,087	--	57	42	--
ZAP	--	19911	14112	2	34,644	--	57	41	--
REEF	4	20568	14441	--	35,671	--	58	40	--
POL	1	21717	15638	1	37,555	--	58	40	--
NEP	4	25065	16031	1	42,020	--	60	38	--
TLK	2	26221	16521	--	43,904	--	60	38	--
ZAP	1	28444	17241	--	46,587	--	61	37	--
POL	7	29351	17539	--	47,883	--	61	37	--
NEP	8	30733	18083	--	49,977	--	62	36	--



Tolstoi rookery in 1952. However, it is the only possibility in the present case. The conditions for using the Peterson method have been previously ascertained by Chapman (Kenyon, Scheffer, Chapman, 1953).

By the simple estimation method using tag recoveries, the total number of male pups born in 1952 is 256,738. Accordingly, $\frac{1}{r}$ can be calculated as 8.354r.

Correction for lost-tags.--Since tag-lost recoveries are not usable in the present study they should be eliminated from the data. As indicated by a clipped rear digit, 140 seals had lost the metal tag from their fore-flipper out of a total of 1197 tagged or once-tagged seals recovered. Thus, the tag-bearing rate can be calculated as $\frac{1057}{1197}$ or 0.8830. If it is supposed that 8,830 tags had been attached to male seals in 1952 instead of the actual number, 10,000, the tag-lost recovery can be eliminated.

Calculation.--If the number of male pups at Northeast Point in 1952, for example, is represented by A, Ar (r is the survival rate of this year return of each rookery. At Northeast Point, Zapadni, and Polovina this class until 1955) must have returned to St. Paul Island, of which Ara rate is 60 to 70 percent which apparently indicates a fairly strong returns again to Northeast Point, and Arb, Arc, Ard, and Are go to Zapadni, Reef, Polovina, and Tolstoi, respectively. The groups separating to the five rookeries all have the Northeast Point tag ratio which is calculated as $2000 \times 0.8830/A$ or 1766A.

The groups which originated at Northeast Point are diluted by seals coming from other rookeries. The total number of three-year-old males landing at Northeast Point is estimated to be 10,213t or 85,319. Then, the following equation can be given:

$$\text{Ara} \times \frac{1766}{A} = \frac{1}{70.9}$$

at Reef is very low. One-third of the three-year-old males born at Reef appeared on Zapadni rookery three years later. Also, the dispersion to

From this equation g is calculated as 0.6804. By the same method b , c , d , and e can also be found, as can the ratio of seals returning to Zapadni, Reef, and Polovina. The results are given in the following table:

TO	FROM			
	NEP	ZAPADNI	REEF	POLOVINA
	Percent			
Northeast Point	<u>0.6804</u>	0.1183	0.1952	0.2819
Zapadni	0.0756	<u>0.6629</u>	0.3207	0.0822
Reef	0.0047	0.0237	<u>0.1262</u>	0.0103
Polovina	0.1323	0.1183	0.1355	<u>0.5925</u>
Tolstoi	<u>0.0398</u>	<u>0.1182</u>	<u>0.1922</u>	<u>0.0555</u>
Total	0.9828	1.0414	0.9698	1.0224

Discussion

In the table given above the underlined figures show the rate of return of each rookery. At Northeast Point, Zapadni, and Polovina this rate is 60 to 70 percent which apparently indicates a fairly strong homing tendency.

The hauling grounds for bachelor seals are located just outside the rookeries. Then the area available for bachelors has no relationship to that of the rookery. Reef rookery, for example, is extensive and produces a large number of pups each year but the hauling ground in its vicinity is very limited. Accordingly, even if bachelors originating at Reef rookery have a very strong tendency to return there, not enough room in a favorable situation is available to them. That is the reason why the homing rate at Reef is very low. One-third of the three-year-old males born on Reef appeared on Zapadni rookery three years later. Also, the dispersion to

Reef from other rookeries is extremely low. 1955

Apart from the homing trend to St. Paul Island, it is clearly indicated that three-year-old males have a strong tendency to return to the rookery where they were born three years earlier. - 15,000 11,000

D. Tagging.

The greatest number of seal pups tagged in one year prior to 1955 was 20,000. This season 50,000 tags were used, of which 130 were spoiled and perhaps 150 to 200 more may be lost because of inadequate clinching. Although taggers were requested repeatedly to check the clinch, some poor attachments will slip by in what is a rather high speed operation. Most closure failures are caused by tags on which the point is not properly lined up with the aperture through which it clinches. Necessarily, we depend on the manufacturer to adjust the tags for attachment because of the time required to examine 50,000 tags.

Polovina Cliffs	6	15,001 - 18,000	3,000
Little Polovina	6	18,001 - 21,000	3,000
Reef	28	3,001 - 4,000	
and Zapadni Reef	9	21,001 - 25,500	4,500
Zapadni	11	25,501 - 31,000	5,500

As in 1953 and 1954 tags were apportioned to each rookery according to the harem bull count. One minor exception to this standard was made on Lukanin-Kitovi rookeries. Three thousand instead of four thousand tags were applied at these two rookeries because of the rough terrain. The extra thousand tags were used on Reef rookery. The tags were attached to the left foreflipper and 1/2 to 3/4-inch of the outer digit of the left hind-flipper was sliced off as a check mark.

Fur Seal Tagging, 1955

Rookery	Percent	Tag numbers	Number seals tagged
Northeast Point	22	4,001 - 15,000	11,000
Polovina Rookeries			
Polovina and Polovina Cliffs	6	15,001 - 18,000	3,000
Little Polovina	6	18,001 - 21,000	3,000
Reef	28	3,001 - 4,000; 37,001 - 50,000	14,000
Kitovi, Lukanin, Tolstoi			
Kitovi-Lukanin	6	1 - 3,000	3,000
Tolstoi	12	31,001 - 37,000	6,000
Zapadni Rookeries			
Little Zapadni and Zapadni Reef	9	21,001 - 25,500	4,500
Zapadni	11	25,501 - 31,000	5,500

Tags 1 - 10,000 had the series designation "H" stamped ahead of the number. The remainder bore a number only. The tags were attached to the left foreflipper and 1/2 to 3/4-inch of the outer digit of the left hind-flipper was sliced off as a check mark.

It was to be decided from the experience of tagging 50,000 seals whether it would be feasible to tag 75,000 or 100,000. The tagging of 50,000 was done fairly rapidly--in eight working days with a crew of 28 men in addition to two biologists, an average of over 6,000 per day. Despite the apparent rapid progress it was necessary at times to search for groups of pups which did not contain a large number of tagged animals tagged. The work was arduous and as is to be expected much personal equipment such as boots, trousers, jackets, and rain gear was ruined. It was necessary to work on some rookeries for several days before its quota was completed. When the tagging on a rookery required more than two days' operations were shifted to another rookery or another part of a large rookery in order to allow the pups to nurse. Although tagging as many as 100,000 pups is physically possible we believe 50,000 is near the practical limit. We would not want to attempt more than this number unless such an operation was absolutely indispensable.

1. Total counts.

A complete count of dead pups was made on St. Paul Island using the same methods as have been described for previous years. Counts were made by biologists, Calvin Lenzink and Ford Wilke, Japanese Government representative, F. Nagasaki, and a local assistant, George Rubovishnikoff. The counts required approximately 10 days. 30 counts were made this season on St. George Island or on Sea Lion Rock. The counts are listed in Table 3 and with the exception of Reef, Ardiguan, and Kiscvi show decreases in pup mortality. Total pup deaths for St. Paul rookeries decreased 21.6 percent from 1954.

2. Sample areas counts.

Table 7—Death rate, dead pup study area - Northeast Point.

IV. MORTALITY.

A. Dead pup study area.

Counts to determine the comparative death rate on a study area of about 15,000 sq. ft. on Northeast Point were begun in 1951. In 1955 counts were made at 5-day intervals except for the final count which was made coincidentally with other dead pup counts at Northeast Point. As on most of the rookeries a substantial decline in mortality took place this season. The final count of 293 made on 23 August (Table 7) is 30 percent less than the 420 dead pups counted on 24 August 1954. In that year half of the mortality had occurred between 27 and 29 July and three-fourths between 1 and 5 August. Comparable dates in 1955 were 30 July to 4 August and 4 to 9 August. Thus, the same degree of mortality was reached about 5 days later in 1955 than in 1954. The overall trend was similar but varied in timing and total extent as indicated.

B. Dead pup counts.

1. Total count.

A complete count of dead pups was made on St. Paul Island using the same methods as have been described for previous years. Counts were made by biologists, Calvin Lensink and Ford Wilke, Japanese Government representative, F. Nagasaki, and a local assistant, George Rukuvishnikoff. The counts required approximately 10 days. No counts were made this season on St. George Island or on Sea Lion Rock. The counts are listed in Table 8 and with the exception of Reef, Ardiguen, and Kitovi show decreases in pup mortality. Total pup deaths for St. Paul rookeries decreased 21.5 percent from 1954.

2. Sample areas counts.

Table 7.--Death rate, dead pup study area - Northeast Point.

Date	Number dead pups	1955	Increase in deaths
15 July	17	5,971	decrease
20 "	49	14,473	32 decrease
25 "	85	2,702	36 decrease
30 "	133	5,964	48 decrease
4 August	188		55
9 "	237	387	49 increase
14 "	280	4,789	43 increase
19 "	290	15,245	43 increase
23 "	293	2,610	3 increase
		1,129	
		6,489	decrease

In 1954, fourteen sample areas were outlined with paint marks. It was intended that counts of dead pups would be made on the sample areas for comparison with the total count. If counts on the sample areas followed closely the total count in trend and extent, counts on the sample areas could be substituted for the time consuming complete count. In 1955 the sample area mortality counts showed an overall decline of 30 percent, about 8-1/2 percent greater than that shown in the total count (Table 9). It would appear that the sample areas thus far selected are not fully representative of all the rookeries and that it will be necessary to set off additional sample areas until the trend of the overall and sample areas counts is closely parallel. Once this is accomplished there will be a worthwhile saving in time since present sample areas can be counted in a little over a day by four men.

Table 8.--Dead pup counts, St. Paul Island, Alaska.

Rookery	1954	1955	Change percent
Northeast Point Rookeries			
Morjovi	8,049	5,571	30.7 decrease
Vostochni	25,233	14,473	42.6 decrease
Polovina Rookeries			
Little Polovina	3,852	2,782	27.7 decrease
Polovina Cliffs	6,413	5,964	7.0 decrease
Polovina	6,459	4,660	27.8 decrease
Reef Rookeries			
Ardiguen	282	387	37.2 increase
Gorbatch	4,900	4,789	2.3 decrease
Reef	12,959	15,145	16.9 increase
Sivutch	---	---	---
Kitovi, Lukanin, Tolstoi			
Kitovi	1,669	2,610	56.4 increase
Lukanin	1,129	1,129	---
Tolstoi	7,552	6,489	14.0 decrease
Zapadni Rookeries			
Little Zapadni	4,979	3,555	28.6 decrease
Zapadni Reef	2,278	1,383	39.3 decrease
Zapadni	<u>10,424</u>	<u>6,607</u>	36.6 decrease
Actual Total	96,178	75,544	- 21
Add 5%	4,809	3,777	- 36
Estimated Total	100,987	79,321	- 30.1
Change in mortality			21.5 percent decrease

*Counts made 15 - 22 August

Table 9.--Sample areas, dead pup counts, St. Paul Island, Alaska.

Rookery	1954	1955	Percent change
Northeast Point Rookeries			
Morjovi			
Area 1	1234	747	- 39
Area 2	702	367	- 48
Vostochni			
Area 1	420	293	- 30
Area 2	741	536	- 28
Polovina Rookeries			
Polovina Cliffs	897	889	+ .01
Polovina	1286	543	- 58
Reef Rookeries			
Gorbach	1692	1542	- 9
Reef	1244	1091	- 12
Kitovi, Lukanin, Tolstoi			
Kitovi	287	336	+ 17
Lukanin	248	371	+ 50
Tolstoi	1452	1140	- 21
Zapadni Rookery			
Little Zapadni	538	423	- 21
Zapadni	---	---	---
Area 1	613	396	- 36
Area 2	<u>1054</u>	<u>845</u>	<u>- 20</u>
Total:	12,408	8,674	- 30.1

long period of years during which similar occurrences take place.

C. Rookery Investigation.

1. Current work.

A detailed report on the 1955 rookery investigation will be prepared by Dr. O. Wilford Olsen.

Following recommendations made by Carl Dixon at the completion of his research in 1954 we repeated the treatment of 2 acres at Polovina with equal

Records of the 1955 dead pup counts have been furnished Dr. Olsen.

An accurate explanation of the decreased mortality in 1955 is almost impossible to make because of our incomplete understanding of the causes of this mortality. The greatest decrease occurred on rookeries where hookworm infection has taken a heavy toll. Rookeries such as Kitovi, Lukanin, and Ardiguén had an increased death rate. It is believed hookworm had little effect in the past on these rookeries. A natural, tentative proposal is that a decline in the hookworm infection was responsible for the lessened mortality. What, then, has caused the change in hookworm infection? The only readily apparent difference between the 1954 and the 1955 season was the coldness and lateness of the 1955 spring and summer. Although there was some delay in the arrival of cows and the birth of pups in 1955 it is not certain how this would be reflected in the mortality rate (Fig. 3). According to the studies of Dr. O. Wilford Olsen and Carl Dixon, there is a constantly decreasing number of larvae in the soil throughout the summer, almost reaching the vanishing point by mid-August. Conceivably, a few days' delay in the peak of pup births coupled with a lessened number of hookworm larvae in the soil might combine to produce the decreased mortality we have observed. Much of this is speculation which we may never be able to substantiate unless observations are made over a long period of years during which similar occurrences take place.

C. Hookworm investigation.

1. Current work.

A detailed report on the 1955 hookworm investigation will be prepared by Dr. O. Wilford Olsen.^{1/}

Following recommendations made by Carl Dixon at the completion of his research in 1954 we repeated the treatment of 3 acres at Polovina with coal

^{1/} Records of the 1955 dead pup counts have been furnished Dr. Olsen.

lar control and 2.5 acres at Northeast Point with cresylic acid. The concentration of the solution was 2 percent, double that applied in 1954. As nearly as possible the solution was put on at the rate of 1 pint per square foot. The phosol coefficient of the soil tar cresol disinfectant used in 1954 was 16.6 and that of the cresylic disinfectant is 9. Results in 1954 were uncertain. Apparently, the number of hookworm larvae had been drastically reduced but no decrease in soil pup mortality followed. At least one more season's test was considered necessary to determine whether these apparently promising disinfectants had real merit or not.

Originally, it was believed that the material should be sprayed. However, the orchard type sprayer used in 1954 was inadequate. The time required to deliver the requisite amount of material was unreasonable. It was found that a pump rather than a sprayer was needed. This season a portable gasoline powered centrifugal pump was used. With a 1-1/4 inch intake hose and a 1-1/2 inch discharge hose the material was delivered at over 15 gallons per minute. It was applied by a flooding method rather than spraying. Difficulty was experienced in getting the pump to prime itself when the intake hose was transferred from one drum to another.

2. Future work.

The investigators have been successful in working out most of the life history of the hookworm, *Uncinaria stenocephala*. Additional information is needed on the causes of mortality among soil pupae and what part of the mortality is hookworm caused.

Figure 3.--Kitovi Amphitheater on 13 July 1950 (upper) and 15 July 1955 (lower) showing variation in cow arrivals.

positive results in terms of reduced pup mortality can be reported yet not

tar creosol and 2.5 acres at Northeast Point with cresylic acid. The concentration of the solutions was 2 percent, double that applied in 1954. As nearly as possible the solution was put on at the rate of 1 pint per square foot. The phenol coefficient of the coal tar creosol disinfectant used is 16.6 and that of the cresylic disinfectant is 9. Results in 1954 were uncertain. Apparently, the number of hookworm larvae had been drastically reduced but no decrease in seal pup mortality followed. At least one more season's test was considered necessary to determine whether these apparently promising disinfectants had real merit or not.

Originally, it was believed that the material should be sprayed. However, the orchard type sprayer used in 1954 was inadequate. The time required to deliver the requisite amount of material was unreasonable. It was found that a pump rather than a sprayer was needed. This season a portable gasoline powered centrifugal pump was used. With a 1-1/4 inch intake hose and a 1-1/2 inch discharge hose the material was delivered at over 15 gallons per minute. It was applied by a flooding method rather than spraying. Difficulty was experienced in getting the pump to prime itself when the intake hose was transferred from one drum to another.

2. Future work.

The investigators have been successful in working out most of the life history of the hookworm, Uncinaria lucasi. Additional information is needed on the causes of mortality among seal pups and what part of the mortality is hookworm caused.

In 1954 and 1955 most of the emphasis in hookworm research has been placed on finding a chemical that will destroy the larvae in the soil. No positive results in terms of reduced pup mortality can be reported yet nor

are any immediate results in prospect. The search may go on for years before a really effective chemical control is found. It is also possible that other mortality factors may remove animals that have been saved from hookworm before they enter the commercial kill. With success, at least in the near future, so unsure, should this research be continued? This is probably an opportune time for decision because we know there is likelihood of several years' work before positive results are obtained. Plans for a continuation should be made for three to five years and anticipate one or more extensions of the same duration.

Table 10.—Reproductive condition of females from landing round 12

Age	Pregnancy prior to 1955				Pregnancy 1955 ⁽¹⁾				Total	
	No.	%	No.	%	No.	%	No.	%		
3	21	100	0	0	0	0	0	0	21	100
4	21	84	1	4	1	4	1	15	24	73
5	69	33	100	53	22	12	13	32	70	145
6	12	11	85	33	59	50	68	63	75	100
7	-	3	9	14	53	30	5	38	22	64
8	1	3	3	14	26	35	13	39	8	26
9	3	15	0	0	17	35	13	26	7	20
10	0	0	9	0	26	100	20	24	26	46
?	2	100	8	47	6	31	15	67	3	33
Totals	164	29	171	31	233	43	100	61	30	360

(1) Conception during 1954 breeding season.

V. REPRODUCTION

Insofar as physically possible genital tracts of female seals taken in the commercial kill were collected for examination. Eighty-one females were missed because of our inability to cope with all that were killed on certain days late in the season. A canine tooth was collected along with each genital tract, as is usually done, in order to determine the age of the animal.

Very few females occur in the early rounds but the number increases rapidly in the late rounds. To illustrate, only 81 females were available for examination by 17 July but 560 were collected by 31 July. Their reproductive condition is summarized in Table 10.

Table 10.--Reproductive condition of females from hauling grounds

Age	Pregnancy prior to 1955				Pregnancy 1955 ⁽¹⁾				Total		
	Nullipara		Primipara		Multipara		Pregnant			Non-pregnant	
	No.	%	No.	%	No.	%	No.	%	No.	%	
3	13	100	0	0	0	0	0	0	13	100	13
4	61	84	12	16	0	0	12	16	61	84	73
5	69	35	104	53	22	12	125	64	70	36	195
6	12	11	35	33	59	56	88	83	18	17	106
7	2	3	9	14	53	83	52	78	12	22	64
8	1	3	3	12	22	85	18	69	8	31	26
9	3	15	0	0	17	85	13	65	7	35	20
10 & 10+	0	0	0	0	46	100	20	44	26	56	46
?	3	18	8	47	6	35	12	67	5	33	17
Totals	164	29	171	31	225	40	340	61	220	39	560

(1) Conception during 1954 breeding season.

The degree of pregnancy declines from 100 percent for females taken in the early rounds to 51 percent for those taken in the final round. An increase in the proportion of young nullipara animals is the cause of most of the change. Four, five and six year old seals predominate among the females killed in the last few days of the season. In addition there is some decline in the proportion of pregnant females among all age classes. It can be seen that the increase of females in the kill near the end of the season is only partly a result of harem break-up. A very important factor is the influx of young females, apparently just arriving on the islands.

Table 11--Reproductive condition of females from hauling grounds by round

Round and Date	Age (1)	Pregnancy History				Pregnancy 1955 ⁽²⁾				Total Females		
		Nullipara No.	%	Primipara No.	%	Multipara No.	%	Pregnant No.	%		Non-pregnant No.	%
Round I	5					2	100	2	100			2
June 23-27	6					2	100	2	100			2
	7					3	100	3	100			3
						7	100	7	100			7
	3	1	100							1	100	1
Round 2	?			1	100			1	100			1
June 23-27	5			1	100			1	100			1
July 2				2	100			2	100			2
Round 3												
July 3-7	4			3	100			3	100			3
	5			5	100			5	100			5
	6					1	100	1	100			1
	7			1	100			1	100			1
				9	90	1	10	10	100			10

Table 11--Reproductive condition of females from hauling grounds by round (Cont'd)

Round and Date	Age (1)	Pregnancy History						Pregnancy 1955 ⁽²⁾				Total Females
		Nullipara		Primipara		Multipara		Pregnant		Non-Pregnant		
		No.	%	No.	%	No.	%	No.	%	No.	%	
Round 4	?			1	100			1	100			1
July 8-12	3	1	100							1	100	1
	5			6	100			6	100			6
	6	1	8	9	75	2	17	11	92	1	8	12
	7			1	50	1	50	1	50	1	50	2
	8	—	—	—	—	1	100	1	100	—	—	1
		2	9	17	74	4	17	20	87	3	13	23
Round 5	4			2	100			2	100			2
July 13-17	5	3	12	19	76	3	12	22	88	3	12	25
	6			6	67	3	33	9	100			9
	7	—	—	—	—	3	100	3	100	—	—	3
		3	8	27	69	9	23	36	92	3	8	39
Round 6	?					1	100	1	100			1
July 18-22	3	1	100							1	100	1
	4	4	57	3	43			3	43	4	57	7
	5	2	13	9	61	4	26	13	87	2	13	15
	6			3	33	6	67	9	100			9
	7			2	20	3	80	7	70	3	30	10
	10+	—	—	—	—	4	100	—	—	4	100	4
		7	15	17	36	23	49	33	70	14	30	47
Round 7	?	3	38	4	50	1	12	5	62	3	38	8
July 23-27	3	5	100							5	100	5
	4	21	100							21	100	21

Table 11--Reproductive condition of females from hauling grounds by round (Cont'd)

Round and Date	Age (1)	Pregnancy History						Pregnancy 1955 ⁽²⁾				Total Females
		Nullipara		Primipara		Multipara		Pregnant		Non-Pregnant		
		No.	%	No.	%	No.	%	No.	%	No.	%	
	5	26	43	26	43	9	14	35	57	26	43	61
	6	4	15	6	21	18	64	23	82	5	18	28
	7	1	5	5	25	14	60	17	35	3	15	20
	8					4	100	4	100			4
	9	1	12			7	83	6	75	2	25	8
	10+	—	—	—	—	16	100	10	62	6	38	16
		61	36	41	24	69	40	100	58	71	42	171
Post Season	?			2	33	4	67	4	67	2	33	6
	3	6	100							6	100	6
July 28-31	4	36	90	4	10			4	10	36	90	40
	5	38	47	38	47	5	6	42	52	39	48	81
	6	7	16	11	24	27	60	33	73	12	27	45
	7	1	4			23	96	19	79	5	21	24
	8	1	5	3	14	17	81	13	62	8	38	21
	9	2	17			10	83	7	58	5	42	12
	10+	—	—	—	—	26	100	10	38	16	62	26
		91	35	58	22	112	43	132	51	129	49	261
Totals		164	29	171	31	225	40	340	61	220	39	560

(1) Only ages listed are those taken in the round.

(2) Conception during 1954 breeding season.