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MARINE MAMMAL INVESTIGATIONS

Work Plan J

Juneau, Alaska

MARINE MAMMAL INVESTIGATIONS

Walrus are hunted mainly by Alaskan Eskimos of St. Lawrence Island, the islands of the Bering Strait, and in the northwest coastal villages. In these locations geography limits economically rewarding pursuits and dependency on wildlife continues. (Photo by U. S. Fish & Wildlife Service)

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ANNUAL REPORT OF PROGRESS, 1960-1961

FEDERAL AID IN WILDLIFE RESTORATION PROJECT W-6-R-2

GAME INVESTIGATIONS OF ALASKA

STATE OF ALASKA

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INVESTIGATIONS PROJECT
COMPLETION OF 1960-1961 SEGMENT

State: Alaska

Project No: W-6-R-2 Name: Alaska Wildlife Investigations

Work Plan: J Marine Mammal Investigations

Job No: 1-a Title: Walrus Biology and Population Status

PERIOD COVERED: July 1, 1960 to June 30, 1961

ABSTRACT:

Examination of reproductive tracts indicate that the resorption of corpora albicantia may progress to such a point that the scars cannot be distinguished from atretic follicles. Therefore, females may have produced more calves than the ovaries indicate. A reproductive rate of approximately 12 per cent was derived from a sample of 18 adult females.

Tooth cross-sections used in age determinations normally contain one less cementum layer than do longitudinal sections, due primarily to the tooth wear pattern. The number of cementum layers lost through tooth wear can be estimated by counting the layers bordering the dentine. In females, the cementum layer method of age determination appears inaccurate.

The male catch curve does not show a linear relationship. Rather, the curve indicates that mortality from all causes increases with age. The computed mortality rate for males falls somewhere between 12 and 15 per cent. Hunter selectivity and walrus migration patterns produce biased sampling.

Among females, computed mortality rate of approximately 21 per cent is probably greater than the true rate as a result of inaccurate ageing methods and hunter selectivity.

The Pacific walrus population is estimated to contain 70,000 to 90,000 animals. Approximately 1,500 to 2,500 walruses were noted in the Walrus Islands during August 1960.

OBJECTIVES:

The objectives of this study are: to obtain additional information about the life history of the Pacific walrus, with special attention to breeding biology and growth; to develop methods for estimating productivity, population size and trend; to develop methods for tagging or marking walruses; and to determine the ecological and physiological significance, size and composition of the walrus herds that haul out on the Walrus Islands.

TECHNIQUES:

Most of the data used in this study were collected during the spring and summer of 1960, principally from the villages of Gambell, Savoonga, King Island, Diomede, Wales and Nome. S. J. Harbo, the author, collected all data except that obtained at King Island; Howard Kantner, a biological aide, collected the King Island information during residence there from April 27 through June 16, 1960.

Interviews with hunters and other informed individuals, personal observations and collection of specimens were the primary methods of acquiring data.

Breeding Biology

Entire female reproductive tracts, or only the ovaries, were obtained from walruses taken by Wales, King Island and Diomede hunters, with the hunters receiving $2.50 per set as a collecting incentive. Most of the hunters were willing to collect the specimens at that price, but their collecting methods often were faulty. In a number of instances when only the ovaries were taken, four or more were often placed in one bag, contrary to repeated instructions, or the pairs were obviously mismatched. At King Island two lymph glands

located anterior and dorsal to the uterine horns were misidentified as ovaries, and subsequently collected, with the actual ovaries discarded in the process.

The uteri were grossly examined for placental scars and then discarded. The ovaries were placed in a five per cent formaldehyde solution and later sectioned into one to two millimeter thick cross sections. The sections were then inspected under low magnification for corpora lutea or corpora albicantia. The number and size of maturing follicles were noted.

Population Composition

A tooth collecting program was instituted at Wales, Gambell, Savoonga, Diomede and King Island during 1960 as a means of obtaining harvest composition information. The two lower canines were requested, and an incentive payment of $1.00 per set offered to each collector. The program proved very successful. The sex notation with the teeth supplied much of the sex composition data.

Age composition information was obtained by sectioning the teeth and counting the cementum layers, or rings, visible in each section. The procedures involved are related in more detail below.

Population Welfare and Size

Age composition data obtained from tooth sections provided a basis for determining the annual mortality rates for the Pacific walrus population. A catch curve was constructed using the tooth data, and this curve was then analyzed according to Ricker (1948).

An estimate of population size was derived by using the mortality rates and the estimated annual kill of walruses. The author accompanied aerial surveys over the Bering Sea during March 1961, sponsored by the U. S. Fish and Wildlife Service, in an effort to obtain an accurate estimate of the population size.

A trip to the Walrus Islands to observe the herds that haul out there, was made during August 1960, by the author and C. Lensink. The trip was limited to a two and one-half

day period due to inclement weather and lack of suitable transportation. Estimates of herd size and composition were obtained.

FINDINGS:

Breeding Biology

Approximately 50 pairs of ovaries, some still attached to the uteri, were obtained at King Island, Diomede and Wales, but only 19 could be used in the present study. The remainder were discarded when it became apparent that the ovaries had been indiscriminately paired by the hunters, or one ovary of a set was missing. The latter case seemed the rule with the specimens submitted by the Wales hunters. A further complication arose at King Island when lymph glands were mistaken for ovaries.

The hunters were requested to include a tooth from each animal with the uterus or ovaries. They frequently did include a tooth with the reproductive organs, but the two specimens were not necessarily from the same animal. I was certain of proper matching in only eight instances.

An inspection of the ovaries (Table 1) reveals that 6 of the 19 females were pregnant when collected during May and June, and another, Diom 13-60, was ovulating when taken on May 30 in the Bering Straits. Nine of the other individuals apparently had nursing calves when captured for their ovaries contained corpora lutea of parturition. Of the three remaining individuals, two apparently had failed to conceive during the spring of 1960, and one had aborted after implantation. The latter individual's right uterine horn was enlarged and thickened and its right ovary contained a 25 mm corpus albicans.

Five was the maximum number of pregnancies recorded for any one individual in the present sample, with two animals showing this number. For those animals showing five pregnancies, the number should be considered minimal, however, for the corpora albincantia are gradually resorbed creating difficulty in accurately distinguishing these scars from atretic follicles. Brooks (1954) has suggested that positive identification is possible for

Table 1. The reproductive history of 19 sexually mature females collected during May and June, 1960.

Field No.	Estimate Age	C. lateum (of preg.)	C. lateum (of part.)	C. albicantia (both ovaries)	Total Preg.
N0528W	11		yes (16mm)	2 (7mm, 7mm)	3
N0581W	9	yes		1 (12mm)	2
N0598W	5 or 6		yes	none	1
N0688W	8 or 9		yes	1 (16mm)	2
N0722W	12		yes	1	2
N0725W	11 or 12			3 (25, 6, 6mm)	3
N0727W	18?			3	3
N0733W	11			2 (5mm, ?)	2
N0789	13	yes (30mm)		2 (17, 17mm)	3
Diom 2-60			yes	none	1
Diom 4-60		yes		3 (25, 8, 7mm)	4
Diom 5-60			yes (22mm)	none	1
Diom 10-60		yes		4 (10, 8, 5, 4mm)	5
Diom 11-60		yes		2	3
Diom 12-60		yes (25mm)		1 (10mm)	2
Diom 13-60				4	4
Diom 16-60			yes	3	4
Diom 17-60			yes (36)	4 (10, 10, 8, 7mm)	5
Wales 2-60			yes	1 (20mm)	2

* Based on tooth cementum layers.

several years, and perhaps for as many as 12 years after formation of the c. lateum. In the present sample, the smallest, and presumably the oldest c. albicans in the ovaries of female Diom. 10-60 was only four mm in greatest diameter. Such a small c. albincans indeed is difficult to distinguish from atretic follicles, some of which are seven mm, or larger, in diameter. It is possible that one female (Diom. 10-60) had been impregnated more than five times, and that the oldest c. albicantia had regressed to an unidentifiable state.

Two relatively young females (11 years based on tooth rings) also contained small c. albicantia, one having a five mm scar and the other two six mm scars. One of the six mm scars probably was less than six years old, and if that scar represents a normal pregnancy and parturition, the decrease in size during the first few years is much more pronounced than that experienced in subsequent years.

Those females for which both the ovaries and teeth were collected were aged by the tooth cementum layer method. Although this method is questionable for most females, as is noted later, it appears fairly reliable in the relatively young age classes. Therefore, tooth layers were used to estimate the age of initial breeding.

Only one female for which proper teeth were obtained had recorded a single pregnancy when taken during May 1960, and that individual had given birth only a week or two prior to capture. On the basis of cementum layers, the animal was judged to be five or six years old, fixing the age of initial implantation at four or five years. This single example agrees with Fay's (1955) findings that females become sexually mature at those ages.

Brooks (op. cit.) and later Fay (ibid), reported that walrus cows bear calves every second or third year, with the triennial pattern most common with the older animals. The present data generally substantiate the above views, though the limitations of the age determination methods must be kept in mind.

Assuming that the average age of initial breeding is five years, the eight females whose ages were determined from tooth rings produced a total of 18 calves during 43

years. This gives an average parturition rate of one calf every 2.4 years.

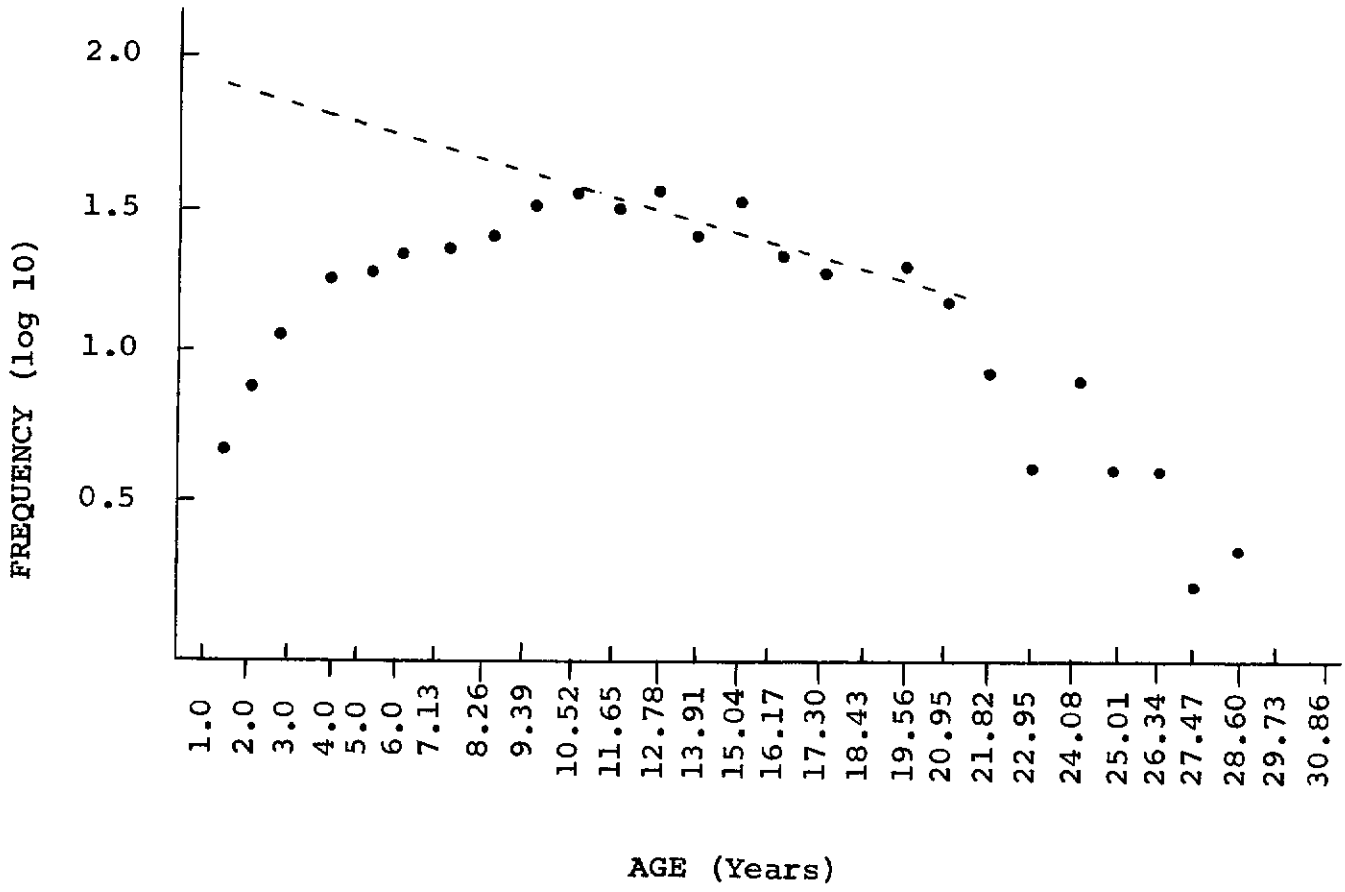
A rough estimate of the reproductive rate can be gained from the present material. Excluding one female which apparently was ovulating when taken, 6 of the 18 females were pregnant. This gives a 33 per cent reproductive rate for the mature female segment of the population.

Relating this reproductive rate to the entire population is more difficult, however, for the exact male:female ratio in the population is unknown. Recent harvest data indicate that males and females are equally represented in the take, and perhaps such a representation is true of the entire population. Due to a lack of more detailed information, I shall assume a 50:50 sex ratio.

Another necessary, but largely unknown, factor in determining the reproductive rate is the ratio of immature to mature animals. Fay (ibid, pp. 144-145) using body morphology and tusk size to determine the ratio of yearlings, two-year-olds and three-year-olds to animals four years or older, visible on selected photographs of large walrus herds, determined that frequency-age class relationships correspond with a projection of the adult survivorship curve based on 1953 harvest samples at Gambell and Savoonga. In essence, the data indicated that the younger age classes were sustaining the same mortality rate as were the older animals. This is surprising, for Fay and others have revealed that human predation accounts for more than three-fourths of the annual mortality, yet the Eskimo hunters, essentially the only human predators of walruses, are very selective for large tusked animals, i.e. the animals older than four or five years. The effect of this selectivity, a lack of young animals in the harvest, is readily apparent in Figure 1.

I have attempted to derive the population structure using the catch curve for males shown in Figure 1. During ages 12.78 and 20.69, an 8.3 per cent mortality rate exists. This rate is less than the computed over-all rate (see Male Mortality) and perhaps is a better approximation of the mortality in the younger age classes than are any of the other rates. Using that figure, I have determined that approximately 30 per cent of the entire population is four years of age or younger.

Figure 1. Age composition, based on tooth cementum layers, of male walruses harvested during spring, 1960. The broken line is a projection of the 8.3 per cent mortality rate derived for age classes 12.78 to 20.69.



A 12 per cent reproductive rate is derived using the above methods and assumptions. This rate is just slightly lower than the rate of 13.3 per cent computed by Brooks (op. cit.) using composition data gathered in the Bering Straits. It seems probable that the true rate is somewhere between 10 and 15 per cent.

The Population

The size and composition of the Pacific walrus population are extremely important facets of the management program, yet these essential data are difficult to obtain. Aerial surveys sponsored by the U. S. Fish and Wildlife Service during 1960 and 1961 should provide better estimates of the population size, but more indirect means are needed to acquire other information such as age composition.

Age composition. Tooth structure has provided excellent ageing materials for certain species of pinnipeds. Work done by Fay (1955) on Pacific walruses and Mansfield (1958) on Atlantic walruses has shown the applicability of the method of this species. During this study, age determination was based on tooth sections.

Tooth preparation. Teeth, mostly the lower canines, were obtained from 886 animals during the 1960 spring hunts at Gambell, Savoonga, King Island, Wales and Little Diomede Island. In order to insure that only one sample of teeth was taken from a given animal, the hunters were requested to collect both lower canines, and an incentive payment of $.50 per tooth was offered to the hunters. At King and Little Diomede Islands, Department personnel collected teeth; generally a lower canine or one of the other large teeth. The largest teeth are preferred, for their cementum layers are more obvious than are those in smaller teeth.

The teeth were sectioned with a four inch circular jeweler's saw rotated by a one-fourth horse power motor. Initially the single teeth were cross-sectioned, with the pairs being sectioned in transverse and longitudinal planes, one tooth receiving one cut and the other tooth the other cut. After inspecting the teeth and comparing results from the two types of sections, the cross sectioning of single teeth was discontinued for certain corrections had to be applied to data from such sections. This is

explained in more detail later. The sectioning in transverse and longitudinal planes was continued for the paired teeth, however, in order to permit comparisons of the two sections.

Generally, no polishing of the sections was needed prior to inspecting them under low magnification with a binocular microscope, using both direct and refracted light. If the roughness of the surfaces masked essential details, the sections were polished with very fine sandpaper.

The number of cementum layers, revealed as dark bands in refracted light and light bands in reflected light, were ascertained for each tooth. In addition, the number of layers bordering the dentine between the tooth crown and the first cementum layer encircling the dentine base were counted in randomly selected teeth. This information was used to determine the number of rings lost through tooth attrition.

All sections received at least two inspections under low magnification, and a few received three or more if discrepancies occurred in the replicate counts. A few sections had to be discarded due to imperfections or abnormalities that masked the layers. The congruity of replicate counts increased greatly as the counter gained experience in tooth inspection, so an initial count was made solely for that purpose.

Tooth inspection results. A few comparisons of cross and longitudinal sections from pairs of lower canines showed that one, or rarely two, cementum layers visible in the longitudinal section, often were missing from a cross section. This is a result of uneven wear on the buccal and lingual edges.

Lower canines from 36 animals, 30 males and 6 females, were inspected to determine the number of cementum bands missed by the cross sections or lost through attrition. The findings are presented in Table 2.

The number of rings missed by the cross sections increases with age. For 7 teeth containing 5-9 rings, the average number missed was 0.3, but for teeth with 10-19 rings it was 1 and for those with more than 20, 1.5.

Table 2. The number of cementum layers lost through attrition or missed by cross sections in 36 pairs of lower canines (30 males and 6 females).

	No. of cementum layers contained in long. section	No. missed by cross section	No. bordering dentine from crown to base	No. lost through tooth wear*
MALES	5	0	5	0
	8	1	6	2
	8	0	8	0
	8	0	8	0
	9	1	6	3
	9	1	8	1
	9	0	9	0
Total for 5-9 group:		2 (average 0.3)		6 (av. 1)
	11	0	7	2
	11	1	7	2
	13	1	6	3
	13	1	7	2
	13	1	8	1
	13	1	6	3
	14	1	7	2
	14	1	7	2
Total for 10-14 group:		7 (av. 1)		16 (av. 2)
	16	1	8	1
	16	1	8	1
	17	1	9	0
	18	1	7	2
	18	1	6	3
	19	1	5	4
Total for 15-19 group:		6 (av. 1)		11 (av. 2)
	21	1	5	4
	21	2	5	4
	23	1	5	4
	24	1	5	4
	26	2	5	4
	27	2	6	3
	27	1	7	2
	30	3	9	0
	30	1	7	2
Total for 20+ group:		14 (av. 1.5)		27 (av. 3)
FEMALES	10	1	7	2
	11	2	6	3
	11	0	7	2
	12	1	7	2
	13	0	8	1
	13	2	7	2
Total for females:		6 (av. 1)		12 (av. 2)

* An average of nine cementum layers are deposited before an unbroken layer encircles the base of the dentine.

This tendency is caused by the tooth growth and wear pattern. The first few cementum layers are more widely spaced than are successive layers, which decreases the possibility of missing a layer in a cross section from a young tooth. Also, as the lower canine grows older, the rate of wear on the buccal and lingual surfaces differs, thus producing a peak on one edge. A cross section, cut so that a complete section results, would go through the base of the peak thus excluding all layers above this base. With exaggerated wear on one surface and virtually no wear on the other edge, the crown of a tooth would slope sharply; a longitudinal section cut through this peak could conceivably include all the layers deposited since the tooth was formed, whereas a cross section might miss two or three layers. A pair of canines listed in Table 2 seemingly portray this situation. The longitudinal section contains 30 bands, including all 9 from the dentine base to crown, but the cross section misses 3 rings, containing only 27.

As noted above, an average of one ring is missed in cross sections of teeth containing 10-19 rings. Therefore, a correction factor of one is added to all the layer counts for those sections containing 10 or more layers, bringing the counts into conformity with the readings from longitudinal sections.

A few cementum layers are completely lost through tooth wear. An inspection of numerous longitudinal sections from lower canines, and measurement and comparison of the linear distance between cementum layers bordering the dentine, indicated that the dentine base usually was completely encircled by the tenth layer deposited in the tooth. Some variation exists, however, for in some teeth the ninth or eleventh layers seemed to be the first complete one, but the average was 10. Therefore, the number of layers lost through attrition can be determined by counting the layers bordering the dentine and subtracting from nine.

The number of cementum rings lost in this manner also increases with age. The average number worn away in teeth containing 5-9 rings is 1, but for teeth containing 10-19 rings it increases to 2, and for those with more than 20 rings, to 3. A correction has been devised as follows: for teeth showing 5-10 rings, a correction factor of 1 is added to the layer counts, and for all teeth containing

more than 10 rings, a correction of 1 plus 0.13 per each ring greater than 10, is applied. Thus a tooth showing 15 cementum rings should have contained 15 + 0.65 + 1.0 = 16.65 layers.

Fay (1955) has shown that two cementum rings are deposited each year during the first few years of a walrus's life, and one each year thereafter, but the exact age at which the deposition rate changes from two to one is questionable. The available evidence indicates the rate changes in the fifth or sixth year, and in the present study I, somewhat arbitrarily, have chosen the sixth year.

The age distribution, for animals six years or older in the 1960 harvest, is shown in the frequency histograms in Figure 2 . Readily apparent is the relative youngness of the female segment of the harvest.

The majority of the female harvest occurred in the 6 to 13 year age group, with only 3 animals, or 1.3 per cent of the female harvest, determined to be older than 21 years and one older than 26. This is surprising in view of the fact that nearly 10 per cent of the harvested males are older than 21 years. Immediately suspect is the ageing method for female walruses.

A check of eight females for whom both the reproductive history and age can be computed from ovarian and tooth sections, respectively, seems to confirm that the ageing techniques are questionable. For some females, such as N0598W, N0725W and N0528W, the tooth ring based age corresponds well with the reproductive history, but with other females, such as N0722W, the determined age and the number of past pregnancies do not agree. In the latter case, the age was determined to be 12 years, yet only two conceptions had occurred, with the last conception at age 11. This female had produced only one calf in a span of five or six years. Either some animals have repeatedly failed to breed, or the ageing technique for females is in error. The latter case seems the more probable.

Fay (1955), using annual tusk growth increments, devised a rough age classification based on tusk lengths. In Figure 3, I have compared the age distributions derived

Figure 2. The age distribution of animals 6 years or older (based on tooth cementum layers) in the 1960 spring harvest.

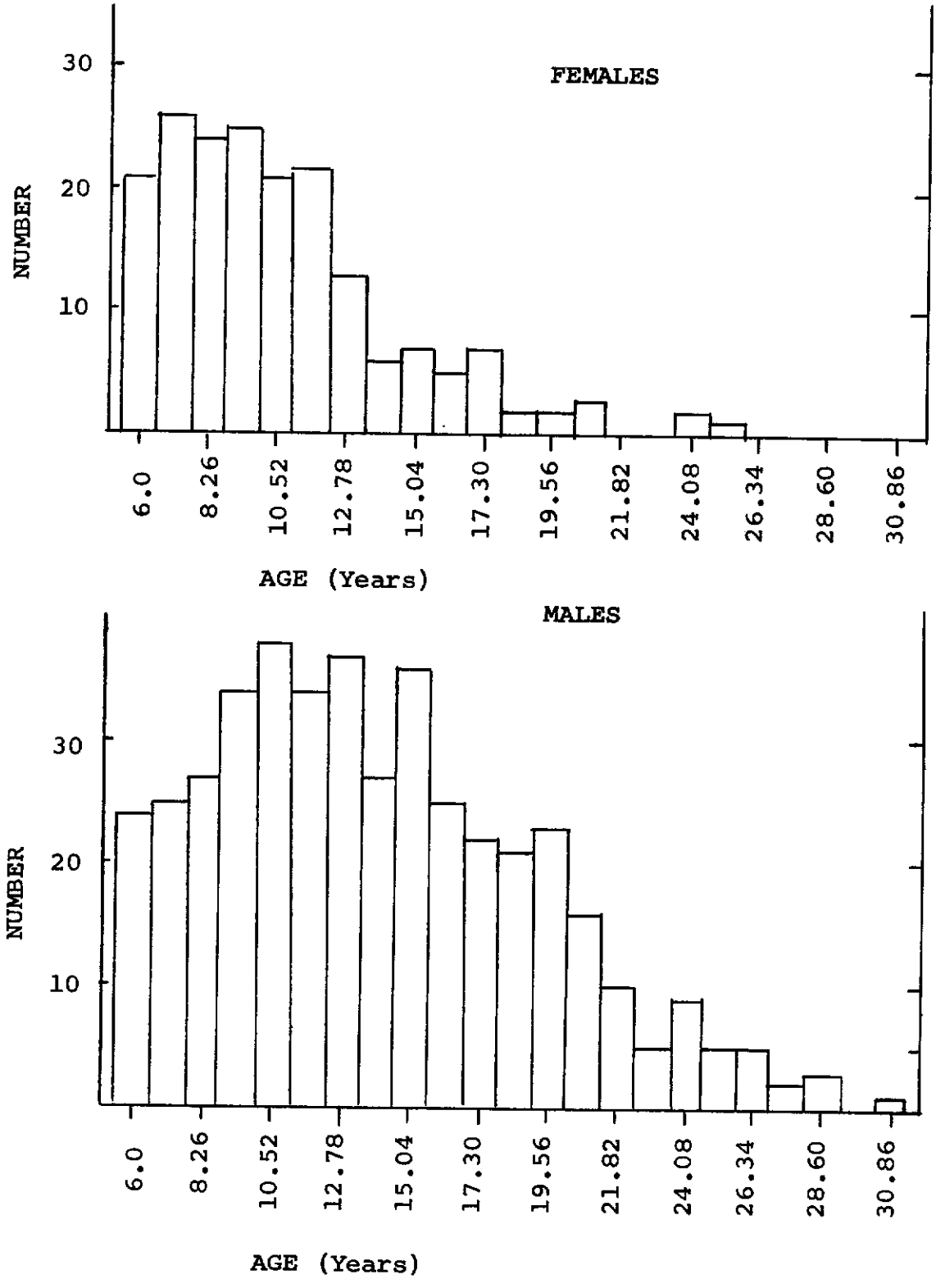
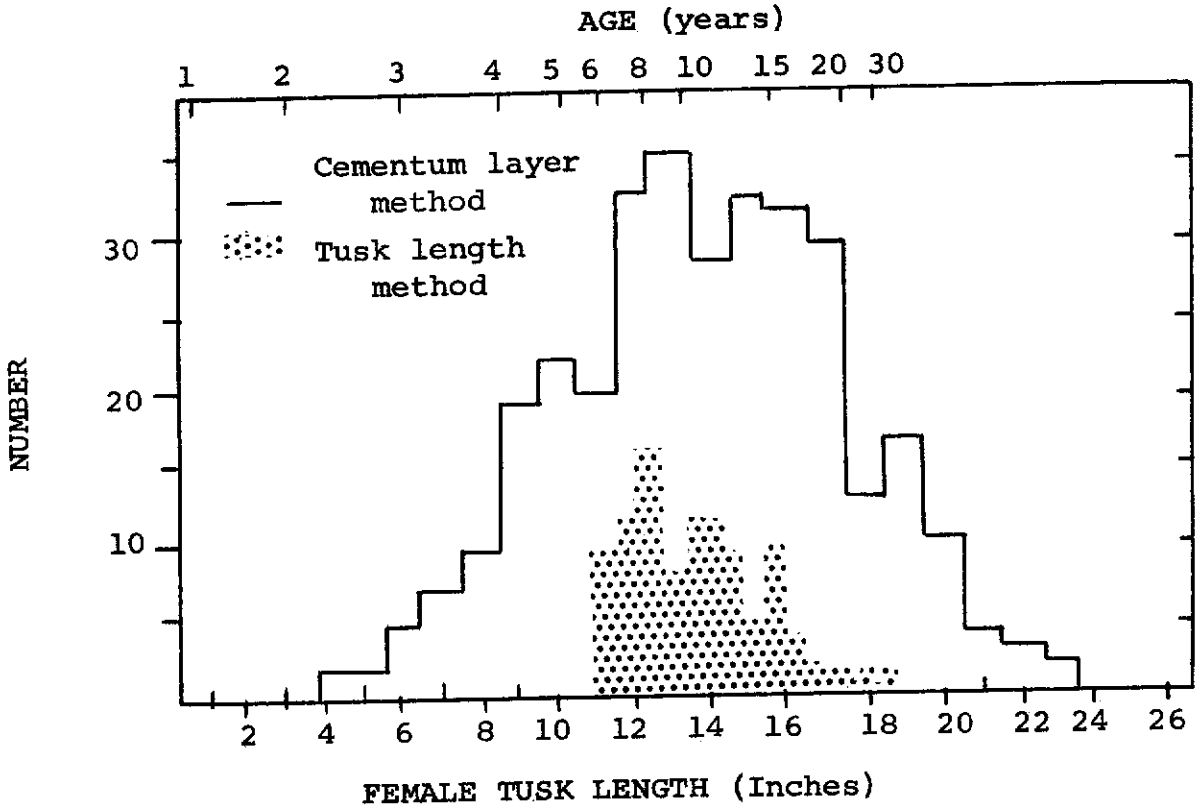
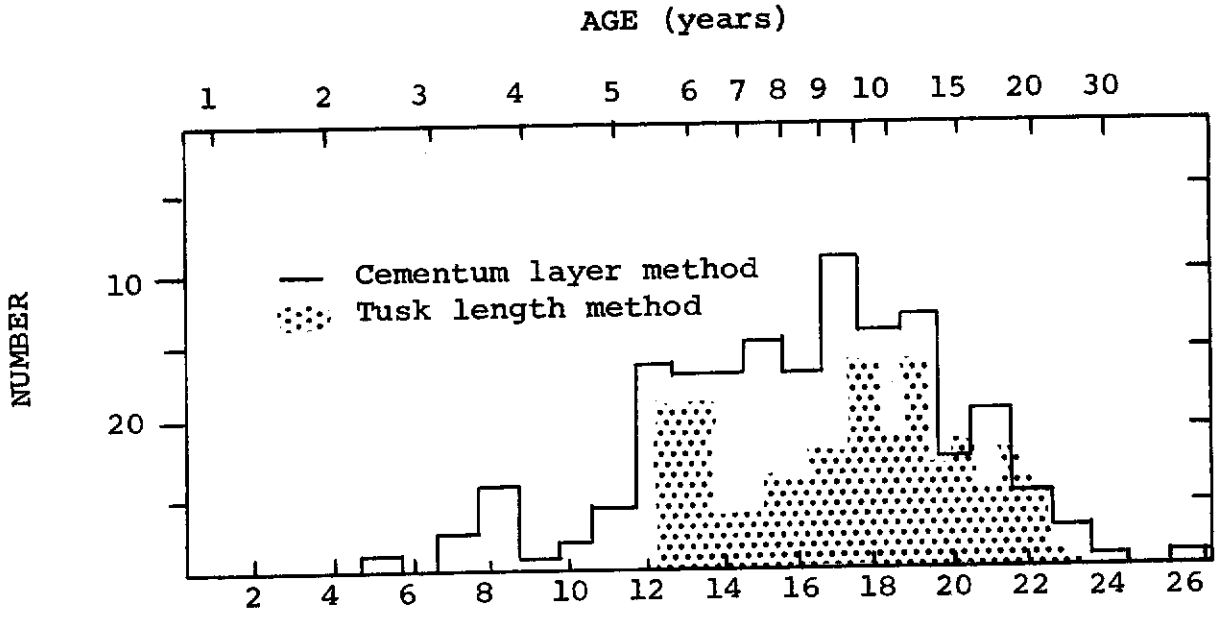


Figure 3. A comparison of the age distributions of the 1960 harvest derived by two methods of ageing, tooth cementum layers and tusk length (after Fay, 1955).*



* The solid line is associated only with the age and frequency scales.



by the two methods, tusk growth increments and cementum layers, for the females harvested at King Island during 1959 and at King Island and Little Diomede Island during 1960, and for the males taken during 1960 at King and Little Diomede Islands.

The two methods of age determination create noticeably different age distributions. With females, the tooth ring method produces a younger population than does the other, but for males the reverse occurs. In both instances, however, the tusk length method produces the maximum-age animals, due probably to loss of tooth rings by attrition.

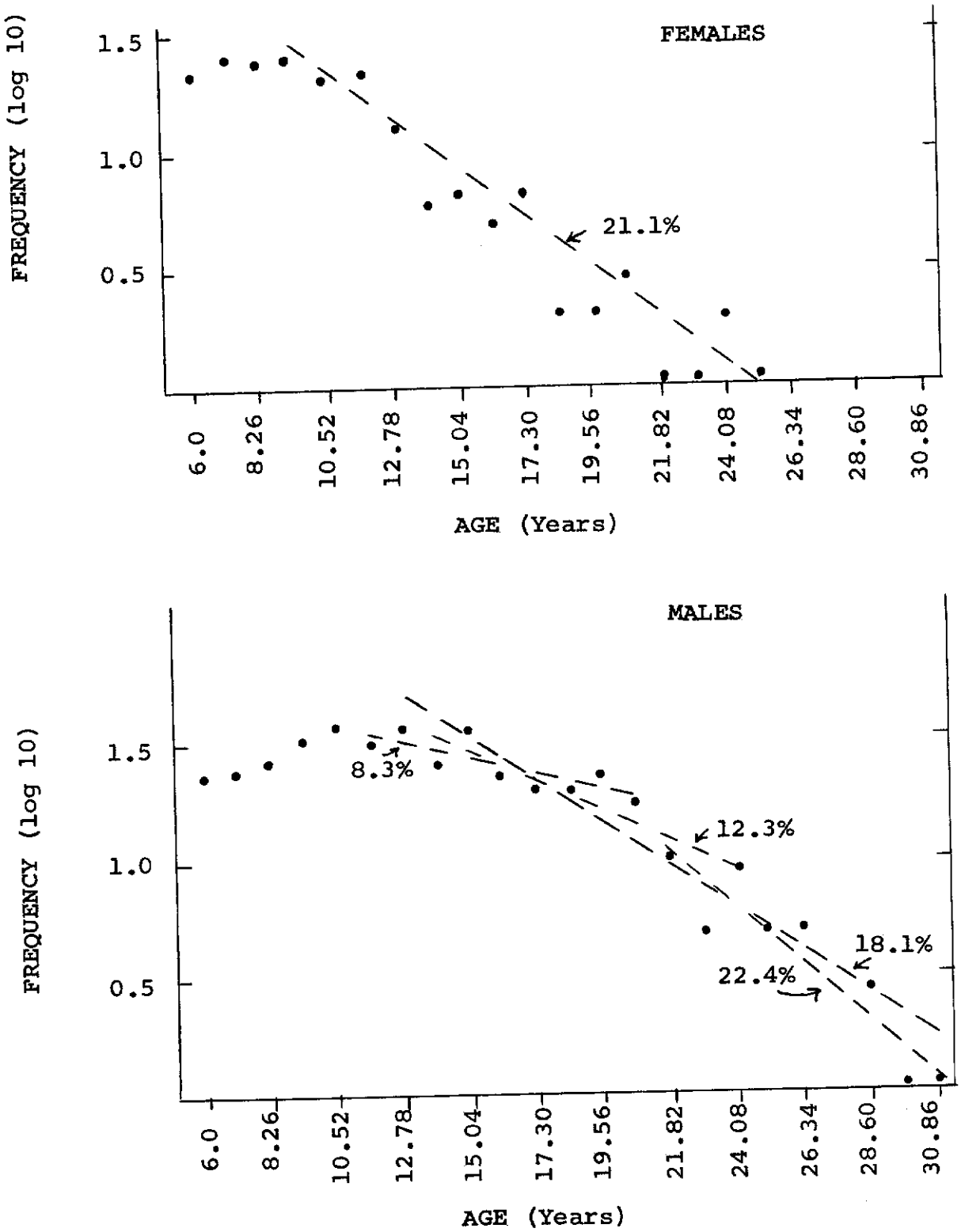
Population welfare. Obtaining total population counts is impossible or impractical with many species, and other methods of determing population welfare is used. One of these is mortality rate. If this rate and the productivity are known, the future of a population can be accurately predicted.

Mortality rate. Ricker (1948) has utilized the catch statistics for certain fish populations as a basis for mortality rate determinations. The data is plotted on an age-frequency basis, with the resultant curve termed a "catch" curve. If the frequency is plotted on a logarithmic scale, the slope of the curve at a given point equals the instantaneous mortality rate for that age class. The instantaneous rate can be used for determining the annual survival rate, or conversely the annual mortality rate.

Ricker's methods were utilized by Fay (1960) in determining the mortality rate of the Pacific walrus population from Gambell harvest data. Fay, initially, computed the rate using 1956 data and then 1957 data, and the results were identical, a 13 per cent mortality rate for each. When he combined the data, however, the mortality rate increased to 15 per cent. With the addition of 1953 data the rate continued to increase to 16 per cent. Clearly, Fay's sample was too small to permit such analysis.

The catch curves for the 1960 male and female harvests are shown in Figure 4. Contrary to Fay's findings based on Gambell data, the descending right limb of the curve is nonlinear. Consequently a number of straight lines were

Figure 4. Catch curves showing derived mortality rates for walruses harvested during spring, 1960.



fitted to segments of this limb by the method of least squares. These lines, which form the basis for the mortality rate estimates, are shown on the curves.

The left limbs of the curves ascend sharply, due to selective hunting methods practiced by the hunters. The young animals, having small tusks, are less prized than are the old, large-tusked animals. Consequently, the younger age classes are taken less frequently in relation to abundance than are the older animals.

Male mortality. The catch curve for male walruses shows a sharply ascending left limb, a relatively broad dome, and a descending right limb. Due to the nonlinear aspect of the right limb, the mortality rate has been determined for the 12.78 to 20.96, 15.04 to 24.08, and 20.69 to 30.86 age class segments, in addition to a composite mortality rate for the entire right limb from age class 12.78 to 30.86.

The mortality rates increases from 8.3 per cent for the 12.78 to 20.69 year-group, to 22.4 per cent for the 20.69 to 30.86 year group. With such pronounced differences in rates, especially since a trend toward increasing rates exists, a derived over-all mortality rate has slight value unless the factors causing the differences can be ascertained.

A total mortality rate that increases with age can result from an increasing recruitment rate, a natural mortality rate that increases with age, inaccurate ageing methods, or selective sampling of the population. The first causal factor, at least to the degree that would cause such marked mortality rate changes, seems improbable in the Pacific walrus population. Rarely does a trend in recruitment continue for a prolonged period and with the walrus population even trends of short duration seem improbable. Variations from year to year undoubtedly do occur, but these would have slight effect on a catch curve. A natural mortality rate that increases with age may occur with this pinniped, but it is unlikely that it would be sufficiently marked to influence the derived mortality rates. The causal agents must be inaccurate ageing or selective sampling.

The age determination method for males appears reasonably accurate. Errors of one or two years per individual might occur but it is improbable that the degree of error would tend to increase or decrease with age. In male teeth the cementum layers are well defined and easily counted and all available evidence points to a one layer per year relationship in all but the young animals.

A bias may have occurred in the tooth collecting program, however, as I departed from Little Diomede Island on June 6, 1960, prior to completion of the spring hunts. Approximately 200 animals were taken subsequent to my departure, but few teeth were collected during my absence. In light of the migration pattern of males, as mentioned later, teeth from old males may have been inadequately sampled. This would contribute to an apparent scarcity of old males.

The hunting methods of the Eskimo hunters perhaps contribute to an age-influenced mortality rate. The hunters are highly selective for large tusked animals, often bypassing those possessing very short or badly broomed ivory. This tendency definitely reduces the number of young, small-tusked animals, and may influence the number of very old animals in the harvest, for as an animal increases in age, the tusk attrition gradually surpasses the annual tusk growth, producing a slight shortening of the tusk. In addition, the frequency of broken tusks probably is a function of age; an older animal undoubtedly has encountered a greater number of tusk-breaking situations than has a younger male.

The migration patterns of walruses also may influence the age composition of the harvest. Old bulls normally are the last northward migrators passing through the Bering Straits area during June. These herds generally are associated with the ice edge, and often occupy small scattered floes surrounded by large ice-free areas. Rough seas during such ice-free conditions effectively curtail the Eskimo's boat activity, and consequently the hunting effort. In addition, these old bulls normally pass King and Little Diomede Islands after earlier hunts have satisfied much of the natives' meat and ivory requirements. This results in greatly reduced hunting incentive during the last part of the migration period.

These conditions do not prevail at one of the most productive harvest sites, Savoonga. Nearly all of Savoonga's harvest consists of males. They are available during the last part of April and May, with large kills often effected. During 1960, approximately 335 males were taken; 260 of these were aged using tooth cementum layers. The catch curve for these animals is shown in Figure 5.

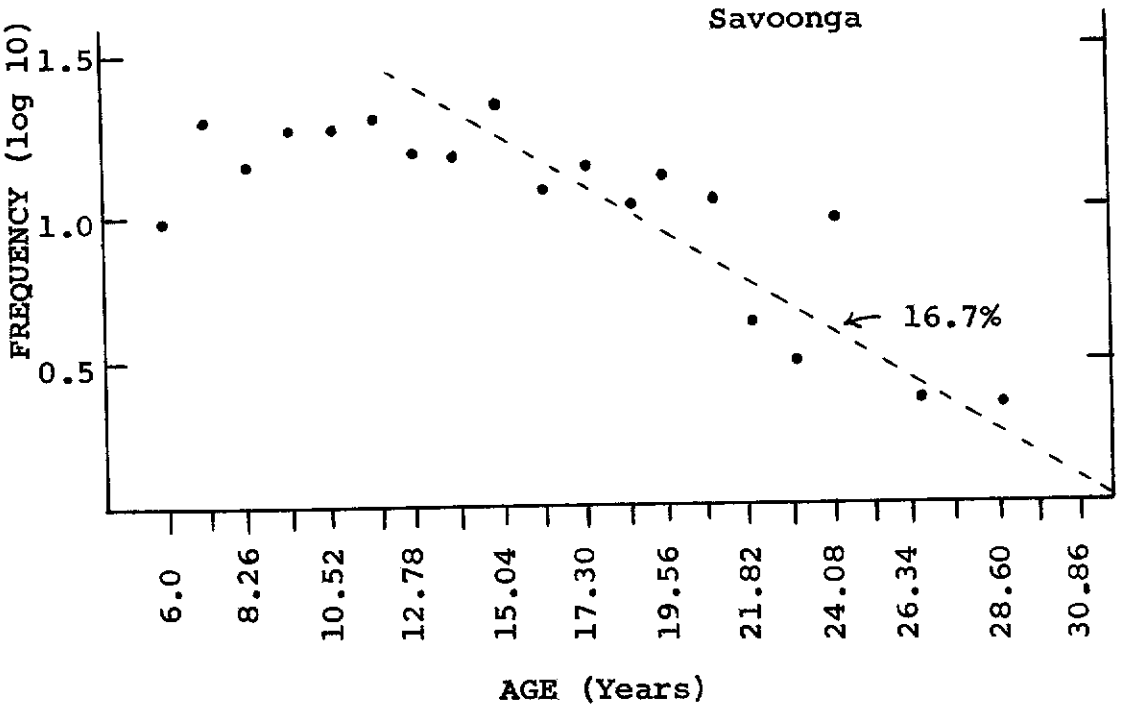
It is interesting to note that 8 per cent of the Savoonga males were older than 22 years, whereas only 4 per cent of the combined Little Diomede, King Island, Gambell and Wales take were past that age. Also, the curve revealed a mortality rate of 16.7 per cent for age groups 12.78 to 30.86. This is slightly less than the rate of 17.2 per cent recorded for the combined data for the other four villages, but substantially less than the 18.1 per cent recorded for all males taken during 1960. Unfortunately, the sample size is insufficient to permit a mortality rate determination for limited age groups.

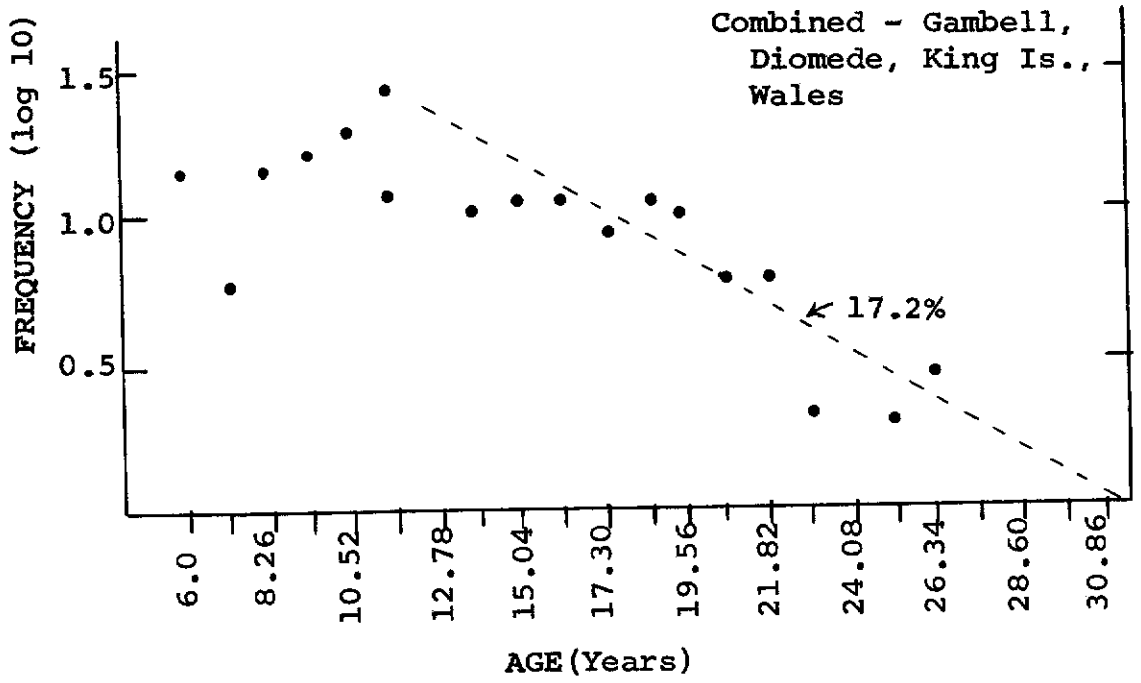
After evaluating the various factors influencing male mortality, I believe that the derived rate for the 12.78 to 24.08 year age-classes is a better approximation of the true situation than are the derived rates for the older age-classes. These mid-age animals apparently are sampled in a more uniform and random manner than are the older animals, thus reducing the error-producing biases. Consequently, I tentatively conclude that the male mortality rate falls somewhere between 12 and 15 per cent.

Female mortality. Teeth for ageing purposes were collected from 225 females taken during spring, 1960. The resultant catch curve shows a 20.3 per cent mortality rate for the 9.39 to 20.69 year age group, and a 21.1 per cent rate for the 9.39 to 25.21 age classes. It is doubtful if these rates actually prevail; inaccurate ageing methods and hunter selectivity perhaps have distorted the data.

As mentioned previously, the ageing methods may be highly inaccurate. Few females are classified in the 20 plus age group, although many males are determined to be older than that age. Also, the reproductive history of some females does not agree with ring count age. Such inaccuracies undoubtedly produce erroneous mortality rates.

Figure 5. Catch curves and derived mortality rates for male walruses, based on the 1960 harvest at Savoonga and the combined takes at Gambell, Little Diomede and King Islands, and Wales.





Hunter selectivity perhaps causes additional errors in the rate picture. Fay (1958) reports that Gambell hunters are highly selective for females with calves; if the assumption is correct that the young adult females are more productive than old females, such selectivity would tend to produce a non-representative abundance of young females in the harvest. Such a bias would create a sharply sloping right limb of the curve, indicating a high mortality rate. Unfortunately, the sample size is not sufficiently large to permit a segregation of the data on a village basis; such a segregation would permit an evaluation of hunter selectivity at the various harvest sites.

It is obvious that little faith can be placed in the derived female mortality rates. Increased accuracy of the age determination methods and an evaluation of sampling biases are essential before we can ascertain the true situation.

Combined mortality rates. Due to the inaccuracies enumerated above, the accuracy of derived rates for combined samples also is questionable; they are listed here for interest only.

The rates range from 18.7 per cent for the 11.65 to 20.69 year age groups, to 22.9 per cent for the 20.69 to 30.86 group; the combined rate (11.65 to 30.86) is 21.5 per cent. Undoubtedly, the derived rates exceed the true rates.

Population size. Brooks (op. cit.) and Fay (1955), in 1954 and 1955, respectively, estimated the Pacific walrus population at 45,000 animals. Subsequent information revealed that these figures were extremely conservative. Later estimates by Fay (1960) using annual kill and mortality rate data, increased the population figure to 70,000 plus animals. Preliminary estimates from the aerial surveys also list the population at approximately 70,000 (Kenyon, viva voca). As an additional contribution, I have derived population figures based on the 1960 mortality rates and the average annual kill.

An average annual kill of approximately 10,500 Pacific walruses is listed by Fay (1958). He based his estimate on

Russian harvest data reported by Krypton (1956) and on known Alaskan takes. More recent information by Geller (1957) on the walrus harvest by Chukotsk Penninsula natives, and recent Alaskan harvest estimates also fix the total kill at approximately 10,000. In the present computations, I used that figure.

The mortality rates I derived for male walruses, i.e 12 to 15 per cent, will serve as the mortality rates for the entire population. This assumption appears reasonable in view of the inaccuracies in the derived female rates, and the fact that recent data (Brooks, 1954; Fay, 1958; and Harbo, 1960) indicate an even sex ratio in the harvest, and presumably equal mortality.

Approximately 70,000 to 90,000 animals is the population estimate using current data. These figures compare favorably with the recent estimate by Fay (1960) and the preliminary estimates from the aerial surveys.

Walrus Islands Herd

On August 19 and 20, 1960, I visited Round Island of the Walrus Islands group in Bristol Bay accompanied by C. Lensink. Delays in procuring a charter vessel from Togiak for transportation to the island, and inclement weather that commenced during the evening of August 20 limited the trip to a two and one-half day excursion; lack of a suitable small skiff also severely hindered the Round Island operation. A very brief visit also was made to Crooked Island during the evening of August 20 and the early morning of August 21.

Location of the herd. All but two of the walruses observed at Round Island were either in the vicinity of, or occupying hauling-out sites on the east side of the island. The individuals not conforming to this pattern were observed during the morning of August 19 hauled out on the west side of the north tip of the island. During the afternoon of the 19th, however, a freshening southwest wind caused a surf on the beach and the two animals entered the water, passed eastward around the island's north point and joined the walruses in the vicinity of the eastern hauling-out site. Judging from the discolorations of the rocks on which the animals

were lying, the two walruses had been occupying this otherwise vacant beach for a period in excess of four or five hours. Probably, the animals had hauled out sometime during the preceeding day.

Numerous animals were observed in the water to the east and southeast of the hauling out areas. Some of these swimming walruses remained within one-half mile of shore, but others were still heading seaward when they disappeared from sight at a distance from shore of approximately two miles. The pattern of submergence and surfacing indicated that the majority of the animals were feeding while at sea.

During the brief stop at Crooked Island, no live walruses were sighted, but a partially decomposed adult carcass was found on a north beach. Interviews with Bristol Bay pilots and fishermen revealed that the only animals sighted during 1960 were in the vicinity of Round Island. Crooked, High, Twin and Hagemeister Islands are sometimes occupied, however.

Size of the herd. During late afternoon of August 20, we circumnavigated the island in an effort to obtain an estimate of the number of walruses present in the vicinity. All of the walruses sighted were occupying hauling-out sites on the east shore; none were seen in the water. In all, 7 groups were sighted, ranging in size from 16 to 500-600 animals. They contained an estimated total of 1,500 to 2,500 animals.

The above estimate should be considered minimal for the Round Island herd, for other uncounted animals were undoubtedly feeding at sea during our passage around the island. For this reason, an accurate estimate of the number of walruses summering in Bristol Bay is difficult to obtain.

RECOMMENDATIONS:

Population Welfare

It is imperative that accurate reproductive and mortality rates be determined for the Pacific walrus population, for these two factors may be the best indices available for determining population welfare.

Reproductive rates. The collection of ovaries and teeth from as many hunter-killed females as possible should be continued. With an adequate sample, these organs will provide an accurate estimate of the reproductive rate of the population.

The reproductive history of the walruses should be used as an aid in evaluating the accuracy of the tooth cementum layer method of age determination. If the method proves reliable, or if other reliable methods are devised, the age specific reproductive rates can be determined.

Mortality rates. Accurate mortality rates for the Pacific walrus population must be determined. Additional teeth should be collected from hunter-killed animals so that the population sample can be analyzed on a village and a selected year-class basis. The significance of the non-linear aspect of the male catch curve must be investigated. In this regard, an adequate harvest sample and an evaluation of hunter selectivity may provide insight into the age-mortality rate relationship.

Age Determination

The accuracy of our present ageing methods, particularly for females, must be ascertained. A large sample of reproductive tracts and teeth should be collected so that a comparison of the reproductive history and the derived age can be effected.

Tagging and Marking

Efforts to tag or mark yearling or two-year-old animals should be intensified, for known age specimens are urgently needed in order to evaluate our ageing methods. Various methods should be attempted and evaluated on the accessible, hauled-out animals on the Walrus Islands. In addition, Eskimo hunters and boat crews should be contracted to supply uninjured, unorphaned subadults for tagging and marking purposes; Little Diomede Island residents perhaps would be able and agreeable to undertake such a task. Sufficient monetary reward is an essential part of such a program.

LITERATURE CITED:

Brooks, J. W.
1954 A contribution to the life history and ecology of the Pacific walrus. Special Report No. 1, Alaska Coop. Wildlife Research Unit. viii + 103 pp.

Fay, F. H.
1955 The Pacific walrus (Odobenus rosmarus divergens): Spatial ecology, life history, and population. PhD. thesis, Univ. British Columbia. 171 pp. (Unpubl.).

———
1958 Pacific walrus investigations on St. Lawrence Island, Alaska. Arctic Health Research Center. 54 pp. (Unpubl.).

———
1960 Investigations of the Pacific walrus. Terminal report, project no. 26, March 1960. The Arctic Institute of North America. 72 pp. (Unpubl.).

Geller, M. Kh.
1954 Conservation of maritime game of Chukot. In Conservation of Natural Resources and the Establishment of Reserves in the U. S. S. R. Academy of Sciences of the U. S. S. R., Moscow. 98 - 107. (Translated from Russian).

Harbo, S. J.
1960 Walrus harvest and utilization. Federal Aid Completion Report, Alaska Dept. Fish and Game. 16 pp. (Unpubl.).

Krypton, C.
1956 The northern sea route and the economy of the Soviet north. New York. Praeger. 219 pp.

Mansfield, A. W.
1958 The biology of the Atlantic walrus Odobenus rosmarus rosmarus (Linnaeus) in the Canadian Arctic. Fisheries Research Board of Canada. xiii + 146 pp.

Ricker, W. E.
1948 Methods of estimating vital statistics of fish populations. Indiana Univ. Publications. Science Series, No. 15. v + 101 pp.

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Volume 2 Report No.J-1b

ANNUAL REPORT OF PROGRESS
INVESTIGATIONS PROJECT
COMPLETION OF 1960-1961 SEGMENT

State: Alaska

Project No: W-6-R-2 Name: Alaska Wildlife Investigations

Work Plan: J Marine Mammal Investigations

Job No: 1-b Title: Walrus Harvest and Utilization

PERIOD COVERED: July 1, 1960 to June 30, 1961

ABSTRACT:

Approximately 4,500 to 4,600 walruses were killed by Alaskan hunters during the spring of 1960, and the fall and winter of 1960-61. Of these, only about 2,300 were retrieved; the remainder either were killed and lost or died as orphaned calves.

The degree of utilization of walrus parts varies greatly. The tusks normally are the only parts receiving complete utilization. At certain sites only five per cent of the meat supply, and only a few of the female skins, are used. Adult male hides, except for an occasional small slab for human or dog food, are never saved.

The potential value of the 1960 harvest is approximately $468,500.

At Gambell and Savoonga the bulk of the spring walrus harvest occurs prior to May 30, but at King and Little Diomede Islands it occurs subsequent to that date. The less-advanced positions on the walrus migration routes of the last two

sites, plus the lack of open water in their vicinities during May, contribute to the lateness of their harvest.

Observations of Russian hunting practices indicate that at certain times only the tusks of walruses are saved.

OBJECTIVES:

To determine the magnitude, utilization, and value of the walrus harvest in Alaska.

TECHNIQUES:

Direct observations by two Department biologists during part of the 1960 walrus harvest at King and Little Diomede Islands, plus interviews with schoolteachers, missionaries, hunters, traders, and other individuals, provided most of the data on the number of walruses taken. A walrus tooth collection program, plus personal observations, previous records and hunter interviews, provided sex composition information. Walrus utilization data were obtained by direct observations and previous reports.

FINDINGS:

The annual harvest of walruses in Alaska waters have been determined by various workers during the last three decades. Perhaps the first reliable estimate was made during the late 1930's by Collins (1939) who computed an annual harvest of approximately 1,300 animals. More recently, Brooks (1954) has estimated an annual harvest of approximately 1,337 animals, and Fay (1955) an annual harvest of 1,200 animals. Harbo (1960) reported a take of 1,150 to 1,400 animals during 1959. These figures are strikingly similar, perhaps indicating that during the last 20 to 25 years the catch has stabilized at approximately 1,300 animals annually. Undoubtedly during certain years the harvest has varied considerably from this average, and on the basis of recent data, 1960 is such a year.

Hunter Kill During 1960

Due to the hunting methods employed in obtaining walruses and the nature of the animals themselves, not all of the animals that are killed are retrieved. Under certain conditions, the number killed and lost can exceed the number secured (Harbo, 1959), which produces a total kill that far

exceeds the apparent kill based on harvest data. In order to emphasize this point, I will consider first the magnitude of the 1960 harvest, and then the total kill.

Harvest during spring, 1960. The accuracy of the harvest figures for the different villages varies, depending largely on the data-gathering methods. Direct observation and tally of the harvest by objective observers furnishes the most accurate counts, but this method is often difficult and impractical to arrange. Frequently, the only recourse is to acquire harvest estimates from the hunters themselves or from other interested villagers, and, judging from personal observations, such estimates often are unduly conservative.

Department biologists, Harbo and Kantner, observed all or part of the 1960 spring walrus hunting activities at Little Diomede and King Islands, respectively, tabulating the walrus harvest as it occurred. The harvest estimates from the St. Lawrence Island villages of Gambell and Savoonga were based on observations made by Dr. F. H. Fay of the U. S. Public Health Service and on data collected through a program for purchasing walrus teeth. At Wales and Nome, Harbo observed part of the harvest and obtained additional harvest data from individual hunters. At Pt. Hope, D. C. Foote, a human geographer with the Atomic Energy Commission, supplied harvest figures based on interviews with each hunter and personal observations. At other sites such as Mekoryuk, Barrow, Wainwright, Shishmaref and Pt. Lay, conversations and correspondence with hunters and traders provided most of the data.

Little Diomede Island. The writer visited Little Diomede Island from May 24 through June 6, 1960. Prior to his arrival and subsequent to his departure, Little Diomede hunters shot additional animals, but by a combination of hunter interviews, analysis of hunting intensity, and a tabulation of tusks sold during the various intervals, an accurate estimate of the total harvest was accomplished.

Approximately 900 adult and subadult walruses were taken by Little Diomede hunters during the spring of 1960. Of 462 known sex animals, 108 (23 per cent) were females and 354 (77 per cent) were males. The relatively small percentage of females in the harvest sharply contrasts with Brook's (op. cit.) observation that the harvest at Little Diomede includes many more females than males. This pronounced change in sex composition undoubtedly resulted from a change in the Alaska

Game Regulations.

A new regulation, effective January 1, 1960, imposed on each resident hunter a limit of seven cows or subadults of either sex, with the no limit provision for male walruses remaining unchanged. The effects of the new regulation were quickly evident on Little Diomede Island, and the hunts on May 30 illustrate this clearly. On that date a strong north wind of two days duration finally abated, and pack ice containing large herds of walruses again appeared from the south. These herds, predominantly females according to hunter reports, congregated at the edge of the pack, and were readily available to the hunters. The high density of the concentration was apparent from the results of a count I made while scanning the pack from a vantage point on the island. Along a three mile section of the pack edge visible from the island, I counted in excess of 4,700 animals; this total does not include the hundreds of swimming animals, nor does it include the herds that passed the islands outside my sector of visibility. From hunter reports, the number of animals east of the three mile sector exceeded the number in the sector. Undoubtedly many more than 5,000 animals were in the vicinity of Little Diomede Island and available to the hunters during the morning of May 30, yet boat crews composed of 7 or 8 hunters returned after 7 to 9 hours of hunting with only 20 to 30 sets of tusks. Considering the availability of the walruses and the efficiency of the hunters, catches of 100 animals per boat could have been expected. A clue to the low catches was provided by the hunters themselves. A few grumblingly remarked that, "having to pass up females makes hunting no good." Apparently much of their hunting time was expended in efforts to locate herds of males among the concentrations of females.

It is doubtful the Little Diomede hunters conscientiously obeyed the regulations during my absence from the island, but a check of approximately 100 tusks purchased from Little Diomede hunters by the Wales Native Store on May 23 revealed that more than 80 per cent of the tusks were from males. Actually, the tusks sold are not a representative sample of the harvest for the heavy male tusks produce greater dividends than do female tusks when sold on a pound basis, and thus the male tusks are first offered for sale. Conversations with Diomede hunters indicated, however, that few females were taken during the first few days of hunting, and that the composition of the sample sold was representative of the take during that period.

Based on the sex ratios of the harvest samples I observed, approximately 200 subadult and adult females and 690 subadult and adult males were taken at Little Diomede during the spring of 1960.

King Island. An accurate tally of the harvest was obtained at King Island by Howard Kantner, a biological aide who resided at the island from April 27 through June 16, 1960. Kantner contacted the hunters as they returned from hunting forays, noting the number of walruses taken and measuring tusks of animals.

A total of 196 adult and subadult walruses and 29 calves were taken by the King Island hunters. Known sex of a portion of the adults and subadults was 142 (75 per cent) females, and 47 (25 per cent) males. Applying these percentages to the total take of adults and subadults produces a harvest of 147 females and 49 males.

Harbo determined that females constituted most of the harvest during 1959, comprising 63 per cent of the take. A preponderance of females in the catch apparently is usual for King Island, due in part to hunter selectivity and perhaps in part to local differences in availability of the two sexes.

Gambell. Dr. F. H. Fay, U. S. Public Health Service, visited Gambell soon after completion of the 1960 spring walrus hunts and estimated a total take of 200 adult and subadult walruses. This figure is one more than the number of sets of lower canines I acquired from Gambell hunters for walrus-ageing purposes. Through correspondence with the individual responsible for collecting the teeth from the hunters I learned that not all of the walrus lower canines were secured by him; a few hunters failed to save or deliver the desired teeth. The number of sets not secured probably was small, however, for the payment of one dollar per set was attractive. Probably no more than 25 sets failed to be delivered. On that basis, the estimated take of adult and subadult walruses is 225.

Information supplied with the sets of lower canines furnished sex composition data. Of the 198 sets containing sex notation, 125 were from females and 73 from males, producing a 60 male : 100 female ratio. This is very similar to the average ratio of 57 male : 100 female recorded by Fay for the 1952-58 harvests. Fay attributed this dis-

proportionate sex ratio to a combination of hunter selectivity and the relative availability to the two sexes.

The harvest information supplied by Fay and by the tooth-buying program did not provide information regarding the number of calves taken by Gambell hunters. Previous investigations by Fay, however, revealed that calves comprise 30 per cent of the total harvest. On that basis, the Gambell hunters took approximately 120 calves, producing an estimated total harvest of 345 animals.

Savoonga. The Savoonga harvest data were derived in a manner similar to that of Gambell : the tooth collection program and material supplied by Fay provided most of the information.

Fay estimated that 300 animals were killed and retrieved by Savoonga hunters during the spring of 1960. This number corresponds favorably with the total of 301 sets of lower canines received from the villagers, but additional information supplied by the Savoonga Native Store manager indicates that not all of the sets were saved. An adjusted total harvest of 350 adult and subadult walruses is estimated.

The sex data furnished with the teeth showed that of 278 sets containing sex notation, 262 (94 per cent) were males. This observation supports Fay's contention that bulls comprise 90 to 95 per cent of an average take. The low incidence of females apparently reflects their scarcity in the vicinity of Savoonga.

Applying the preceeding compositon figures to the estimated harvest produces a computed take of 20 females and 325 males. No information is available concerning the number of calves harvested, but the assumption that one-third of the females had calves that were captured seems valid. On that basis, 7 calves were taken, increasing the total to 352 animals.

Wales. Direct observations of part of the harvest, hunter interviews, a tooth collecting program and a hunter report system aided in determining the number of walruses taken by Wales hunters.

Approximately 50 adult and subadult walruses were taken during the spring of 1960. Of 36 known sex animals, 11

(30 per cent) were females, and 25 (70 per cent) were males. Applying these percentages to the total take gives a computed harvest of 15 females and 35 males.

Ten calves were reported killed by the hunters.

Nome. Based on hunter interviews, an estimated take of 20 adult and subadult walruses occurred at Nome during spring, 1960. Most hunters reported a lack of females in the catch, due primarily to an absence of migrating females in the waters off Nome. The reports indicate that only 5, or 25 per cent, of the take consisted of females.

Point Barrow. Jerry Crow, a protection aide stationed at Pt. Barrow during late winter of 1960-61, contacted hunters and store owners to obtain an estimate of the 1960 walrus harvest. His findings revealed that the crews of 7 large and several small boats took 90 to 95 animals, exclusively males. Such a disproportionate sex composition in the Barrow catch apparently is normal (Brooks, op. cit.)

Wainwright. Harvest estimates for this village were obtained from the Bureau of Indian Affairs Principal Teacher and from the resident missionary. The estimates varied greatly, ranging from 40 to 85 animals, but the two informants were in accord on one aspect: the 1960 harvest was substantially larger than the reported average annual take of 15 to 20 walruses.

The informants indicated that males were more often taken than females, but the exact composition is unknown. In light of the meager information available, I have postulated that females normally comprise only 15 per cent of the adult and subadult kill. If such a condition exists, then 6 to 13 females and 34 to 72 males were taken during 1960.

Point Hope. D. C. Foote, an Atomic Energy Commission investigator, furnished information about the 1960 walrus kill at Pt. Hope. His data show that only two animals were taken during May and June, and only six during fall and winter. This total of 8 animals is substantially less than the total 1959 catch of 32 animals reported by Foote.

Other areas. A few additional sites, such as Mekoyruk, Shishmaref, and Kivalina, also harvest walruses, but their combined annual take probably does not exceed 50 animals.

Harvest during fall and winter, 1960. A few walruses were harvested by Alaskan natives during the fall and winter, but for most villages the take during those seasons is exceedingly small compared to the bountiful spring harvests. Two villages, Gambell and Savoonga, are possible exceptions to this rule.

Gambell. Fay (1958) reports that 80 per cent of the annual harvest of walruses by Gambell hunters occurs during May, but some are obtained in November and December, a few from January through April, and a few in early June. The bulk of the fall, winter and early spring kills are males.

Based on the above kill distribution data and on information obtained from St. Lawrence Island residents and visitors, an estimated take of 30-40 animals, of which 20-30 were males, occurred during fall, 1960, and winter and early spring, 1961.

Savoonga. Apparently large walrus kills are sometimes made during fall and winter at Savoonga. Thayer (1958) visited Savoonga during the spring hunts of 1958 and obtained harvest data for that spring and for the preceeding fall. One Eskimo informant told him that approximately 280 walruses were taken during the fall of 1957, and approximately 30-35 during the winter. Reports from individual hunters largely substantiated the informant's estimates, and Thayer apparently accepted those figures. No comment was made regarding the relative frequency of such large fall and winter kills, but elsewhere in the report Thayer states, "the spring hunt through the month of June accounts for 80 per cent of the year's walrus kill for the Savoonga hunters."

Two reports from Savoonga, one from a Savoonga resident and one from a visitor, fix the 1960-61 fall and winter walrus harvest at approximately 50-75 animals. The sex composition of the kill apparently is similar to that recorded during the spring hunts, and applying those statistics to the above kill figures gives a sex composition of 45-70 males and 5-7 females.

Other areas. The combined fall and winter take at the remaining walrus harvest sites probably does not exceed 50 animals. The King Island and Wales hunters harvest approximately 5 animals at each site, and the Little Diomeders normally acquire 10 to 15 animals. Mekoryuk, Point Lay, Wainwright and a few other villages also report small catches,

and Point Hope reported a take of 6 animals.

A nearly even sex ratio is reported for the King Island, Wales and Point Hope catches. This ratio probably is representative of the entire walrus population, for hunter selectivity is lacking during these hunts. Instead, the hunters are opportunists, taking any available animals.

Assuming an even sex ratio for the entire fall and winter harvest at these sites, a catch of 25 adults and juveniles of each sex is estimated.

Total harvest during 1960. Approximately 2,045 to 2,135 adult and juvenile walruses were harvested in Alaskan waters during the spring of 1960, and the fall and winter of 1960-61 (Table 1). This figure is substantially larger than the computed average annual take of 1,300 animals, or the 1959 harvest of 1,150 to 1,400 walruses. The increase reflects the exceptionally large kill made by Diomede hunters during the spring of 1960.

The sex ratio of the harvest, based on known-sex animals is essentially 140 males : 100 females. If the data for the Wainwright and Barrow harvests were included, the number of males to females undoubtedly would increase for few females are harvested at the two sites.

Total kill during 1960. One feature of an ideal harvest, retrieving all of the killed or wounded animals, is virtually impossible to obtain when harvesting pinnipeds, but the current losses during walrus hunting seem excessive.

Brooks (op. cit.), subsequent to two seasons of field observations at Little Diomede Island, was convinced that, "accidental hunting losses . . . . surpass the harvest as a depressing influence on the walrus population." Kenyon (1958) visited Little Diomede Island during the spring of 1958 and during 10 hunting trips which he accompanied, determined that 53 per cent of the animals killed were lost. A similar condition exists at King Island, for Harbo (1959) determined that the number of walruses killed and lost during the spring of 1959 at least equalled, and probably exceeded, the number killed and retrieved.

The losses perhaps are not quite so large at certain other Alaska villages. Based on extensive observations at

Table 1. A summary of the 1960 walrus harvest and kill in Alaska waters.

Village	WALRUSES RECOVERED: Adults & Juveniles: Unid. to Sex	♂	♀	Calves	Total	Adult & Juv. Killed & Lost	Total Adults & Juv. Killed	Calves Abandoned & Left to Die	Total Kill
Gambell	57-67	73	125	121	376-386	170	425-435	185	610-620
Savoonga	120-145	262	18	7	407-432	275	675-700	12	687-712
King Island	12	47	142	29	230	200	401	150	551
Little Diomede Island	448-453	354	108	35	945-950	910	1,820-1,825	210	2,030-2,035
Wales	19	25	11	10	65	55	110	16	126
Nome	20	--	--	2	22	20	40	2	42
Wainwright	40-85	--	--	3	43-88	60	100-145	5	105-150
Barrow	90-95	--	--	--	90-95	90	180-185	0	180-185
Point Hope	6	1	1	--	8	8	16	4	20
Other Areas	65	--	--	15	80	65	130	30	160
TOTAL	877-967	762	405	222	2,266-2,356	1,853	3,897-3,987	614	4,511-4,601

St. Lawrence Island, Fay (1958) estimates that the losses at Gambell and Savoonga approximate 40 per cent of the total kill. Although this loss figure is smaller than that recorded at Little Diomede and King Islands, it is of sufficient size to greatly influence the total mortality figure.

Another feature of the walrus harvest pattern is the orphaning of calves. At certain harvest sites, many adult females are harvested with no attempt made to capture the calves. Such orphaned calves of the year probably perish for they are still dependent on the mother. In addition, the survival of orphaned yearlings is questionable. Friemann (1940) believes that the "young change over to independent feeding not before two years of age," and Kenyon (op. cit.) concludes that "a calf orphaned at less than two years of age would probably not survive." On the above premises, and the realization that nearly all of the harvested females are adults capable of bearing a calf every two or three years, it seems safe to assume that at least one half of the females had calves unable to sustain themselves as orphans. In computing the mortality of walrus calves, I shall use the 50 per cent mortality figure.

Listed in Table 1 are the kill figures for the 1960 harvest. The total computed kill is 4,500 to 4,600 animals. This figure is much larger than the 1959 kill of approximately 2,730 to 3,600 animals (Harbo, 1960). The increase resulted primarily from the unusually large take that occurred at Little Diomede Island.

Utilization

The patterns of utilization, and often their causal factors, were noted and studied at King Island, Little Diomede Island, Wales and Nome.

Ivory. Ivory continues to be the prime incentive for the hunting of walruses.

The Alaska Department of Fish and Game on January 1, 1960, imposed a law making it illegal to purchase, sell, barter or export raw ivory without a permit. This regulation was designed to decrease the traffic in raw ivory, thus reducing the incentives for making a large walrus kill, with its attendant "head hunting" (saving the tusks only). To date, no appreciable lessening of "head hunting" has resulted from

this regulation, for extensive traffic in raw ivory still occurs between native hunters and carvers. However, a few village native stores and organizations catering to native arts and crafts, normally copious buyers of raw ivory, have evinced a reduced interest in the commodity. If such a trend continues, the value of raw ivory as a trade or cash commodity should decrease, and with it the incentives for such large catches.

The exceptionally large harvest at Little Diomede Island during the spring of 1960 provided a supply of tusks in excess of that needed by the Diomede carvers. Consequently, many of the Diomeders, on their frequent trips to Wales, bartered part of their raw ivory stock, normally the less desirable, heavy, checked male tusks, to the Wales Native Store for groceries, drums of gasoline, ammunition and other goods. During the hunting season the Wales store purchased in excess of 350 tusks, and approximately 200 of these were still on hand during May 1961. Many tusks were also purchased by the Diomede Native Store, with 157 male and 47 female tusks still in stock at the start of the 1961 spring walrus hunting.

The hunters receive for their raw ivory an average price of $2.00 per pound from the curio shops and native stores. On that basis, the 1960 Diomede take of tusks was worth approximately $19,000 in an uncarved state.

Carving the tusks increases the worth of each set. Fay (1958) estimates that the average value of carved ivory from one adult walrus is at least $125. On a carved-ivory basis, the tusks taken at Little Diomede during 1960 were worth $112,500, or more than 4 times greater than the value sold raw.

Kenyon (op. cit.), during the relatively unsuccessful 1958 season at Little Diomede (only 95 adults and subadults taken), observed that, "If the cost of obtaining an adult walrus is roughly $10 to $15 ($6 to $8 each for ammunition and gasoline) it is evident that head hunting is very uneconomic, especially when the ivory is sold in an uncarved state." That observation seems true if the walrus harvest is small, and if a male hide is worth approximately $150 FOB Seattle, but, from a native hunter's point of view, the statement seems less applicable as the harvest size increases, the village meat and skin requirements are met, and the demand for male skins decreases, as occurred during 1960.

For instance, during the period May 28 - June 5, 1960, the Diomede hunters obtained 189 adult and subadult males and 83 females during 870 man hours (124 boat hours) of hunting. These animals apparently were in excess of the amount needed for food, skins or an ivory supply. Assuming an average expenditure of $12 to obtain one walrus, approximately $3,300 was expended to obtain $5,400 worth of uncarved ivory. This produces an attractive return of $2.40 per man hour.

If the sex ratio of the above harvest had been reversed, i.e. 189 females and 83 males, the returns would have been less satisfying, decreasing to only $.70 per man hour. The salient point is this: after the village meat,skins and ivory requirements have been met, it is economically feasible for the natives to save from males only the ivory and then sell it raw, but it is not feasible to do so with females.

Meat. The degree of utilization of walruses as food varies from village to village, and from year to year. A village harvesting only males will utilize them for food, whereas a village harvesting an adequate number of females considers the males unpalatable. Also, a village experiencing a large harvest will be more selective, and more wasteful, than one having a small harvest.

Adult male walruses generally are considered fit only for dog food, although at certain villages they serve as human food; their toughness seriously reduces their palatability. Certain parts such as flippers, hearts and kidneys, receive greater utilization, and at nearly all walrus hunting sites at least some of these parts are consumed. The quantity utilized seems inconsequential in the total food pattern, however.

Females, subadult males and calves are the animals usually taken for food, but only the calves are fully utilized when taken. At times, the utilization rate is extremely low, even of the choice parts. An example is the 1959 spring harvest at King Island. Harbo (1959) determined that only 10 per cent of the meat from 162 females was utilized, with essentially none of the male meat (94 animals) saved. Meat was considered utilized if it was brought to the village by returning hunters. Not all of this meat was used, however, for careless handling, improper storage, and wasteful consumption practices produced additional loss. During 1960, the walrus take at

King Island decreased to 142 females and 47 males, and the rate of utilization of females increased to 24 per cent; again, virtually none of the male meat was used for either human or dog food.

Similar utilization patterns exist at Little Diomede Island. During 1958, Kenyon (op. cit.) recorded 28 per cent utilization of the small harvest of 85 adults and 32 calves, but during the 1960 study, only 5 per cent utilization of 272 adults and 16 calves (the observed segment of the harvest) was recorded. Insofar as meat requirements are concerned, even the relatively small 1958 harvest is excessive.

Considering the copious quantities of walrus meat harvested each year at the coastal villages, large quantities are available for marketing. Isolation, lack of suitable facilities and equipment, and high transportation costs have curtailed the development of this industry, and at present only small quantities are marketed. Two markets at Nome handle walrus meat, acquiring their supplies from local hunters or from Gambell. One of the markets secures its year's supply during the spring hunts, freezing part of the stock for future sale during the winter months when walruses are unavailable to the Nome hunters. The price varies from $.75 to $1.00 per pound. One of the market owners stated he could handle more walrus meat than he does at present if an adequate quantity was available at a "reasonable" price.

Skins. Walrus skins serve a variety of uses in the native community, but the most important single use is for boat coverings. Recently, thick male skins were desired by certain jewelry manufacturers, but the demand is decreasing. This will be considered in detail later. For a list of other uses of skin, see Brooks (op. cit.), Fay (1958) and Kenyon (op. cit.).

Female skins. Many of the coastal natives still use skin covered boats, oomiaks, for their ocean travel. Such boats, each requiring two to five split female skins, are re-covered with new skins every two or three years, which necessitates a harvest of a few skins each year. A few of the Eskimo villages are located in relatively unproductive walrus hunting sites thus requiring additional skins to be obtained from more fortunate villages. The

current local prices for skins in a fleshed and split stage range from $15 to $50 each. These prices are not sufficiently high to create interest in marketing split skins for a great deal of time and effort is required to prepare each skin. Consequently, the few split skins marketed each year go to friends or relatives of the seller. During May,1960, the Little Diomede village council received a telegram from the Shishmaref residents requesting split female skins. Most members of the council reacted unfavorably to the message, with one member stating, "Why don't they (Shishmaref hunters) come out here and get them (female walruses). They got boats to hunt with." It is doubtful that the Shishmaref residents' needs were met. The King Islanders have expressed similar sentiments about selling split hides. Unless faster and easier methods are developed to flesh and split a hide, the number of hides marketed will not increase.

Male skins. A small market for adult male hides of one inch minimum thickness has existed during recent years in the buffing industry. Generally, the supply of suitable hides was neither sufficient nor reliable, forcing many of the consumers to switch to other substitutes. Efforts have been made at a few Alaskan localities to stimulate interest in marketing male hides, but to date only two hides have been shipped from Alaska. This lack of interest is contributing to the repression of this market.

A recent query to Green, Tween and Company of Philadelphia, prominent buyers of walrus hides for buffing purposes, indicates that their present source of supply is sufficient. They are no longer interested in developing an Alaskan source, and as one official commented, only ". . .a limited and declining market exists." Apparently nearly all firms using buffing equipment are switching to other types of buffers, and the market for male hides is now virtually non-existent.

Value of the Walrus Harvest

Determining the potential value of the harvest by assessing the unit value of such items as meat and skins is difficult because supply and demand, as well as market accessibility, greatly influence the price. Thus, a unit price of 10 cents per pound is used in evaluating the meat

supply, even though a small quantity sells for approximately 90 cents per pound in the Nome stores.

A similar situation exists with split female hides. At some villages the hides sell for as much as $50 each, but at other sites the usual price is $20 or $25. The assessed value of $20 per skin used in this study reflects the fact that most skins sell for much less than $50, and that a few cannot be saved due to various reasons.

The value of the 1960 harvest is shown in Table 2. Readily apparent is the fact that walruses are of prime importance to the coastal villagers, for the greatest potential value of the harvest is nearly half a million dollars.

Chronology of the Harvest

The bulk of the annual walrus take in Alaskan waters occurs during the spring and early summer. In many localities walrus hunting is confined to one or two months, but even in localities affording hunting during fall, winter and spring, a one or two month period normally accounts for most of the kill.

The tooth collecting program and direct observations furnished the 1960 kill distribution data for Savoonga, Gambell, King Island and Little Diomede. Data for the 1958 spring hunts at Little Diomede Island and the 1959 spring hunts at King Island are available from Kenyon (op. cit.) and Harbo (1959), respectively, permitting limited comparisons with the 1960 data.

Figures 1, 2 and 3 show the distribution of the harvests at the four villages and clearly illustrate the uneven chronological distribution of the harvest, as well as the differences in the harvest patterns for the three islands. At Gambell and Savoonga the harvest is spread over a greater period of time than is true at the other two islands, with the majority of the 1960 harvest, 97 and 90 per cent for Gambell and Savoonga, respectively, occurring prior to May 30. At Little Diomede and King Islands, only 48 and 28 per cent, respectively, of their harvests occurred prior to that date. The lateness of the King and Little Diomede Islands' harvests accurately reflects the less-advanced positions of the walrus migration routes of these two sites, but another factor, the

Table 2. Value of the 1960 walrus harvest.

Village	Harvest* ♂	♀	Calves	Ivory** Raw	Carved	Realized Income	Bacula*** Potential Value	Realized Income
Gambell	108	152	121	$ 4,100	$ 32,500	$ --	$ 756	$ --
Savoonga	335	79	7	8,800	51,700	--	2,345	--
King Island	51	149	35	2,700	25,000	20,000	357	250
Little Diomede Island	700	212	35	18,900	114,400	70,000	4,900	2,500
Wales	37	17	10	1,000	6,700	6,700	259	--
Nome	15	5	2	300	2,500	2,500	105	100
Wainwright	52	10	3	1,300	7,700	--	364	--
Barrow	92	0	0	2,200	11,500	--	644	--
Point Hope	4	4	--	100	1,000	--	28	--
Other Areas	32	32	15	1,100	8,000	--	224	--
TOTALS	1,426	660	228	$44,100	$261,000		$9,982	

* Sex composition based on observed segment of harvest, previous harvests and from other sources.
** Average set male and female tusks worth $24 and $10, respectively. Carved ivory value based $125 per set tusks.
*** Value based on $7 per bacula.

Table 2 Continued. Value of the 1960 walrus harvest.

Village	Meat* Potential Value	Meat* Realized Value	Skins** Potential Value	Skins** Realized Value	Greatest Potential Value
Gambell	$ 21,100	$ 12,100	$ 3,040	$ 700	$ 57,400
Savoonga	38,300	--	1,580	--	93,900
King Island	14,300	1,900	2,980	660	42,600
Little Diomede Island	83,200	3,500	4,240	650	206,700
Wales	4,800	--	340	--	12,100
Nome	1,800	1,700	100	100	4,500
Wainwright	5,830	--	200	--	14,100
Barrow	9,200	--	0	0	21,300
Point Hope	600	--	80	--	1,700
Other Areas	5,300	--	640	--	14,200
TOTALS	$184,430		$13,200		$468,500

* Value based on 1,000 pounds meat from one male, and 600 pounds one female, at 10 cents per pound. Realized income based on meat actually utilized.

** Assessed value of $20 per female skin; male skins no value.

Figure 1. The chronological distribution of the 1960 spring walrus harvests at Savoonga and Gambell, Alaska.

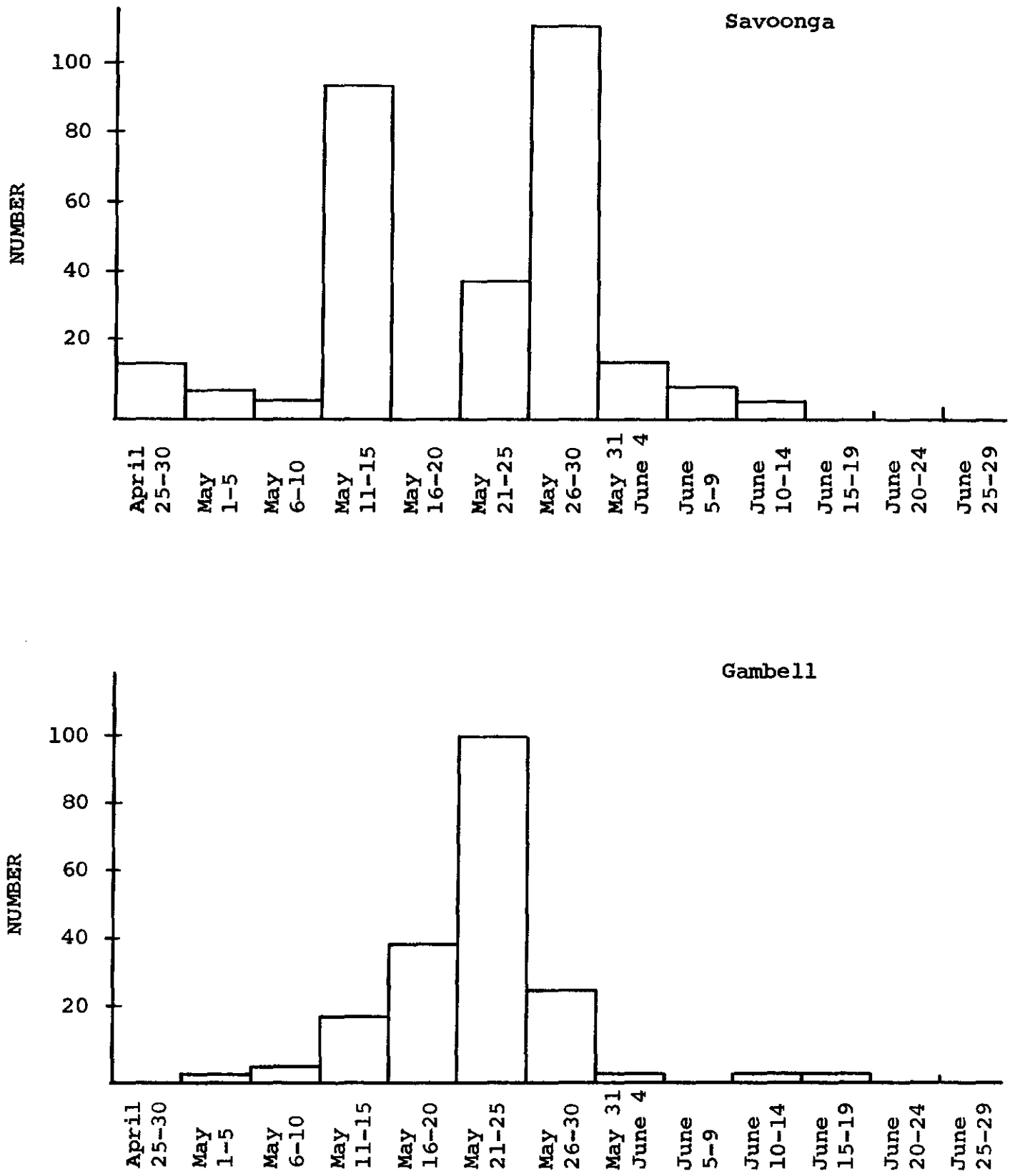


Figure 2. The chronological distribution of the 1958 and 1960 spring walrus harvests at Little Diomede Island, Alaska.

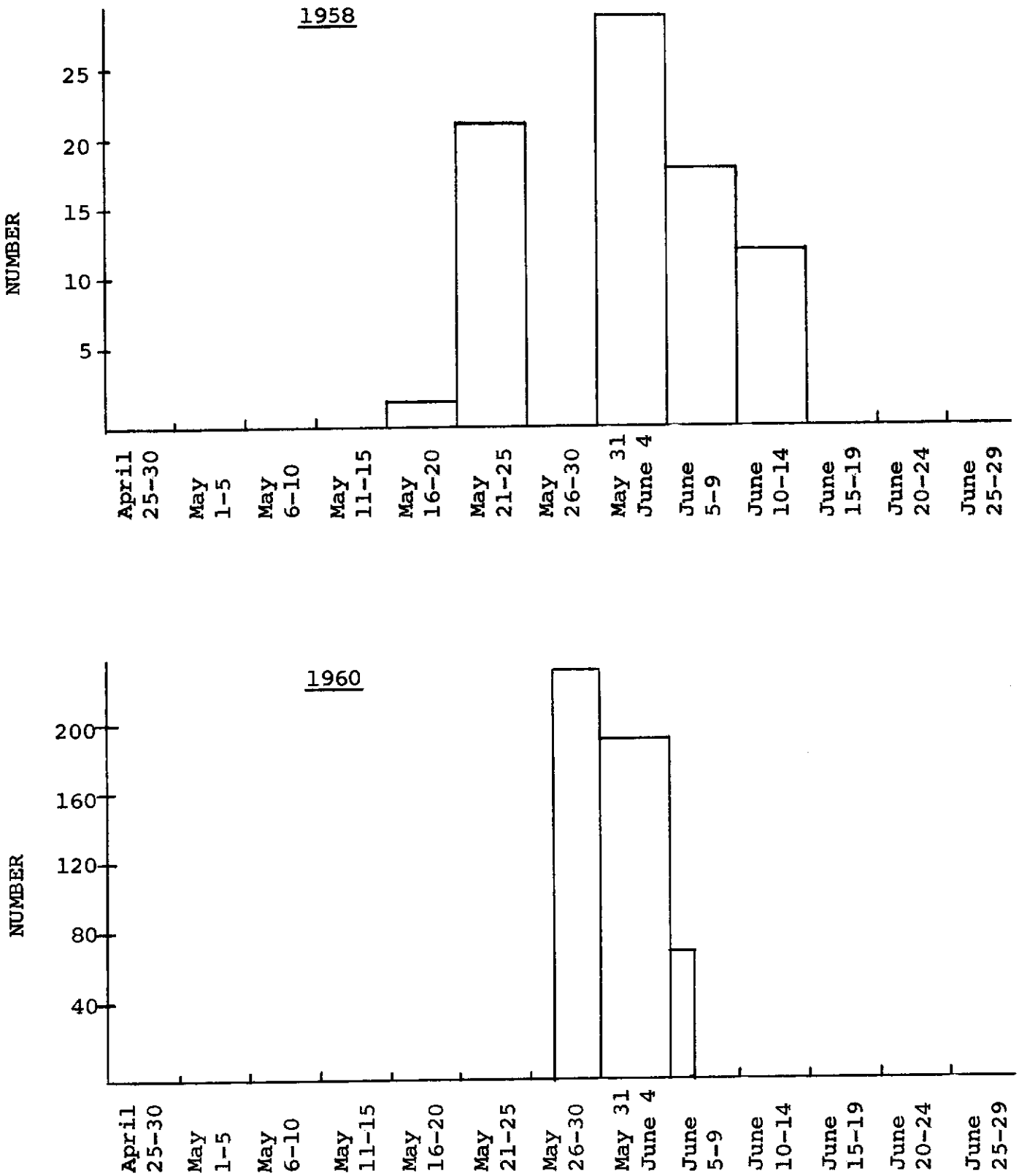
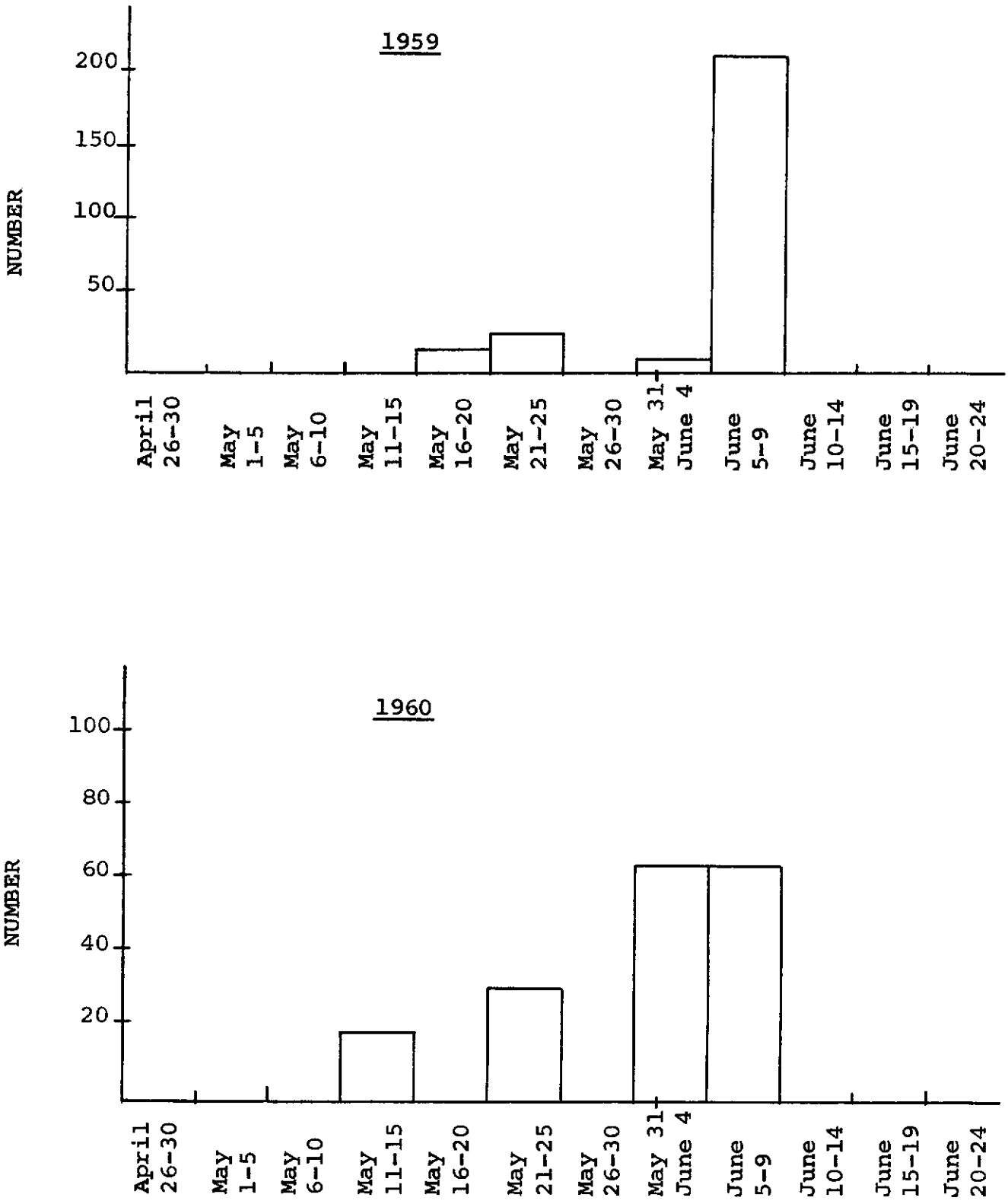


Figure 3. The chronological distribution of the 1959 and 1960 spring walrus harvests at King Island, Alaska.



small amount of ice-free water during May, undoubtedly contributes to the low percentage of early kills.

The effects of an extensive ice cover were evident during the spring of 1959 at King Island. Prior to May 31, only 36 walruses, or 14 per cent of the 1959 harvest, were taken (Figure 3), yet many walruses had been sighted by that date. For example, on May 21, approximately 600 to 1,000 animals, all hauled out on ice floes, were sighted from the island, but a shifting wind drove the ice pack toward the island, curtailing all boat activity. During the short hunting foray before the ice shift, only 21 animals were taken. If the ice mass had not encircled the island, the boats could have continued operating and a much larger walrus kill effected.

Lack of suitable open water also permitted some walrus herds (perhaps 1,000 animals) sighted May 28, and 500 animals sighted May 30, to pass the island unmolested. Information supplied by Kantner indicates that such situations also existed during 1960. It seems logical that such conditions are normal at King Island.

The situation at Little Diomede Island is slightly different than that at King Island, due in part to the winds and strong currents present in the Bering Straits. These two factors cause extensive ice movements in the vicinity of Little Diomede Island, producing numerous open leads and frequently large ice-free areas located either north or south of the islands. These ice-free areas permit fairly frequent, if limited, boat activity in the Diomede area during May. Considering the ice difference at the two sites, the walrus migration pattern in the north Bering Sea may be more accurately reflected in the walrus harvest pattern at Little Diomede Island than in the one at King Island.

Russian Hunting Practices

Fairly recent reports from various sources often credit Russian walrus hunters with exemplary hunting practices. One source (Kleynenberg, 1937) maintains that no swimming walruses are killed, and that the killing of cows with calves is forbidden. The validity of such claims is questionable.

Kenyon (op. cit.), through interviews with Little Diomede natives who have had contact with Russian hunters as late as 1959, reports that the walrus take at East Cape, Siberia, includes all sex and age classes of walruses, as well as

swimming animals. During my stay on Little Diomede Island during 1960, my conversations with the Little Diomeders and my personal observations substantiated Kenyon's statements.

On June 1, 1960, while in Little Diomede village, I heard shooting originating in a spot southwest of Big Diomede Island. From a vantage point near the village I spotted, using a 25 power telescope, three Russian boats in the ice-free waters approximately 6 miles southwest of Big Diomede Island. The boats appeared very similar to the 30-foot, skin-covered boats used by Little Diomede hunters and each boat contained 6 to 8 crew members. The pattern of operation suggested that the hunters were pursuing swimming walruses, and reports from returning Little Diomede hunters indicated that swimming animals were numerous in the vicinity of the Diomedes.

The hunting pattern consisted of short runs with the boat, a brief stop, a series of rifle shots, another short run, a brief stop, additional rifle shots, etc. At times, the routine varied slightly, with only a very short run made subsequent to the halt and series of shots. Often this short period of activity consisted of small circular turns with the boat during which time the crew continued to fire sporadically at something in the water, undoubtedly swimming walruses. Three such maneuvers apparently were successful during the hour I observed the boats, for a boat would be brought alongside a still object in the water, presumably a dead, floating walrus, and a harpoon or other object affixed to it by a man standing in the boat. Usually the boat would heel over at a sharp angle soon after this action, but the men leaning over the side did not appear to pull any large objects over the gunwale and into the boat. The boat and crew remained in such a position for approximately 10 minutes. At the conclusion of this period the hunters resumed their normal positions in the boat and the craft proceeded underway. In at least one instance the boat proceeded at a speed comparable to that made on previous runs indicating that no large object was being towed by the vessel. These three points, 1) the hunters killed and retrieved a large animal, undoubtedly a walrus, 2) no large objects or series of objects were loaded into the boat, and 3) the craft proceeded at a speed comparable to that made previously, force the conclusion that perhaps the Russian hunters were engaged in "head hunting" of walruses.

RECOMMENDATIONS:

Harvest Data Collections

The number of Pacific walruses harvested and killed in Alaskan waters should be determined annually. In addition, efforts should be made to acquire from Russian sources the size of the annual kill in Russian waters.

Accurate sex composition of the annual kill should be obtained from all harvest sites.

Loss Through Wounding, Sinking or Orphaning

Additional information is needed to determine accurately the frequency of occurrence of animals sinking, escaping mortally wounded, or perishing after being orphaned. This segment of the total kill is extremely important for it may surpass in size the more easily observed part of the kill, the harvest.

Trophy Hunting

The hunting of walruses for trophy purposes should be encouraged and publicized by the Department, for wiser utilization and better management of our walrus stocks would result. In many instances the absence of sport hunting pressure reflects not a lack of interest by sportsmen, but rather the sportsman's lack of knowledge about walruses, and the methods and attractions of walrus hunting.

LITERATURE CITED:

Brooks, J. W.
1954 A contribution to the life history and ecology of the Pacific walrus. Spec. Report No. 1, Alaska Coop. Wildl. Res. Unit, 103 pp.

Collins, G.
1939 Report on Pacific walrus (Odobenus divergens). Unpubl. MS 11 pp. (Copy on file U. S. Fish and Wildlife Service, Juneau),

Fay, F. H.
1955 The Pacific walrus (Odobenus rosmarus divergens): spatial ecology, life history, and population. PhD thesis, Univ. Brit. Col., 171 pp., (Unpubl.).

_____
1958 Pacific walrus investigations on St. Lawrence Island, Alaska. Arctic Health Research Center, U. S. Public Health Service. 54 pp. (Unpubl.).

Harbo, S. J.
1959 A study of the walrus and the King Island economy. Alaska Department Fish and Game. 47 pp. (Unpubl.).

_____
1960 Walrus harvest and utilization. Fed. Aid Comp. Report. Alaska Department Fish and Game. 16 pp. (Unpubl.).

Kenyon, K. W.
1958 Walrus studies Little Diomede Island, Alaska. Bureau of Sport Fisheries and Wildlife, Bureau of Wildlife Res. 112 pp. iii. (Unpubl.).

Kleynenberg, S.
1957 On preserving the walrus. Priroda, 7:101-103.

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Volume 2 Report No. J-2

ANNUAL REPORT OF PROGRESS
INVESTIGATIONS PROJECT
COMPLETION OF 1960-1961 SEGMENT

State: Alaska

Project No: W-6-R-2 Name: Alaska Wildlife Investigations

Work Plan: J Marine Mammal Investigations

Job No: 2 Title: Seals, Magnitude and Characteristics of Harvest

PERIOD COVERED: August 1, 1960 to June 30, 1961

ABSTRACT:

Harvest data and specimens were collected whenever feasible during the year. However, the analysis has been delayed until a sufficient quantity has accumulated to warrant detailed processing and interpretation.

OBJECTIVES:

To determine the magnitude, characteristics, and value of the harvest of various species of hair seals in Alaska; and to determine seasonal movements, abundance, food habits and other life history characteristics of seals.

PROCEDURES:

Data concerning the magnitude, characteristics and value of the seal harvest in Northwestern Alaska were collected as time and opportunities permitted. Specimens and measurements derived from hunter-harvested carcasses were collected in conjunction with walrus investigations.

FINDINGS:

The information pertaining to the harvest and biology of seals was collected whenever possible, although no particular field expedition was conducted solely for this project. Rather, most seal data were obtained in conjunction with walrus investigations.

Sufficient data have not been obtained to warrant detailed processing and analysis; those phases should be completed after more information has accumulated.

The data are on file in the Nome office of the Alaska Department of Fish and Game.

RECOMMENDATIONS:

The collection of information pertaining to the seals of Northwestern Alaska should continue; the data should be analyzed when a sufficient amount has been collected.

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