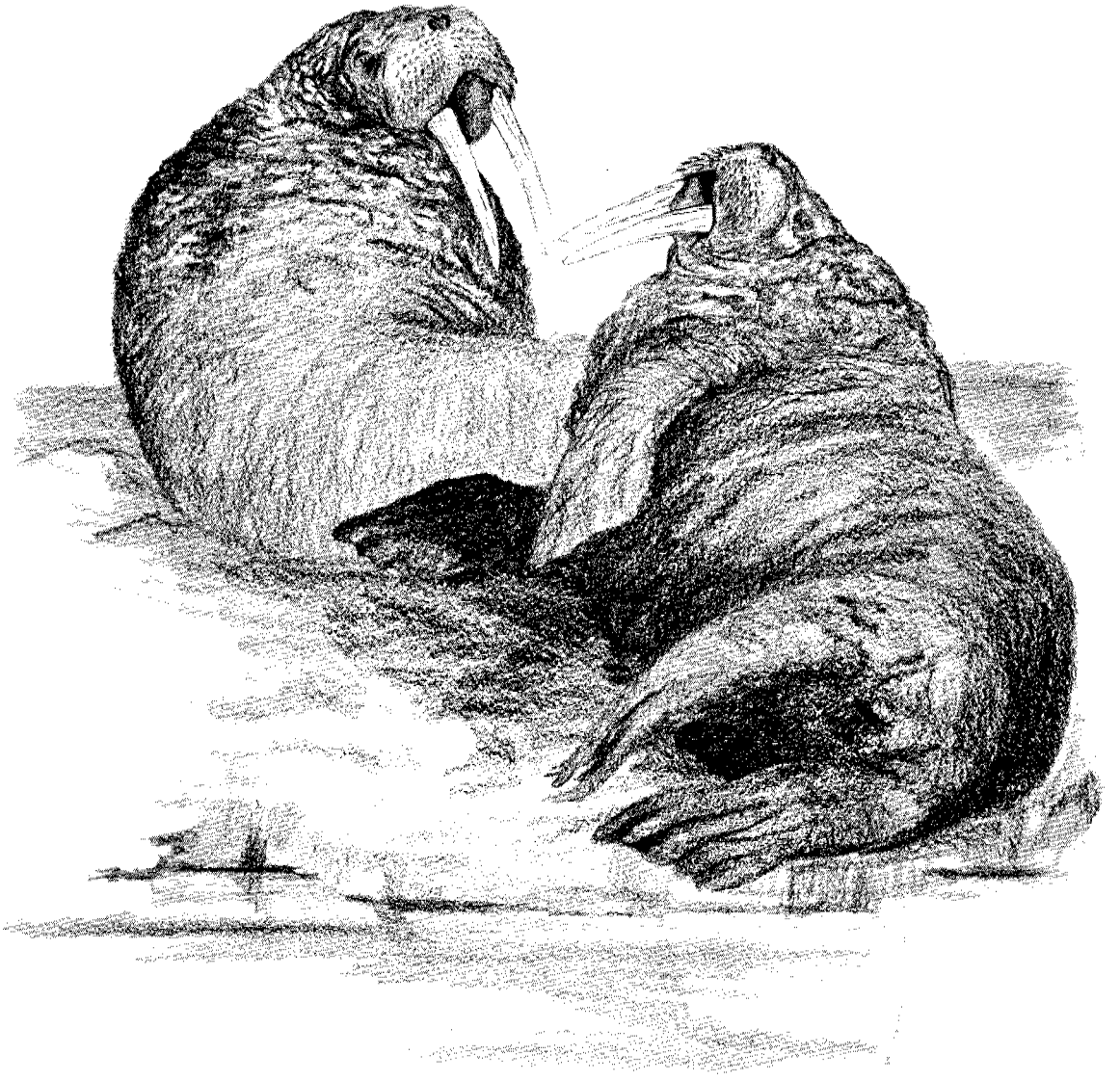
THE WALRUS

IN ALASKA



ITS ECOLOGY AND MANAGEMENT

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by

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ABSTRACT

Prior to the advent of American whaling in the western Arctic, there were at least 200,000 Pacific walrus. As the result of exploitation the herds declined steadily, reaching their smallest numbers apparently around 1930. Since that time they have been slowly recovering.

Female walrus begin breeding as early as age four, but some females do not breed until age ten. Approximately 80 per cent of the mature females produce calves every other year, 15 per cent every third year and the remainder less frequently. The number of cows that calve two years in succession is insignificant.

In the herd as a whole, adult females produce a calf every 2.3 years, resulting in a recruitment rate of about 14.0 per cent. Average annual mortality in the male segment of the herd (and probably in the herd as a whole) is presently computed at about 13.0 per cent. The net annual increase is therefore calculated at approximately one per cent.

Soviet and American hunters kill an estimated 11,700 walrus per year, from a total population estimated at no less that 90,000 animals.

A continued increase in the walrus population can be brought about by adopting conservative hunting practices, which would decrease the number of animals killed without affecting the number harvested. About one-half of the total annual kill is not being retrieved under present hunting practices.

INTRODUCTION

The Pacific walrus is of considerable value to the economy of certain Eskimo villages in western and northwestern Alaska. These animals fill two vital roles: they supply food and articles used for hunting, and a commodity of cash value--ivory.

Although walrus have always been important to the Eskimos they have also been actively hunted by white men, particularly during the last half of the 19th century. The early exploitation by American whalers and subsequent decline of the Pacific walrus was documented by Fay (1957). He estimated that during the period 1650 to 1860, the herds numbered no less than 200,000 animals. According to Clark (1884), American whaling vessels turned to walrus hunting during the decade between 1860 and 1870. From 1870 to 1880 the Arctic whaling fleet was estimated to have taken 100,000 animals. As pointed out by Fay (loc. cit.), heavy exploitation resulted in drastic decline of the herds, and they probably reached their smallest numbers between 1930 and 1950.

The actual size of the Pacific walrus population during the early 1950's is not known, but it has been estimated as something near 45,000 animals (Brooks, 1954; Fay, 1955, 1957). Recent information concerning the rate of increase indicates that these estimates may have been too low.

There has apparently been a slow increase in the population of Pacific walrus, although they have not reached half of their reported former abundance.

The situation at present seems to be one of fair walrus abundance with a rate of exploitation near or equal to the rate of increase. The prime objective of these investigations has been to uncover facts on which to base a management program which will insure the future availability of this resource.

This report is not intended as an all inclusive documentation of the biology of the Pacific walrus, nor as an extensive treatment of the socio-economic problems involved in the utilization of walrus by the people that hunt them. Rather, it is meant as a report consolidating recent findings with previous contributions to the knowledge of this important animal. In some cases, findings of previous investigators were found to be subject to doubt.

Much is already known about the life history of walruses. Methods of determining age (within limits), and the reproductive history of individual animals have already been developed. The most pressing needs have been to obtain data on the rates of reproduction, the extent of exploitation, and the present status of the walrus herds.

The Pacific Walrus

Considering both the Atlantic form (Odobenus rosmarus rosmarus) and the Pacific form (O. r. divergens), walruses have a circumpolar distribution. They are usually found in close association with ice. However, segments of the population will remain in ice-free areas.

Several minor differences are apparent between the subspecies. The description and illustrations by Allen (1880, pp. 156-171) show the tusks of O. r. divergens to be longer, thicker and more incurved (actually less divergent) than in O. r. rosmarus. Bobrinskoi (1944, p. 167) found that skull width at the level of the canines is 60 to 64 per cent of the width between the mastoid processes in the Atlantic form, while in the Pacific form it is 64.5 to 89 per cent. Pedersen (1962) pointed out several differences which he recognized from photographs. These are the greater vertical depth of the upper lip in the Pacific walrus, and the fact that the nostrils are raised to the upper side of the head while in the Atlantic walrus they lie on the anterior side of the head.

The walrus has been grotesquely described by early writers, many of whom had seen only the tusks brought back by seamen or polar wanderers. Pedersen (1951) depicts some of these earlier descriptions.

Walruses are among the largest of pinnipeds, exceeded in size only by the elephant seals (genus Mirounga). They are generally seal-like in appearence, with flexible hind limbs and a thick heavy neck. The most striking features are the two prominent tusks which are modified upper canine teeth. Functions of the tusks are still matters of speculation. However, walruses do use their tusks during quarrels with each other, when attacking other animals or objects such as a boat, to pull their body up and forward on land and ice (hence the generic name Odobenus which means "tooth walker") in shepherding calves, and reportedly to dig clams and other items of food from the ocean floor.

They grow to 12 feet in length, and the heaviest recorded weight, that of an adult male killed during late July, 1958, was 3,432 pounds (Kenyon, 1958). Undoubtedly, large animals in winter condition (with a thick blubber layer) are considerably heavier. The skin of older animals, particularly bulls, is very thick with a sparse covering of hair. Depending upon the circumstances (in water, hauled out in sunlight, etc.) the color of bulls varies from reddish brown to pink. Cows are usually brown. Calves when first born appear silver grey, but rapidly become dark brown. Mature males have many tubercles especially about the neck, and these are considered secondary sex characteristics.

Although ungainly and slow on land or ice, they are fast and maneuverable swimmers, and can dive to considerable depths.

Age determinations, based on the number of cementum layers observed in sectioned lower canine teeth (a more detailed discussion follows) indicate that some walrus live to be at least 33 years old. Others are probably older, but loss of cementum rings through tooth wear, in the older animals, does not permit accurate age determination.

Importance to the Area

The Pacific walrus is hunted by inhabitants of both western Alaska and eastern Siberia. Hunting occurs whenever the animals are available. In Alaska, the period of greatest availability is April through June at the villages of Mekoryuk, Gambell, Savoonga, Northeast Cape, King Island and Little Diomede Island, and July and August at Wainwright and Point Barrow. The harvest by Siberian hunters is reportedly larger than the Alaskan take (see Krypton, 1956). Recent papers (Popov, 1960; Krylov, 1962) indicate that the Soviet hunting is probably a more organized activity, in some cases being conducted from "hunting schooners". At hunting points in Siberia, walrus are available in greater numbers, to more hunters, for a longer period of time, than at most Alaskan hunting points.

In the past, walrus were important because they supplied many if not almost all of the material needs of certain groups of the Eskimo and Chukchi people. Walrus meat was used as food; the skin for covering dwellings, large skin boats (umiaks), kayaks, and for making rope. The bone and ivory were used in the manufacture of hunting implements; intestine, for the manufacture of translucent window coverings and rain gear. There were countless uses for the various other parts of the walrus.

With the shift toward a more westernized culture, many of the former uses of walrus products no longer exist. Alaskan Eskimos no longer live in skin covered houses. They now use fuel oil (exceptions are Diomede and King Islands), gas lamps, rubber rain gear, metal harpoons, rifles and other "modern" articles.

However, walrus still retain their importance as a source of food, and the hides are still used to cover boats and for making rope. There has also been renewed interest in the commercial sale of the walrus hides which are used in abrasive wheels. The sale of carved ivory has become an important source of income, especially since the beginning of World War II. The fact that ivory had a cash value was one of the causes for the harvest by the whalers. At King and Little Diomede Islands the walrus are still hunted primarily for their ivory.

The role of walrus in the Eskimo economy dictates that their future availability be insured. This is effectively pointed out by Rogers (1963) in his statement that:

> The Native Alaskans of aboriginal stock are increasing at a steadily expanding rate, [sic] the 1960 crude rate of natural increase (excess of birth over deaths was 38.4, a rate which is only approached in certain Latin American nations.

The importance of walrus in the modern Eskimo community is apparent on St. Lawrence Island. Although a construction job is the most sought after type of employment, most men working during the hunting season make every attempt to secure an adequate supply of walrus meat. Unemployed young men are encouraged to hunt. Meat is the sole incentive of the hunt, as few of the hunters on this island carve ivory. At this location raw ivory has little value, and is a commodity of which there is a surplus.

In many instances the traditional prowess of the walrus hunter is a thing of the past. The present day hunter is equipped with a high powered rifle which he often used indiscriminately. Hunters often fail to use harpoons, or in many cases do not even have them. As a result, where unretrieved losses of dead and mortally wounded animals were negligible during the early days, they have been as high as 65 per cent in recent years (Burns, 1963).

Previous Contributions to Knowledge of Walruses

Walruses are mentioned in a large number of publications. Their appearance, locations where encountered, and numbers taken, are chronicled in the numerous journals of Arctic whalers, sealers, explorers and adventurers. Some of these records have provided an indication of former abundance and distribution.

As is the case with most easily exploited natural resources, concern over the future of both Atlantic and Pacific stocks of walrus was not expressed until exploitation has resulted in a major population decline. A decline in the population of Pacific walrus was evident by 1880, and was indicated in the writings of Allen (1880), Clark (1884), Murdoch (1885), and Nelson (1918). The decline was attributed solely to over exploitation by whalers.

Some of the early writings concerning physical characteristics of the walrus include the works of Murie (1871) and Allen (1880).

During the first two decades of the 20th century most of the writings concerning the walrus continued to describe the population decline, their absence from areas where they were formally found, and the need for measures to conserve these animals. Such were the writings of Osgood (1904), Bernard (1925), Bailey and Hendee (1926), Nechiporenko (1927), and Carver (1929).

Soviet biologists took the lead in initiating basic biological and ecological investigations, starting in the 1930's. Notable contributions to our knowledge of walruses include: "The walrus of the Kara Sea," by Chapsky (1936); "On the migrations and ecology of reproduction of the Pacific walrus (Odobaenus rosmarus divergens Illiger)," by Belopolsky (1939); "Contributions to the biology of the Chukchi walrus," by Freimann (1940); "Chukchi walrus," by Nikulin (1941); and a paper dealing with reproduction in pinnipeds of the Far East (Sleptsov, 1943).

More recent studies have been reported on by the following writers: Brooks (1954); Fay (1955, 1957, 1960); Loughrey (1955); Mansfield (1958, 1959); Popov (1960); Harbo (1961); Krylov (1962); and Burns (1963).

In addition to the literature referred to above, there are several other papers dealing with the walrus.

Current Opinions Concerning Walrus as a Utilizable Resource

There are at present, two widely held concepts concerning the utilization or exploitation of natural resources. These can be broadly classed as (1) utilization to the maximum limit; and (2) utilization on a sustained yield basis with provision for successful propagation.

With non-renewable resources, unlimited exploitation is usually the only practical course of action. Maximum utilization, as long as it is economically feasible, is probably a nonescapable reality whether it be prolonged over a period of time, or involves extensive, concerted activity. Examples of this type of exploitation are evident in the mining and oil industries.

Renewable resources are subject to the effects of both concepts of utilization. Unfortunately, many interests engaged in their exploitation advocate unlimited harvesting, especially if an income is realized. This philosophy is very much in evidence and the extirpation or extinction of animals such as the Steller sea cow, Philippi fur seal, Carribbean monk seal, sea otter, blue whale, and many others has not made a very great impression. This is certainly the view (either conscious or subconscious) held by some of todays's Antarctic whalers, and North Atlantic seal hunters. As Fay (1957) pointed out, near extinction of the Pacific walrus during the late 1800's might have resulted, "...had the nucleus of its population not escaped the onslaught by seclusion in remote ice fields."

Both concepts of exploitation are held by the walrus hunters of the present day, and it is interesting to examine the reasons underlying the two views.

In general, the more conservative hunters are those from the larger villages where the procurement of adequate quantities of meat is often a problem. In these villages, meat is the primary objective of the hunt and ivory is of secondary importance. Hunting walrus for meat can limit the kill, as when the boats are filled (few skin boats can carry more than six walrus) they must return to the village. The hunters are aware of the importance of walrus as exemplified by the self imposed bag limits at Gambell and Savoonga. There two villages have a human population of over 950 persons, and total dog population of approximately 1,300 animals. The two Village Councils have established a daily bag limit of

four walrus per boat. The inhabitants of these villages, and the other large villages where walrus are an important food item, are fully aware of the consequences that would result from a major decrease in the walrus population.

Unlimited exploitation is advocated primarily by hunters from King Island and Little Diomede Island. These are both small villages. The human population at King Island during recent years has been around 35 persons, and at Little Diomede Island, between 85 and 90. Walrus pass these two villages in large numbers, and occasionally big harvests are obtained. For instance, during the 1960 spring hunting season approximately 900 walrus were taken by Diomede hunters. Since the meat requirements of these villages are relatively small, utilization of the animals killed is slight. At these villages, obtaining ivory is the main object of the hunt. Ivory is a major source of income and the more ivory that is obtained. the greater the income. Head-hunting (hunting walrus solely for their ivory) presents problems when the animals that are taken are females. It decreases the number of reproducing animals in the population, and also results in the orphaning of young walrus, many or all of which perish as the result of starvation.

Utilization of walrus as a source of income is justifiable if it does not affect the walrus population to the point that it is decreased and thus less available in other hunting areas. Effort have been made to shift the hunting pressure from the reproductively active females, to the bulls. This has been accomplished by the establishment of a limit on females (see section on Harvest Characteristics).

As can be seen from the above discussion, hunters entertaining both ideas concerning utilization are presently trying to decide the fate of the Pacific walrus. It appears rather obvious that utilization for food, animal products, and income, on a sustained yield basis offers the greatest benefits.

Objectives of the Present Investigations

The ultimate objective of the walrus investigations presently being conducted, is to determine the means for realization of maximum benefits for present and future generations of people that

depend upon them. To attain this goal some basic facts concerning the walrus must be uncovered. We must know how long a walrus lives; at what age it begins to produce young; how often young are produced; the rate of increase (or decrease) for the population as a whole; the survival success of maturing animals; and the total size of the population. We must recognize the factors supressing population growth, and answer many questions such as: What proportion of males and females should be maintained to insure normal rates of reproduction? How important is natural mortality? How many animals are killed by hunters each year? What level of exploitation can the walrus herds sustain without being reduced? These and many other questions must be answered in order to gain an accurate understanding of the life history of the walrus, and recognize the points of greatest vulnerability.

The distribution and habits of the walrus are such that answers to the above questions must be found by indirect methods. In the present study, as well as those conducted by Brooks (1954) and Fay (1955, 1960), the age of walrus is determined on the basis of the number of cementum layers observed in cross sections of the lower canine teeth. From 1959 to 1962, tusk measurements and lower canine teeth of female walrus from which reproductive tracts and supporting data had been secured, were collected. Previous investigations, particularly the one reported by Fay (1960) supplied information on the age at which males become sexually mature, and the period of breeding activity. Reproductive history of individual females was ascertained through examination of reproductive tracts particularly ovaries. Correlated with age data this provided information on ages at which initial breeding occurred the period between births, and the crude rate of increase. Annual observation at the villages where the largest numbers of walrus are taken, and correspondence and personal interview, provided information on the magnitude of harvests in Alaska. Survival and mortality were estimated from the abundance of successive age-groups according to the methods outlined by Ricker (1948, 1958).

Observations of migration and recognizable behavior traits were recorded as opportunity arose. Partially successful attempts have been made to observe hauled out walrus on the Punuk Islands, during the southward fall migration. Other data of purely scientific interest were obtained and will continue to be obtained whenever the opportunity arises.

FINDINGS

In the following discussion of research findings, the reader should keep several points in mind. It should be remembered that most of the material collected for this study has been gathered during the spring hunting seasons, from March through June. Also, as far as possible, we have tried to recognize and take into account the many sources of bias inherent in this research project. Some of the sources of bias are: differences in the availability of walrus to hunters, differential sampling resulting from hunter selectivity, and segregation of the various components of the herd during migrations. Segregation of males and females during the spring migration has been pointed out by Brooks (1954), and Fay (1955). There is also a difference in the migratory patterns of females accompanied by calves and those without calves. In general, the cows accompanied by calves form the larger herds which are observed, and pass north further from the Alaskan mainland than do the pregnant and barren cows. Disproportionate sampling of this segment of the population results in high estimates of natality and mortality.

Reproduction

Previous investigators concerned with reproduction of the walrus have arrived at several different conclusions regarding age at sexual maturity, and the frequency of calving. The varying opinions are the result of differences in the methods used to determine age of walruses and reproductive condition of the cows (pregnant, parturient or barren). For the most part, Soviet investigators have used zoological (body) length, measured from the tip of the nose to the tip of the tail along the curvature of the body, to determine age. Thus, Popov (1960) states that females 250 cm. in length are mostly two year olds, those 260 cm. long are three years olds, and 270 cm. in length are four years old. During the present study body length was found to be an inaccurate indicator of age because of (1) individual and seasonal variation in the condition of animals; (2) the problems involved in measuring large, heavy animals, killed in various positions and; (3) individual variation in length between animals of the same age. In view of the sources of error, I feel that a difference in length of only 10 cm. is probably not a satisfactory criterion by which close age groups can be separated.

Tusk length as discussed by Freimann(1940), Brooks (1954) and Fay (1955) is a better indication of age, but beyond a few years of life individual variation in growth and wear results in inaccuracies.

For the purposes of the present study, the most satisfactory and practical means of determining age was by examination of tooth sections for cementum rings. For more detailed discussions of the processes of dentine and cementum deposition in pinnipeds see Laws (1953), Carrick and Ingham (1962), Brooks (1954), and Fay (1955).

Age of Sexual Maturity in Males

The annual reproductive cycle in male walrus has been extensively studied by Fay (1955, 1960). He concludes that seasonal activity of testes, based on differences in the stage of development and histological examination, indicates that male walrus begin to attain sexual maturity (sexual maturity being indicated by breeding activity) at five years of age, and most become mature between six and eight years of age. Krylov (1962), citing Freiman (1940) also states that males reach maturity at five or six years of age.

With regard to mating habits, I concur with the conclusions of Nikulin (1941), and Brooks (1954) that the walrus are polygamous and more specifically polygynous.

Age of Sexual Maturity in Females

There are many different opinions regarding the age of sexual maturity in females. Popov (1960) is of the opinion that a small percentage of the females begin breeding in their second year of life. Some investigators feel that walrus begin breeding as three year olds (Freiman, 1940; Nikulin, 1941; Krylov, 1962), and others claim that four or five years is the age of first breeding activity (Fay, 1955; Chapsky, 1936; Belopolsky, 1939; Brooks, 1954).

Information gathered during the present study supports the view that a few females begin breeding during their fourth year of life. However, the picture is more complex as some females do not breed until much older. The age of sexual maturity varies greatly between individual animals.

Table 1 is a summary of the ages of first ovulation in 33 female walrus between 3 and 11 years of age. Those animals showing evidence of only one pregnancy are included. Animals which have recently given birth (ovaries contain a large corpus leteum of lactation) mated during the previous year. As an example, if the ovaries of a nine year old animal show only a large corpus luteum

of lactation, it was initially bred as an eight year old. Unfortuantely, the sample obtained during this study contains no four year old cows. However, the work of Fay (1955), and information based on inferences made from the present sample indicate that in some cases breeding activity commences at age four.

Ovaries of three year old animals contained many small follicles, none approaching maturity. Of the remaining 29 animals between 5 and 11 years of age (see Table 1), five initially bred at age five, eight at age six, seven at age seven, ten at age eight, and two at age ten.

Table 2 summarizes the reproductive history of 22 animals between 5 and 8 years of age. Of the 14 female walrus which were in their seventh year of life, three were pregnant for the first time, six were pregnant during the preceeding year (bred at age six), and five showed evidence of two pregnancies. The occurrence of two pregnancies in the latter age group can result in three ways: (1) animals were bred during the fourth and sixth years of life; (2) animals bred during the fifth and seventh years of life; (3) due to the loss of the first calf, or to unusually early calving, animals became pregnant two years in succession. Interpretation of size and condition of corpora lutea and corpora albicantia indicate that two of the animals did breed at four and six years (both were accompanied by a new calf); two were bred at five, bore calves as six years olds, and were again pregnant; and one bred as a five year old and again as a six year old (she was accompanied by a new calf, and the corpus albicans approached the corpus luteum in size). Unfortunately, the fate of the first calf was unknown.

As can be seen by the above information, female walruses begin to mature as four years olds, but some individuals do not begin breeding until in their tenth year of life (and probably later). Most cows mature between their fifth and eighth years of life. Another pinniped, the ringed seal (Pusa hispida), approaches maturity in the fifth to eighth year (McLaren, 1958).

Rates of Reproduction

Investigations conducted by Freimann (1940), Brooks (1954), and Fay (1955) showed that cows most commonly bear calves every other year, or once in three years. Older animals calve less frequently. The views of these investigators are substantiated by the present data. It is interesting to note that the two most recent papers on walrus, those of Popov (1960) and Krylov (1962)

Table 1. Age of first pregnancy in 33 walrus between 3 and 11 years of age. Animals showing a corpus luteum of lactation were pregnant during the preceeding year*

Age Group	N.	First Corpus Luteum of Pregnancy	First Corpus Luteum of Lactation
Third year.....	4	0	0
Fourth year....	0	...	...
Fifth year.....	2	2	0
Sixth year.....	2	2	0
Seventh year...	9	3	6
Eighth year....	6	2	4
Ninth year.....	8	0	8
Tenth year.....	2	2	0
TOTAL.....	33	11	18

* Single pregnancy is based on the presence of only a single corpus luteum of pregnancy or of lactation.

Table 2. Reproductive History of 22 female walrus between 5 and 8 years of age.

Age Group	N.	Animals with First C.L. of Pregnancy	Animals with First C.L. of Lactation	Animals with Two Pregnancies
Fifth year	2	2	0	0
Sixth year	6*	2	3	0
Seventh year	14	3	6	5

* One 6 year old animal had not ovulated.

present some rather startling and irreconcilable views.

Both Popov and Krylov made assumptions and employed techniques that are subject to doubt. They, as well as earlier Soviet investigators are of the opinion that the breeding season occurs mainly between April and June. Nikulin (1940) states that mating occurs after calving, in April. Popov (1960) implies that walruses mate primarily during the latter part of April and during the first half of May.

On the basis of changes in testicular development, Fay (1955, 1960) concludes that the breeding season extends from December through May, with the peak of activity during February and March.

Popov (1960) further assumes that parturition is closely followed by copulation. This situation actually occurs very seldom as the peak period of calving is in April and early May--subsequent to the main breeding season. Also, follicular development is apparently inhibited during the period when the corpus luteum is active, and after parturition most cows are unable to conceive as they have produced no ova. In certain instances (as will be seen later) if a calf is produced during the early part of the breeding period, the cow can occasionally become pregnant during the same year.

Both Popov (1960) and Krylov (1962) apparently obtained their information on rates of reproduction through observation in the field. Their methods consisted of observing cows with or without calves, examining mammary tissue for evidence of lactation (it can be expected that most lactating cows are supporting a calf), and by examination of uteri for recognizable embryos or fetuses. Apparently ovaries were not sectioned and examined for corpora lutea or corpora albicantia.

In most instances I was unable to determine whether a female walrus was pregnant by field examination during May and June. During this period the blastocyst is still not implanted, and can be recovered only through careful procedure. The only indication of pregnancy is the presence of a corpus luteum in one of the ovaries.

The occurrence of delayed implantation in the walrus is evidenced by the facts that although proliferating corpora lutea of pregnancy are present, implanted embryos are not found until after the middle of June. Also, there is a time lapse between the breeding period and the occurrence of implanted embryos. Combined data of Brooks (1954), Fay (1955), and I indicate that in most instances implantation occurs between mid-June and mid-July. In individual animals this period may be protracted.

Apparently the Soviet investigators do not acknowledge the occurrence of delayed implantation in walrus (nor in the ringed seal where its occurrence is proven: see McLaren, 1958, p. 42). As a result, their findings are questionable. In several instances, I examined walrus during early June, which showed no visible signs of pregnancy and were not lactating. The ovaries of some of these animals contained corpora lutea of pregnancy. Although these animals were pregnant, they would have been classified by Krylov and Popov as barren. Many of Krylov's specimens were collected before implantation occured and may have been erroneously classed as barren. He classified 75 (43.3 per cent) of 173 sexually mature females as barren. During the period of delayed implantation the only satisfactory method of determining pregnancy is by critical examination of the ovaries.

Fedoseev (1962) using results published by Mansfield (1959) states that the annual increment in the Pacific walrus is about 8 per cent. My data indicates an annual increment of approximately 14 per cent.

Of 410 reproductive tracts collected since 1961, data from 303 were used in the present study. Of these, 72 were from animals of unknown age, and 231 were from animals for which age has been determined by examination of tooth sections. Also included is information from 19 reproductive tracts upon which Harbo (1961) based his conclusions.

Table 3 is a summary of the number of indicated pregnancies of 237 females, five years old or older. The relationship of the number of pregnancies to age is subject to the variables of differences at the age of first pregnancy, and individual variation with respect to duration between pregnancies. The present data substantiate the findings of Brooks (1954) and Fay (1955), indicating that cows most commonly bear calves every other year or once in three years. Occasionally cows bear calves two years in succession as established in the following discussion.

During hunting operations, the identification of cows with calves becomes almost impossible, particularly if the herds are large and contain many calves. We could be sure of positive identification of cows with new calves only when small groups of animals were involved. Field observation indicated that 61 cows were positively indentified as being accompanied by calves, and 17 cows were not with calves.

Table 3. Age composition and number of pregnancies observed in 227 walrus taken in the Bering Strait area during the springs of 1961, 1962 and 1963.

Age	N	Total Number of Pregnancies	Pregnancies for the age class
5	2	2	1.00
6	6	5	.83
7	15	22	1.47
8	20	38	1.90
9	32	70	2.19
10	15	40	2.67
11	16	49	3.06
12	23	65	2.83
13	26	87	3.35
14	12	44	3.67
15	22	92	4.18
16	7	37	5.28
17	9	50	5.55
18	7	39	5.57
19	5	31	6.20
20	3	19	6.33
21	1	3	3.00
22	3	24	8.00
23	1	4	4.00
24	-	-	- -
25	1	7	7.00
26	-	-	- -
27	-	-	- -
28	1	3	3.00
TOTAL	227	731	

Of the 61 cows with calves, one (1.6 per cent) was also pregnant. The calf which accompanied the pregnant cow, although much smaller than a yearling calf, was larger than calves born in April and May. It was probably born in January or early February, during the early part of the breeding period. Ovaries of this cow (D-26-63) contained two corpora lutea (one of pregnancy and one of lactation). There was also a large corpus albicans, 19 be 15 mm. This reproductively active cow was a nine year old animal.

Of the 17 cows not accompanied by calves, 13 were pregnant and 4 were barren. At present we have no evidence of cows bearing calves during three successive years.

Examination of ovaries of the 61 cows accompanied by calves showed that with the exception of the one pregnant animal, the others were not capable of becoming pregnant. Follicular development was depressed to the point that only small, undeveloped follicles were present in the ovaries. During pregnancy hormone secretion by the placenta, and possibly the corpus luteum (the importance of which decreases as the placenta assumes a more active role), apparently inhibits development of Graafian follicles. After parturition (normally subsequent to the breeding season) when these centers for the secretion of hormones important in maintaining pregnancy are no longer present, the maturation of follicles can proceed. This does not occur until the breeding season following parturition, when many cows are again capable of becoming pregnant.

The lactation period in walruses is reported to be about 18 months (Popov, 1960). My information, as well as that of Brooks (1954), indicates that it occassionally lasts as long as two years. In some animals such as cattle and primates (including man), estrous cycles tend to be supressed during lactation. However, in most pinnipeds this does not seem to be the case. Walrus commonly become pregmant the year following parturition, although they are still supporting a nursing calf.

Observations by Soviet biologists, of cows with more than one calf (see Krylov, 1962) may have been influenced by the large proportion of cows accompanied by calves during the spring migration. The concentrations of migrating females accompanied by calves leave the observer with the false impression that many cows must calve annually to produce the high calf:cow ratio observed.

During the spring of 1962, the main northward migration of cows with calves passed through eastern Bering Strait between June 1 and

8. Excerpts from my field notes of 11 June indicate my impressions concerning the number of cows with calves.

> In reviewing observations of the past (the just concluded) hunting season, I have the impression that this may have been an unusual season. The majority of cows observed from 1 June to 8 June were accompanied by calves. The best estimate I have for this period is that 70 to 75 per cent of the cows observed during this period had calves, and the number of calves orphaned by hunters was extremely high.

Similar observations were made during 1963, and pointed up the fact that pregnant and barren cows, although generally migrating during the same period as parturient cows, are more loosely grouped and often travel closer to the coast.

Laboratory examination of reproductive tracts collected during 1962 and 1963 also supported the observations reported above. The following is a classification of the reproductive condition of 213 females taken during these years:

Year	N	Parturient	Pregnant	Barren
1962	104	72 (69%)	21 (20%)	11 (11%)
1963	109	74 (68%)	25 (23%)	10 (9%)

Considering all observations of adult female walrus (before and after the main migration, and those passing north near the coast), it appears that between 40 and 45 per cent are accompanied by calves. To obtain further data on this aspect of reproduction, specimens should be obtained from such points along the migration route as Mekoryuk, Wainwright and Barrow.

My information tenatively indicates that about 80 per cent of the mature cows calve every two years; 15 per cent bear calves every third year, and the remainder calve less frequently. The older cows calve less frequently than once in three years but comprise a steadily decreasing segment of the population. The proportion of cows that calve two years in succession is insignificant.

Using six years as the age of initial pregnancy, our sample shows that 227 cows were pregnant 731 times in 1384 reproductive years--once each 1.9 years. Approximately 85 per cent (Fay, 1964 MS) of the conceptions result in live calves. In the herd as a whole, the average parturition rate is one calf every 2.3 years. The rate derived by Harbo (1961) was one calf every 2.4 years. Twins

occasionally occur as indicated by Belopolsky (1936), Nikulin (1940) and Krylov (1962).

Approximately 36 per cent of the walrus population is younger than six years (Fedoseev, 1962, also states that 36 per cent of the population is composed of new born young and immature walrus). If we assume a 1:1 sex ratio which is generally indicated by our information of the ratio of calves, the annual increment, as stated previously, is approximately 14 per cent.

Harvest Characteristics

As mentioned before, walrus were taken in large numbers by American whalers during the latter part of the 19th century. During the period 1870 to 1880 the harvest was estimated at more than 10,000 animals annually (Allen, 1880; Clark, 1884). In addition, Eskimo and Russian hunters were making inroads on the stocks of these animals. Sporadic hunting ventures, employing large vessels, continued at least until 1917. During that year a vessel hunting in the vicinity of Wrangell Island took a little more than 1,300 walrus (Cameron, viva voce). Informats of Brooks (1954) indicated that heavy hunting pressure continued during and following World War I. During this time hunters employing small vessels, used Nome as a base of operations.

Recent Harvest

Little quantitative information is available concerning the actual magnitude of the total annual walrus kills, or the retrieved harvests, during the early part of the present century. Collins (1939) estimated annual harvests during the 1930's to be approximately 1,300 animals. The largest kills were (and still are) made at St. Lawrence, King and Little Diomede Islands, Wainwright and occasionally at Point Barrow. According to Brooks (1954), the average annual harvest between 1951 and 1953 was 1,337 walrus. He suggested that during the 15 or 20 years preceeding his investigations, the retrieved kill was stable at about 1,300 walrus annually. Hunting loss at that time (as at present) was estimated to be 50 per cent.

Since 1959, biologists of the Alaska Department of Fish and Game have been compiling information on the harvest (retrieved kill) and the total kill of walrus by Alaskan hunters. This information is reported by Harbo (1960, 1961), and Burns (1962, 1963, 1964), and is summarized in Table 4.

Table 4. Harvest and total kill of walrus by Alaskan hunters during the years 1959 through 1963.

Year	Walrus Harvested	Total Kill
1959	1,153-1,453	2,700-3,600
1960	2,300	4,500-4,600
1961	1,201-1,486	2,402-2,972
1962	1,263-1,353	2,829-3,064
1963	1,594-1,725	3,443-3,713

The harvest approximated the long time average of 1,300 walrus in 1959, 1961 and 1962. The excessive harvest during 1960 was the result of unusual availability to hunters at Little Diomede Island. The recorded harvest at that village was 900 adult and subadult walrus (Harbo, 1961). The higher than average harvest during the fall-winter-spring period of 1962-63 was the result of good hunting conditions during the fall, particularly at St. Lawrence Island (Burns, 1963).

Sex Composition

Since 1960 the sex composition of the Alaskan harvest has been greatly changed as the result of a regulation which became effective on January 1 of that year. This regulation established a limit of seven cows or subadults per hunter per year. No limit was placed on bulls.

Prior to this regulation, cows comprised the greatest portion of the kill, especially during years when hunting was good at Gambell, King Island, and Little Diomede Island. Since establishment of the limit, the potential harvests have been suppressed, and realized harvests have been composed primarily of bulls. It is estimated that in recent years the total Alaskan take of adult walrus was composed of 70 per cent bulls and 30 per cent cows.

This limit imposed no hardship upon hunters (except those killing walrus solely for the ivory) as the meat from seven females is more than enough to satisfy the needs of a family. Also, hunters

who feel they require more meat, can take as many bulls as they can utilize. The purpose of this regulation was to encourage greater utilization of the walrus that are retrieved, and to protect the juveniles and adult females (the reproductive heart of the population) from excessive exploitation solely for their ivory. It was later found that a limit of five cows or subadults would not inflict hardship upon any of the hunters, and this limit was established on July 1, 1961.

The present limit (5 cows or subadults) is certainly adequate from the standpoint of the hunters' requirements as evidenced by the fact that utilization of the females killed during years when they are plentiful, is still less than 50 per cent (see Burns, 1963).

Parturient cows and calves usually gather in large, compact herds which are particularly vulnerable to the Eskimo hunters at Gambell, King Island, and Little Diomede Island. Prior to 1960 the American harvest of walrus in Northern Bering Sea and Bering Strait was composed primarily of females. Thus Brooks (1954) indicated that the harvest at Little Diomede included many more females than males. Data for 1959, recorded by Harbo (1960) indicates that during that year the recorded harvest in Alaska was composed of 34 per cent adult and sub-adult males, 42 per cent adult and sub-adult females, and 24 per cent calves. The limit on cows and subadults resulted in a shift of the sex ratio favoring males. The recorded sex ratios during the years 1960, and 1962-64, in the Bering Sea-Bering Strait area are as follows:

Year	Number harvested (Bering Sea-Bering Strait)	Per Cent Males	Per Cent Females
1960	1646	65	35
1962	1128	61	39
1963	993	56	44
1964	450	71	29

The total Alaskan harvest is actually comprised of even a greater proportion of males than is the Bering Sea-Bering Strait harvests, because mainly adult bulls are taken at Mekoryuk, Wainwright and Barrow.

Age Composition

A knowledge of the age composition of the walrus harvest provides information from which conclusions concerning the population as a whole can be drawn. In brief, age determinations used for this study were based on the number of cementum layers counted in longitudinal cross sections of lower canine teeth. Sections of canine teeth were examined using low magnification with a binocular microscope. The light used for examinations was either direct or refracted, depending upon which proved most satisfactory with individual cross sections. In most instances, tooth sections did not require polishing. Cementum layers appeared as dark bands in refracted light, and light bands in direct light.

A certain degree of inaccuracy occurred in examining teeth from old animals, where cementum rings are lost through tooth wear. Commenting on this point, Harbo (1961) stated:

> The average number [of annual rings] 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.

For a more complete discussion of the use of cementum layers for determining age in Pacific walrus see Harbo (op. cit.) and Fay (1955).

Since 1959, teeth representing 2,271 individual animals have been examined, and the age of the animals determined. In addition, results of examination of teeth from 540 walrus were supplied by Dr. Francis Fay, Arctic Health Research Center.

Of the total sample of 2,811 walrus for which the age has been determined, 1,651 are males, 906 are females, and 254 are from animals of undetermined sex.

At present, natural mortality is not recognized as a significant factor in limiting walrus numbers. When it occurs it is generally age- rather then sex-specific. Thus, animals reportedly killed (crushed) in stampedes (see section on Hauling Out Areas) are the smaller ones. The sex ratio of new-born calves approximates 1:1, and it is presently assumed that this ratio prevails in the adult population. However, only the age composition information from males is used for estimating the size of the Pacific walrus stocks as the female segment of the herd is subject to extremely biased sampling. This is the result of migration patterns, herding tendencies and hunting vulnerability.

The age composition of the male segment of the population during years when sizable samples were obtained, is illustrated in Fig. 1 (A through C). Age composition of the combined sample of males obtained during 1953, 1956, 1957 (data supplied by Fay), and 1959 through 1963 is illustrated in Fig. 1, D. It appears that the age composition of the harvest during the period for which data are available is generally the same.

The mortality rate in the Pacific walrus was first determined by Fay (1955 unpubl. report) using a "catch curve" described by Ricker (1948), and was estimated at 11 per cent. Subsequent estimates of mortality by Fay (1960) placed the mortality rate at 15 per cent. Harbo (1961), using a sample of 492 male walrus, estimated mortality 12 to 15 per cent.

To derive a catch curve, I have combined age composition data from previous investigations with information obtained from the 1961 and 1962 harvests. The combined samples include data from 1,651 male walrus for which age has been determined. The resulting curve exhibits a non-linear decending right limb (Fig. 2), as did the curve described by Harbo (1961 op. cit.) A number of straight lines were fitted to segments of this limb by the method of least squares, and after analyzing the various factors influencing male mortality, I concluded (as did Harbo) that the line depicting the derived mortality rate for male walrus between 13 and 27 years of age was the best approximation of the actual mortality rate.

Analysis of the catch curve following the methods of Ricker (1948, 1958) indicates that mortality for age groups 13 through 27 years is 13.1 per cent. This falls within the range of 12 to 15 per cent which was postulated by Harbo (1961). I feel that the derived mortality rate of approximately 13 per cent represents the actual mortality in the male segment of the population.

Size of the Walrus Population

As recently as 1958 the Pacific walrus population was estimated at 45,000 animals, and the annual kill of 10,500 animals (including the Soviet and Alaskan kill) was said to constitute 23 per cent of the estimated total population (Buckley, 1958). These estimates were obviously incorrect, as proven by the fact that walrus still exist with no apparent decline in numbers. The best available tool for calulating the size of the Pacific walrus population is a knowledge of the annual mortality and rate of mortality.

Fay (1957) estimated the annual total kill of Pacific walrus, by Alaskan hunters, since 1950, to be approximately 2,200 animals.

Since 1959 the annual kill has increased to approximately 3,400 walrus. Buckley's (1958) estimate of a total annual kill (including hunting loss) of 8,300 walrus in Siberian waters seems reasonable, and in view of increased Soviet hunting pressure inferred from the papers of Popov (1960), Krylov (1962) and Fedoseev (1962), this figure may be conservative. My estimate of the present total annual kill is 11,700 walrus.

If the annual mortality rate for the male segment of the herd is approximately 13 per cent, the minimum population of Pacific walrus is 90,000 animals.

On the basis of information concerning harvests in Alaskan waters, this estimate is considered conservative because:

1. The mortality rate for the male segment of the population is used for calculating over-all mortality, and at present more males than females are taken

2. Age determination in older animals is inaccurate as the result of loss of annual rings in the teeth. It can be assumed that if the older age classes were correctly represented the derived mortality rate would be decreased.

The population estimate of 90,000 Pacific walrus is higher then the number estimated by Fay (1960), and falls within the estimates of 70,000 to 90,000 made by Harbo (1961), and 78,000 to 113,000 made by Kenyon (1960). The estimate made by Kenyon (loc. cit.) was based on aerial surveys.

Although additional data concerning harvests (especially by Soviet hunters) and rates of reproduction are needed, it seems justifiable at this point to draw some conclusions about population trends.

Informants at Little Diomede Island and King Island are of the opinion that walrus are increasing. The increase in the annual kill by Alaskan hunters (although fewer hunters are involved) would tend to confirm this opinion. Also, in recent years walrus have been observed in areas which reportedly had not been frequented for many years. On April 8, 1962 this writer, along with U. S. Fish and Wildlife Service personnel observed a herd of 100-120 walrus which were hauled out on Amak Island, close to the northwestern tip of the Alaska Peninsula. Also, during the summer of 1963, several walrus carcasses in relatively good condition were found in the vicinity of Cold Bay, on the Alaska Peninsula (Gilpen, viva voce).

For many years walrus were not reported east of Point Barrow. During both 1962 and 1963 they were observed in the vicinity of Barter Island. During the latter year, at least two were killed by Eskimo hunters.

On the basis of present findings it appears that the walrus herds are slowly increasing. The difference between the rate of reproduction (14 per cent) and the mortality rate (13 per cent) indicates that all possible steps should be taken to prevent removal of the small annual increment by continued protection of cows and calves, and by encouragement of less wasteful hunting practices.

Food Habits

Gross stomach examinations by Brooks (1954) and Mansfield (1959) indicate that clams are the most important single food item in the diet of walruses. Of the several species of clams present in the Bering-Chukchi Sea area, the two which were found by Brooks (loc. cit.) to be utilized in the largest quantities were Mya truncata and Clinocardium nuttalli. Many other invertebrates were also found to be included in the diet; Brooks (loc. cit.) for example states:

> ....the full stomach of a bull walrus killed on June 17, 1953, weighed 109 pounds, about 50 pounds of [which were] Mya truncata siphons and 35 pounds the feet of Clinocardium nuttalli. In this locality [Bering Strait] bull walrus seem definitely to select the above two mollusks and, to a lesser extent, the echinoderm Molpadia arctica v. Marenzeller. Cows, and especially immature animals, favor the small mollusks, as Astarte sp., Macoma calcarea, as well as the annelid Nephtys sp. and a sipunculoid worm.

In addition to the many kinds of invertebrates, walruses occasionally eat fish (Nikulin, 1941), and other marine mammals such as the ringed seal (Pusa hispida) and the bearded seal (Erignathus barbatus) (Brooks, 1954; Mansfield, 1959). Some walruses apparently eat seals as carrion on occasion, and others are reported by Eskimos to subsist on seals. Walruses which kill seals for food are reported, by hunters, to have short, stained, widely divergent tusks. Informants indicate that the seal-eating walrus are usually solitary, and more slender than their "normal" brethren.

My own studies have not included quantitative investigations of walrus food habits. Vibe (1950) in addition to the authors mentioned above, reported on this phase of the animals's life history.

Migration

Unlike their counterparts in the Atlantic, which are apparently more sedentary (Mansfield, 1959), the Pacific walrus undertake spring and fall migrations which, in some instances, cover a distance of at least 2,000 miles. The actual reasons which prompt migration are unknown, but it seems apparent that walrus are generally dependent upon ice, although they can remain away from it for considerably periods of time. In his discussion of shore aggregations of walrus, Nikulin (1947) states that although walrus frequent established hauling grounds along the Chukchi Peninsula during the summer and early fall, they utilize drifting ice when it is available. According to Nikulin (loc. cit.) "They use the ice for resting as long as it is present in the shallow water zone. If the ice thaws or drifts away over greater depths the walruses again come into shore."

Wintering Areas

Walruses generally remain in association with the southern edge of the pack ice. In late January, February and March, they probably occur along the edge for most of its length, but there are two areas in the American sector of Bering Sea where they apparently concentrate. These are, according to Kenyon (1960), "... south and west of St. Lawrence Island and south and east of Nunivak Island." The spring migration pattern during most years confirms this conclusion.

During winters when the southward advance of the pack ice is retarded, animals in large numbers occur between St. Lawrence Island and Bering Strait. During the fall and winter of 1962, walrus were available to hunters on the north side of St. Lawrence Island as late as January.

A small proportion of the herds remain far north of the others, and are found widely scattered throughout northern Bering Sea and Chukchi Sea. They usually occur singly (are these the seal killers?) or in small herds of less than 15, and are almost always males. Pilots, flying over the ice in search of polar bears, observe these animals, usually during February and March.

Although information on sex composition of walrus in the wintering areas is fragmentary, animals taken during the spring migration indicate that those south of St. Lawrence Island are of both sexes. Composition of the spring harvest indicates that the males may remain near the southeastern part of the Island.

Spring and Summer

Northward migration occasionally begins as early as March, but walrus usually become available to hunters at St. Lawrence Island during the latter part of April, and early May.

During the 1962 spring migration, walrus were most abundant in the vicinity of Gambell during the period May 12 to May 22. Large concerntrations of walrus did not reach Bering Strait until June 1. They continued passing through the Strait in large numbers until June 7 (Burns, 1963). The distance from Gambell to Little Diomede is approxiamtely 160 miles.

After passing through Bering Strait the walrus disperse, most of them apparently travelling north and northwest. During the summer months of July, August and early September walrus occur along the north coast of the Chukchi peninsula and as far west as the eastern part of the East Siberian Sea (Fedoseev, 1962). In the American sector of the Arctic walrus have, in recent years, been reported as far east as Barter Island.

Distribution of male and female walrus in the summering areas is not adequately known but it appears that while males frequent the established hauling areas, females, especially those with young tend to remain in close association with ice, except when it occurs over waters which are too deep for efficient feeding. By remaining in close association with suitable ice, the females and young are never far from feeding areas, and can resort to the ice during periods of high winds (ice prevents the sea from becoming very rough), and when escaping from enemies. Walrus utilizing coastal hauling areas may have to travel further to feeding areas, and often travel in areas of extensive open aater.

Informants from the U. S. Coast Guard icebreaker U.S.S. Northwind indicated that during August 1963, females and young were encountered primarily in the areas north of the Chukchi Sea, from 164° W to 180° W.

Fall Migration

The fall migration is the most poorly documented of the annual movements undertaken by walrus. Fedseev (1962) points out that the southward fall migration begins duirng the period when young ice is formed, During the first part of October Fedoseev saw walrus travelling in a southeasterly direction from the Long Strait area to the Inchoun District of eastern Siberia. The southeasterly travels of walrus in this area continued until late October. Although many animals (mostly bulls and cows unaccompanied by calces) pass through extensive areas of open water, the cows with calves proceed south with the advancing ice. In 1962 bulls and non-parturient cows occurred in the vicinity of St. Lawrence Island as early as October 15, a month before the ice ar arrived. During that same year the large herds of cows and calves did not pass south through central and eastern Bering Strait until November 27. At that time they were associated with the heavy Arctic ice. These observations also indicate the close association of cows and calves with ice.

During October 1963, the first walrus observed in the vicinity of eastern St. Lawrence Island were young bulls. On October 28, Several bulls were observed in the water between East Cape, on St. Lawrence Island, and the Punuk Islands (approximately 8 mi. off-shore). On November 4, a small group of adult bulls and cows was observed hauled out among the rocks at the eastern most tip of the Punuk Island group. The major migration of walrus did not reach St. Lawrence Island until the last part of November Many animals remained in the vicinity of Gambell on St. Lawrence Island until the latter part of December.

Walrus in the eastern Bering Sea travel much further south, arriving in the vicninty of Nunivak Island about the same time as the central Bering Sea group arrives at St. Lawrence Island. As illustrated in the aerial survey charts of Kenyon (1960), the pack ice reaches its most southern terminus in the vicinity of Bristol Bay, Alaska.

Walrus are occasionally trapped by closely-packed ice and are unable to reach water. During March 1962 a small herd (10-15) of dead walrus was observed by polar bear hunters north of Bering Strait. These animals were no less than 15 miles from the nearest open water (Robert Curtis, viva voce). Murie (1936, p. 342), citing Geist (in litt.) says that:

> Mr. Geist states that when long north or northwest storms close the ice...these animals [walrus and fur seals] have been known to haul out

> and go overland to the southwest or even south side [of St. Lawrence Island], some fifteen to twenty miles, where they are sure of [finding] open water.

According to the speculations of Murie (op. cit.), one of the causes of fracture in the walrus' os penis bone, is that the animals are occasionally forced to travel over ice and/or land, and the poorly supported weight of the animals may cause fracture. In view of the rough ice conditions which commonly occur, the explanation seem plausible.

Several informants at Savoonga said that walrus have been killed on St. Lawrence Island by hunters that followed walrus trails with dog teams.

Hauling-Out Areas

Although they are most commonly found in association with ice some walruses spend time "hauled-out" on land. Traditionally, the same areas have been used year after year, and in the past included Amak Island, the Walrus Islands, the Pribilof Islands, Hall Island, St.Matthew Island, the Punuk Islands, St. Lawrence Island, Besboro Island, the Diomede Islands and numerous other areas along the mainland of Alaska (Fay, 1957).

According to Fay (loc. cit.) there are no longer any regularly frequented hauling grounds in Alaska, with the exception of the Walrus Islands in Bristol Bay. However, more recent evidence indicates that former hauling grounds are again being used to some extent, and it may be that such use will increase with increases in the walrus population. Recent sightings are listed here for the sake of general interest and as a reference for future investigators. Almost certainly, additional sightings are going unrecorded.

Male walrus frequent the Walrus Islands in Bristol Bay each summer. During late June, 1958, Kenyon (1958) estimated the population on these islands at between 1,500 and 2,000 adult and subadult males. On August 19, 20, and 21, 1960, Harbo (1961) visited the Walrus Island group and estimated that a minimum of 1,500 to 2,500 walrus were either hauled out or swimming in the vicinity.

As mentioned previously, on April 8, 1962, approximately 100-120 walrus of both sexes were seen by Karl Kenyon and David Spencer (both of the U. S. Fish and Wildlife Service), and myself, hauled out on Amak Island, in southern Bristol Bay near the end of the

Alaska Peninsula.

Fred Woldstad, of the Alaska Department of Fish and Game, saw a single adult male walrus near Cape Constantine on July 6, 1963 (viva voce). This area is on the mainland in Bristol Bay, east of the Walrus Islands.

On August 15, 1961, a herd of approximately 200 adult and subadult bull walrus was seen on Besboro Island is eastern Norton Sound. The animals were hauled out on a gravel spit and were at first reluctant to leave, even though several rifle shots were fired (Regnart, viva voce). Although Eskimos at Unalakleet consider Besboro a traditional hauling area, 1961 was the first time in recent years that walrus were observed there.

The Punuk Islands, approximately 8 miles south of Southeast Cape (St. Lawrence Island) are often visited by walrus, especially during the fall migration. Many walrus reach these islands during October and apparently utilize them until the heavy ice arrives in late November. During October 1962, an estimated 1,500 walrus utilized the eastern-most of the three islands, and were hunted by Eskimos whenever weather conditions permitted boat travel from nearby St. Lawrence Island. The walrus apparently returned to the island after being hunted. During late October and early November, 1963, on or near the Punuk Islands, I saw a total of 20 to 25 walrus consisting of bulls and cows which were not accompanied by calves.

In recent years dead walrus (mostly females and small subadults have been found each summer on the eastern-most island of the Punuk group. Death of these animals occurs sometime in the period after the hunters visit the islands in November and before they get there in early June, indicating that the Punuk Islands are also used during the winter or early spring, even though ice may be close by. Ivory of the dead walrus is claimed by the boat crews which first reach the islands each spring.

Commenting on the occurrence of dead walrus on these islands, Marks (MS) states:

> This year (June 7) [1962] four of the six boats attempting the journey reached the islands through the fog and found thirty-one dead walrus. Most of the animals found this year were females.

> The ivory was divided among the four crews. Last year [the year before Marks was there] I was told the hunters found over fourty dead animals and the year before around sixty.

According to hunters on eastern St. Lawrence Island, the occurrence of dead walrus on the Punuk Islands is a new phenomenon. Death of these animals is probably not the result of hunting activity as walrus killed or wounded during the spring hunts would not normally drift around to the south side of St. Lawrence Island in large numbers. Also, the hunter kills in this area are primarily adult bulls whereas the dead walrus found on the Punuk Island are mostly females or subadults. The Eskimos believe that the deaths are caused when the walrus are stampeded from the beach. The larger animals are said to crush the smaller ones. Low-flying aircraft, approaching and taking off from a near-by military installation, are reportedly the cause of the stampede(s).

Another sighting of walrus in this vicinity was made on November 4, 1963, when I saw three animals near Southeast Cape, on St. Lawrence Island. Murie (1936), commenting on the Punuk Islands and near-by St. Lawrence Island, states, "The walrus frequent Punuk Island and East Cape of St. Lawrence annually though in small numbers."

Two additional sightings of walrus hauled out along the mainland of Alaska include one of a subadult bull in the vicinity of Cape Prince of Wales during late July, 1963 (Horton, viva voce); and a medium sized walrus (sex unknown) seen by several hunters near Point Hope, on August 10, 1963.

Hauling areas in the American sector are usually rocky or gravel beaches located near high promontories of islands, or at the base of headlands projecting into the Bering and Chukchi Seas. Utilization of this type of hauling area is probably the result of selection by the walrus, as well as chance. The headlands and higher parts of islands can be located at a greater distance by walrus seeking a place to haul-out. From the stand-point of random selection of hauling areas, most of the islands and headlands along the migration route are high with narrow rocky or gravel beaches.

The most extensively used hauling areas in the American sector, those occurring on the Walrus Islands, are presently protected as the result of State Law. Enactment of the law establishing

the Walrus Islands State Game Sanctuary, in 1960, was an attempt to protect the walrus (found in that area during the summer and fall) from being killed while on the hauling grounds, to perpetuate use of this hauling area, and to set aside a limited area where walrus can be observed, photographed, studied, and enjoyed without being subjected to undue disturbance.

Behavior and Miscellaneous Observations

The close parental attachment of female walrus and their calves has been mentioned many times in the literature. Walrus calves are easy prey for hunters when the female walrus have been killed. The calves are reluctant to leave the area of the kill, and often climb on the females (in many cases causing them to sink), or closely approach the boat.

Calves are often observed clinging to the neck and shoulders of the cows while they are swimming. In many instances when the animals surface, the hind flippers of the calves are extended much like a rudder. However, the calves were not observed to more their flippers as do animals which are swimming.

During both the 1962 and 1963 spring hunting seasons at Little Diomede Island I was able to observe many herds of 50 to 150 walrus, as hunters tried to locate bulls among the large herds of cows, calves, and subadults. In Many instances these herds were not routed from the ice even though the boat passed within 20 yards of them. When animals did become alarmed, cows often pushed the calves into the water before entering themselves. In at least one instance a calf, apparently reluctant to enter the water, was "scooped" up between the front flippers, chest and neck of the cow. The body of the calf was perpendicular to that of the cow when she dove off the ice, into the water. The top of the ice cake was approximately 3 1/2 feet from the water. Adult cows were commonly seen clasping calves between their front flippers.

Walrus calves seem to be rather inquisitive and, apparently due to their inexperience, are not alert to the dangers of an appraoching boat. When animals which have not been fired upon by hunters are frightened from an ice floe into the water, the younger animals often remain in the area until they are "herded" away by the older walrus. The hollering of the calves can be heard at a considerable distance, and the older animals continue to return to the edge of the ice until the last of the noisy calves has been encouraged to leave.

When large mixed herds of cows, calves, bulls, and subadults are hunted, the confusion after the opening round of shots is almost unbelievable. Bellowing adults and hollering calves flee from the ice into the water. The older animals leave the area but many of the younger ones remain and even try to climb out on the ice with the dead animals. During all this activity the hollering of the young walrus sets up an inescapable background noise. Invariably the older animals will return as many times as is required to encourage and herd the younger animals from the area. Usually it is not until the last of the young has been herded away, that all the older animals depart, and quiet prevails.

Males as well as females take part in the efforts to remove the juveniles from the danger area. In fact, many of the cows with calves flee without returning and it is the non-parturient cows, cows that have apparently lost their calves, and especially the younger age bulls that return, sometimes pushing the calves under water.

In all cases where walrus hunts have been recorded in the literature, the returning of the adults is interpreted as a reprisal attack by the walrus against the hunters. Pictures accompanying these descriptions of the "reprisal attack" (i.e. Borden 1928, p. 157) show groups of thrashing and diving animals, many of which are juveniles.

The following description of walrus hunts at Little Diomede Island is used by Kenyon (1958) to express his own observations, which in general characterize many descriptions:

> Eskimo walrus hunts have been described by numerous writers. Those quoted here amply express our own observations. Albert Heinrich describes Little Diomede walrus hunting as follows (letter 1946): "When a boat spots a group of walruses on the ice (Nunavuk, plural Nunavait), the procedure is simply to go over to the ice pan and when you get to almost point blank range, everybody empties his rifle...the boat is pulled up on the ice. Sporadic shooting usually goes on at this stage, but there is more or less of a lull, giving the men time to reload for the returning walrus. The surviving individuals invariably return to make an attack [emphasis added] .... Their efforts, naturally, are rewarded by a counter attack of bullets. After one, two or three sessions of this, comparative quiet reigns,

> though an occasional walrus, often a wounded one, coming up for air, will be seen and fired upon...the resultant gore is indescribable."

Contrary to the above opinions, it is my conclusion that the animals return in response to the vocalization of the young animals. When herds consisting solely of adult animals are routed from a resting area on the ice they generally flee as fast as possible, with only the mortally wounded or stunned animals remaining behind.

Occasionally walrus, particularly young bulls, do attack a boat or kayak. The infrequency of these attacks even when a boat is caught in the midst of a returning herd indicates that walruses are generally not agressive.

This writer was present during two instances when walrus did attack a skin boat. On both of these occasions the attacking walrus were not observed on the surface, as are the animals returning for calves. The walrus came up directly under the boat and struck, apparently with their heads, in a manner similar to breaking through young ice. One, a small bull with tusks approximately 7 in. in length, rotated in the water and pierced the boat with its tusks.

That walrus attack from beneath rather than on the surface, is apparently known to Eskimo hunters at least at King and Diomede Islands. When boats or kayaks are forced into a position where crew members feel they may be attacked, all hands put their paddles in the water and wave them under the boat, in a attempt to scare the walrus away. In the two incidents to which I was a witness, the Eskimo belief that walrus strike only once, was upheld. Whether this is fact remains to be proven. Older hunters from King Island (where kayaks were once used extensively) indicate that attacking animals strike the kayaks from underneath, and try to capize them. In some instances they were apparently successful.

The use of the tusks when climbing out of water onto ice was demonstrated several times. Walrus were observed to crawl on a submerged estension of an ice flow, push thier tusks into the ice above the surface of the water and, through the combined efforts of pulling on the tusks by contracting the neck muscles, and walking on the flippers, climb up the steep edge onto the exposed ice. On gradual inclines, the animals walked without using their tusks.

On June 8, 1963, while traveling by boat from Diomede to Wales a young walrus with tusks about 4 in. long, came out of the

water onto an ice floe in one continuous motion. The animal was not observed until it materilized a short distance from the boat. This animal rose up, threw the upper two-thirds of its body on the ice (about a foot about the water), and used its front flippers to "walk" its hind end out of the water. The procedure was the same as that observed in the so-called "trained seal" (Zalaophus californianus) when it is leaping out of the water onto a platform.

During late May, 1963, three adult bulls were approached by hunters in a skin boat. The animals were lying on the ice closely grouped, and one was waving its extended front flipper in the air. The day was bright and clear, the wind calm, and the temperature about 47° F.

Waving the flippers has been recognized by Bartholomew and Wilke (1956) as a means by which the Alaskan fur seals (Callorhinus ursinus) dissipate body heat. It is a common occurence under conditions of heat stress.

Commenting of flipper waving in the walrus, Fay (1960) states:

> The relatively bare skin of walrus is probably the principal route through which heat is dissipated, but when its capacity for heat transport is exceeded or impaired by excessive insolation, the flippers must be used to lower the body temperature.

The occurrence of flipper waving in the walrus has been recorded when hauled out on land, usually on warm, clear days. The occurrence of this phenomenon during the spring, when animals are on the ice, is probably the result of heat stress caused by direct sunshine, and the fact that the walrus still retained much of their thick winter blubber, which decreases their capacity for heat exchange. It is interesting to note that although the animals were a pinkish-red color from dilated peripheral blood vessels, and were waving their flippers, they remained closely huddled. Apparently their mutual desire for companionship was greater than the discomforts caused by heat.

CONCLUSIONS

During the latter part of the 19th century, many writers familiar with the exploitation of whales and walrus in the western Arctic, were of the opinion that continued exploitation would eventually lead to extermination of both. Failure of the Arctic whaling industry, during the late 19th century, removed some of the heavy hunting pressure from the walrus stocks. The United States Government took steps to protect the Pacific walrus in 1941 when the "Walrus Act" was passed. This act allowed for the taking of walrus only by Alaskan oboriginals. As was pointed out by Buckley (1958) the "Walrus Act" made no provision for regulating harvests, and its prohibition against the export of raw ivory was unenforceable. The "Walrus Act" was amended in 1956 to permit the export of hides, and trophy hunting by white hunters. It did not provide for the establishment of bag limits for Eskimo hunters killing walrus for food, not did it provide for control of U. S. Nationals beyond territorial waters of the United States. As Buckley (loc. cit.) pointed out,

> The feature of the amendment which permits unlimited harvest by Eskimos for food is obviously well-intentioned but ineffective--in practice it is difficult to demonstrate.

Shortly after Alaska became a state, the Alaska Board of Fish and Game took the first active step to reduce the kill of female walrus. Starting January 1, 1960, a bag limit of seven adult cows or subadults of either sex, was established. As previously, no limit was placed on the number of bulls that could be taken.

The limit on cows and subadults was further reduced to five per hunter per year, on July 1, 1961. There was no limit on bulls. Results of these regulations have been noteworthy in that they have not only changed the sex ratio of the harvest to leave more females, but at certain points the total harvest has been reduced. As I pointed out in an earlier report (1963), this limit was probably one of the biggest factors in restricting the size of the harvest by Diomede hunters.

Present Population Status

In previous sections it was pointed out that the total annual kill of Pacific walrus by both Russian and American hunters is estimated at 11,700 animals. Analysis of age composition data using the method outlined by Ricker (1948, 1958) shows that the mortality

rate for male walrus is approximately 13 per cent. Thus, the population contains a minimum of 90,000 walrus. The crude rate of reproduction is calculated to be approximately 14 per cent, with annual pre-hunting recruitment estimated at 12,500 animals.

From the information presented above it is readily apparent that the realized annual increase (annual recruitment minus annual kill minus natural mortality equals realized increase) during one or more years could be easily wiped out during a single hunting season, if conditions permitted.

Prior to commercial exploitation, the walrus herds were estimated to contain 200,000 animals (Fay, 1957). Although the number of walrus was drastically diminished apparently no other marine mammal has utilized the semi-vacant niche. Thus, Brooks (1954, p. 11) states:

> ...no clam-eating substitute for the walrus has yet appeared on the scene; the stratified, fluid habitat of marine mammals is not subject to easy change, or to alternative use. Thus, the niche of the walrus seems specially reserved for them, a condition with obvious advantages.

This is indeed an advantageous situation and there is no reason why, with an effective management program, and cooperation from hunters and organizations interested in the welfare of the Eskimo, the numbers of walrus should not be increasing faster then they are. An increase in walrus numbers would directly benefit inhabitants of the villages where walrus were formerly taken in larger numbers (as Point Hope), and again provide an important source of food and other useful products.

Management Considerations

The problems involved in walrus management today are essentially the same as those commented upon by Brooks (1954) when he so correctly stated that:

> The expression 'walrus management' really implies 'human management', because killing by hunters appears to be the only force capable of seriously depressing the walrus population. No population checks such as range or food limitations, competition, predation, or disease are known to be significantly operative at the present time.

There is still a definite lack of agreement among the various organizations concerned with the welfare of the Eskimos, regarding the recognition and thoughtful consideration of many of our renewable natural resources, including the walrus. With regard to the walrus, the problems created by the wasteful killing for ivory alone, should be officially recognized, and this type of hunting discouraged whenever possible. Unless opposition to waste is actively voiced, apathy on the part of the organizations involved, as much as condones poor utilization.

Of the average annual kill of walrus by Alaskan hunters (3,400 animals), only half of the animals are retrieved.

Ironically, "modern technology" has contributed to the wasteful and inefficient hunting methods of the present day Eskimos, who during recent past generations were considered cunning hunters in a harsh and demanding environment. The often quoted comments of Dunbar (1956), concerning walrus hunting by Canadian Eskimos are unfortunately descriptive of hunting methods in Alaska, and they point out changes brought about by the introduction of "modern" weapons. He states as follows:

> ...the introduction of the rifle has, amongst other things, had the effect of making increasing numbers of Eskimos 'trigger-happy', especially since Government relief to families, and family allowances, have made cartridge-thrift less important. The result is that hunting parties, formerly models of stealth and cunning, now rival those fairy-tale hunters in 'Peter and the Wolf' 'coming through the forest, and shooting as they come.' The total fire-power of the hunting party is let loose on the herd of walrus, wounding rather than killing and allowing many maimed animals to escape, to die later. Pregnant females are killed and wounded as well as males, so that the total waste is difficult to estimate. Quite apart from the waste involved in the escape of mortally wounded animals, there is also the danger, in summer, of animals sinking before they can be harpooned, particularly in this haphazard method of hunting

There is certainly much room for improvement of hunting methods in Alaska. Hunters should be able to realize the same annual harvests from a greatly reduced total kill if they employed

better hunting techniques. It is quite obvious that the total kill can, and should, be reduced. This could be accomplished if the hunters adopted procedures such as the following:

1. Use rifles of a caliber adequate for doing the job. Although some of the smaller calibers will kill the cows, they are inadequate for bulls.

2. Keep hunting equipment including rifles, harpoons, lines, pokes and hooks in good condition so that they will not fail when they are used.

3. Do not hunt walrus unless adequately equipped. Lack of harpoons and other equipment is one of the major causes of hunting loss.

4. Whenever possible, walrus should be hunted on the ice rather then in the water where they often sink beyond recovery.

5. Hunters should avoid situations where the skin boats are in danger of being surrounded by a returning herd of walrus. The ruthless killing of animals swimming near a boat results in high losses which could be entirely avoided.

6. Hunters should pursue herds of such a size that the concentrated firepower of a boat crew can be used most effectively. It is better to hunt small herds where the animals are killed outright, and retrieved rather than to shoot into the larger herds where many animals are wounded and lost.

7. When walrus calves are not wanted, cows with calves should not be killed. If the mother is shot and killed, the abandoned calf will also die. This is a cause for high losses which could be almost completely avoided. There are no benefits gained from unnecessary loss of this nature.

8. As much of each animal killed as possible should be utilized. This includes saving undesirable parts for dog food, and selling carved rather than raw ivory.

9. Only as many animals as are necessary, should be taken by hunters. Killing female walrus for ivory alone is inexcusable.

The most important step in effective management of our walrus stocks, that of implementing the management program, is in the hands of the organizations involved with the welfare of the Eskimos, and the hunters themselves.

Additional Research Needs

Many questions relating to walrus biology remain to be answered. Until several phases of the life history of this animal are understood, we can make no claim to enlightened mangement of this resource. Points deserving further investigation include the causes and significance of natural mortality; the age-specific rates of reproduction; the survival success of the younger cohorts in the population, especially orphaned calves; the ratio of males to females necessary to sustain the normal rates of reproduction; herd composition, especially in the wintering areas; and the aspects of behavior which might shed light on the unanswered questions of breeding biology.

Since man is the most important cause of mortality, and harvests vary significantly from year to year, current information concerning the kill of walrus should continue to be obtained. Accurate information of both the Soviet and American kill is essential.

Conclusions concerning the population status of the Pacific walrus are based on statistical analysis of samples, Efforts to recognize and evaluate the variables contributing to biased samples which are being obtained, should be continued.

In recent years, walrus have been observed in areas which they have not frequented for many years. For comparative information, sightings of walrus, especially when they are hauled out on land, should be compiled and recorded.

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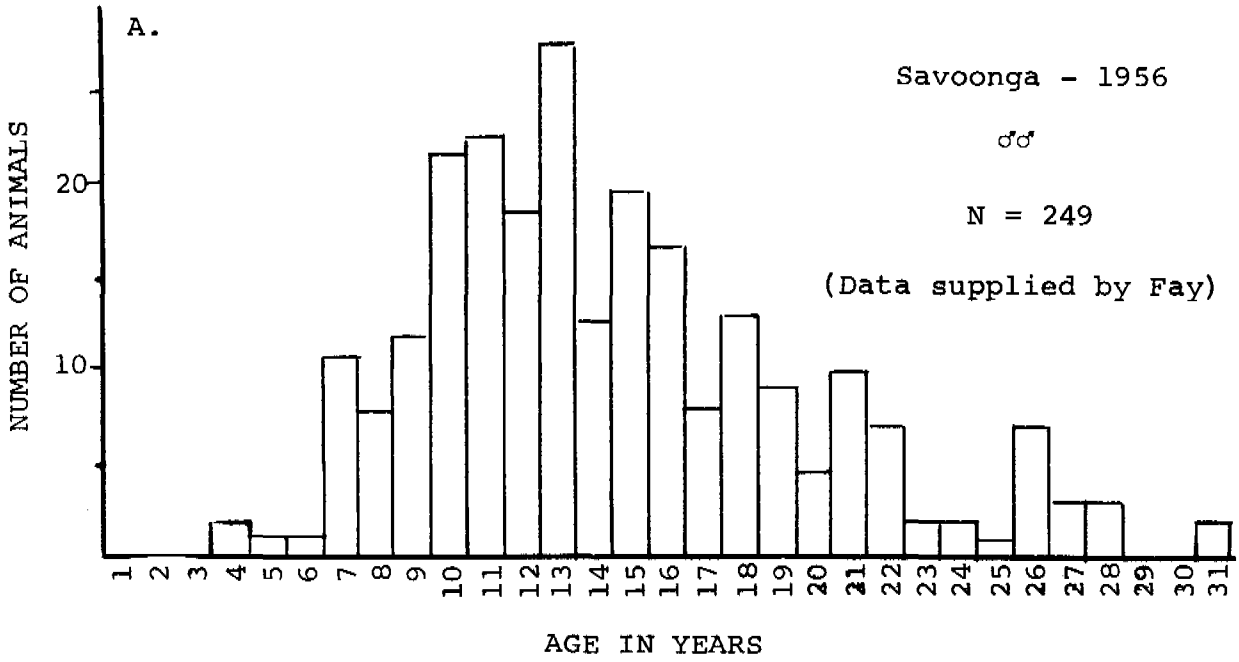
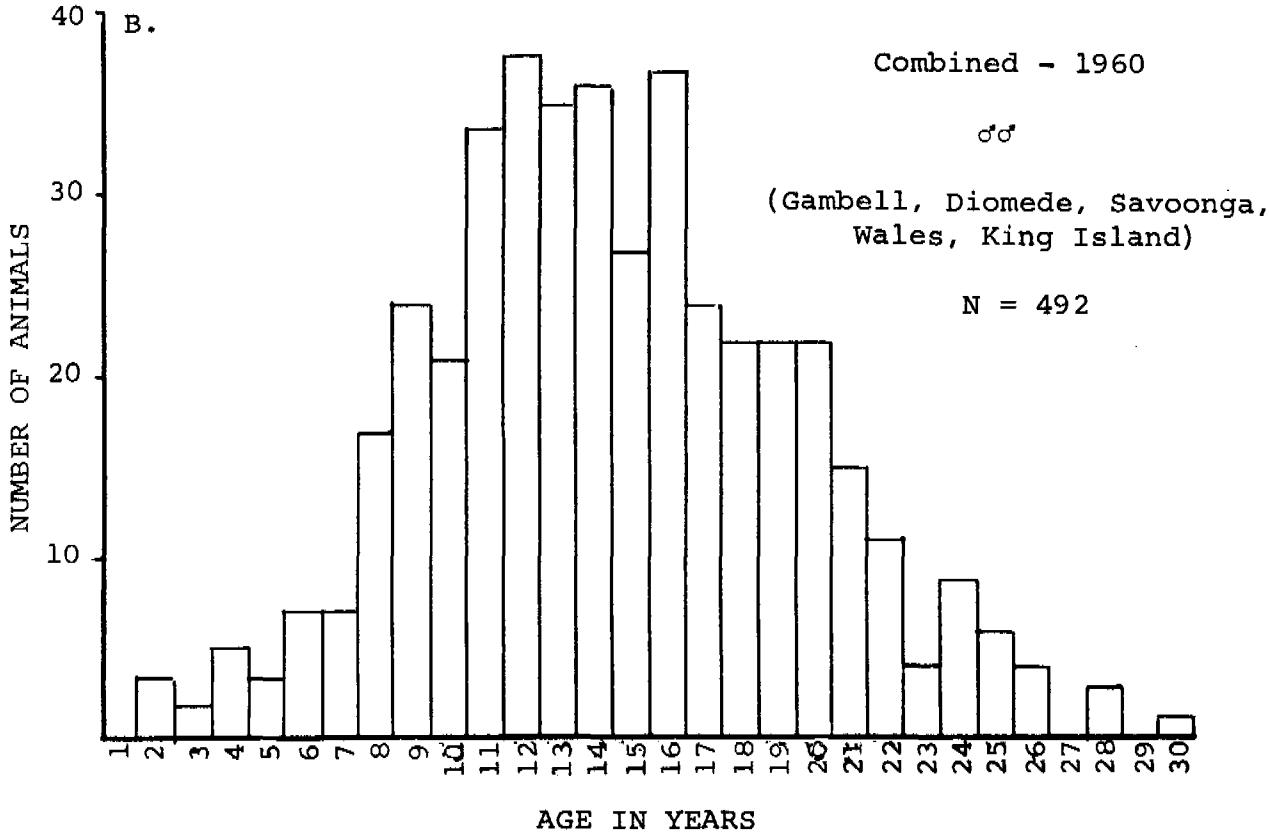
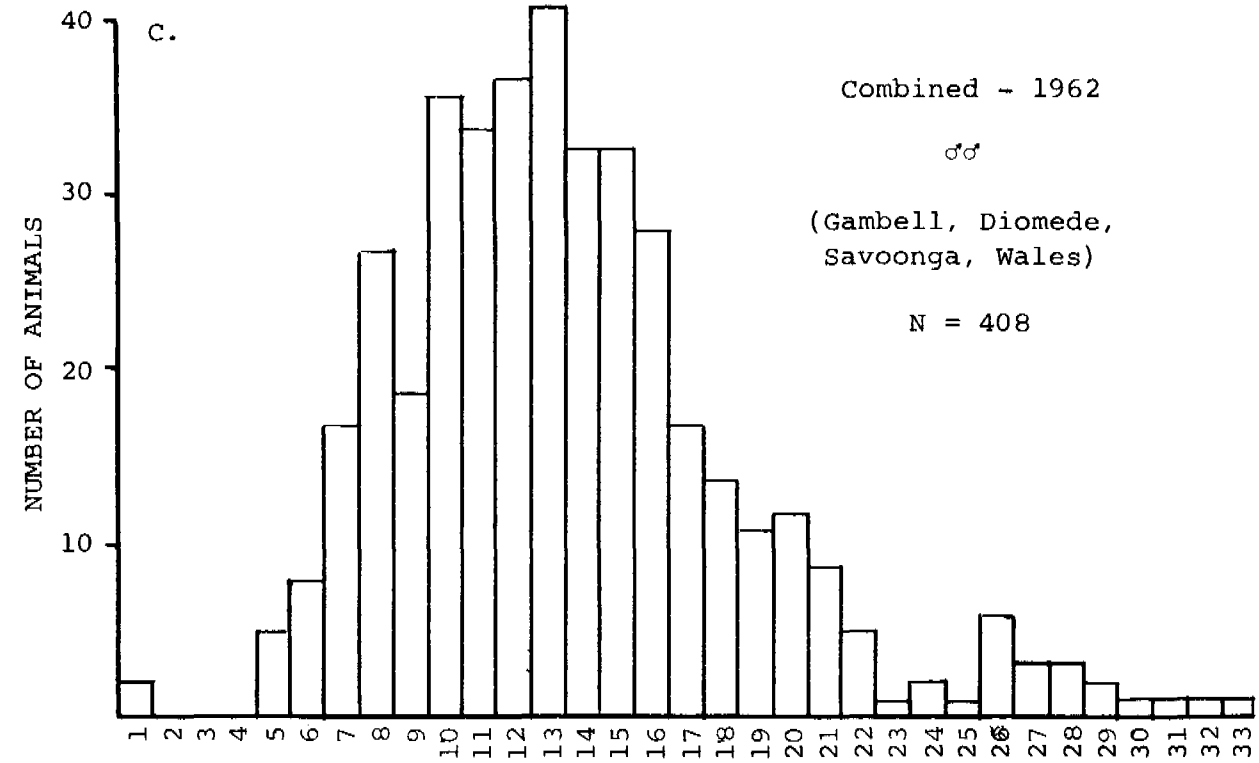
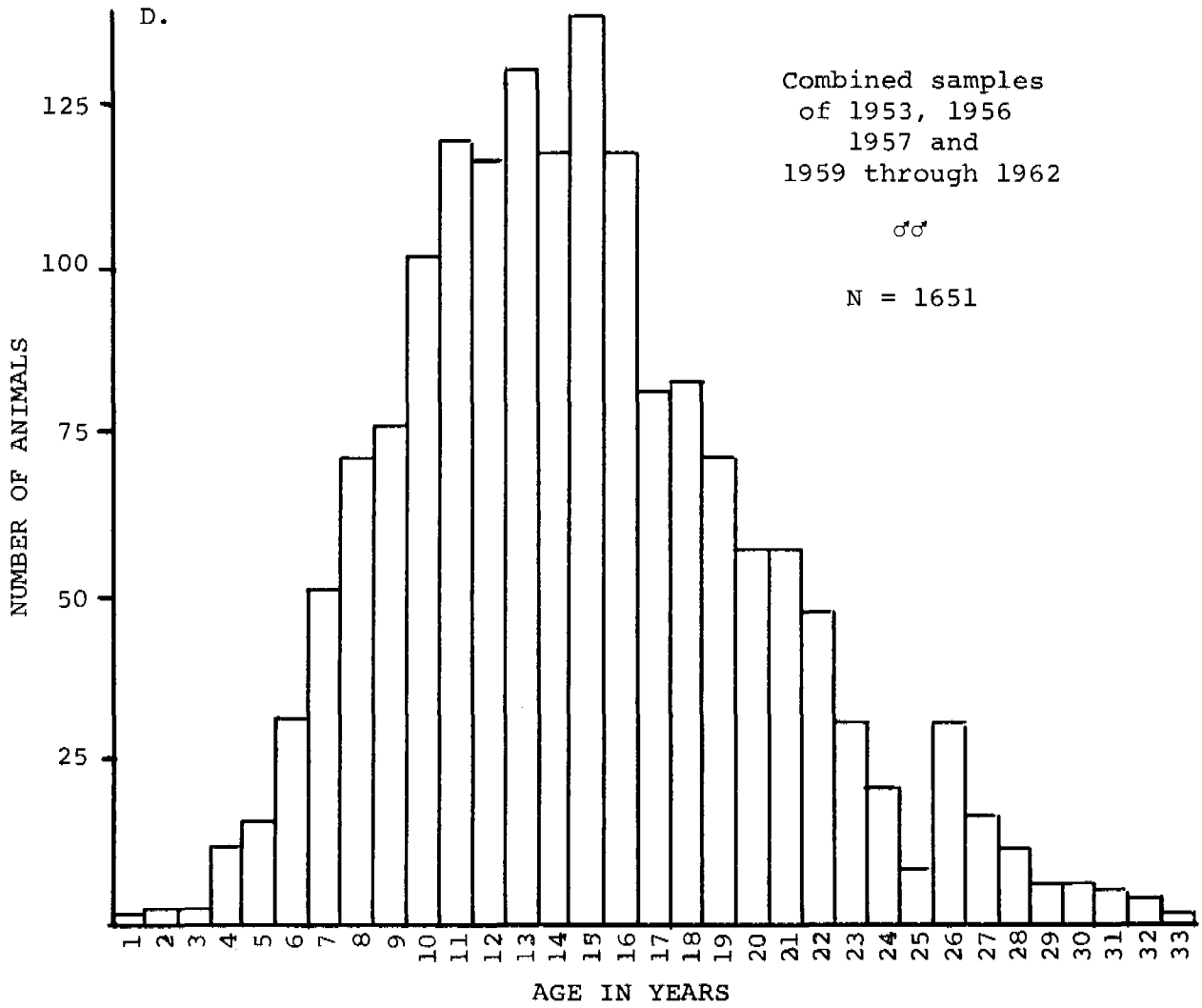
Fig. 1 Age composition of the male segment of the walrus harvest during (A) 1956, (B) 1960, (C) 1962, and (D) a combined sample from 1953, 1956, 1957, and 1959 through 1962.






C.
Combined - 1962
♂♂
(Gambell, Diomede, Savoonga, Wales)
N = 408
NUMBER OF ANIMALS
40
30
20
10
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33


D.
Combined samples of 1953, 1956 1957 and 1959 through 1962
♂♂
N = 1651
NUMBER OF ANIMALS
125
100
75
50
25
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33
AGE IN YEARS

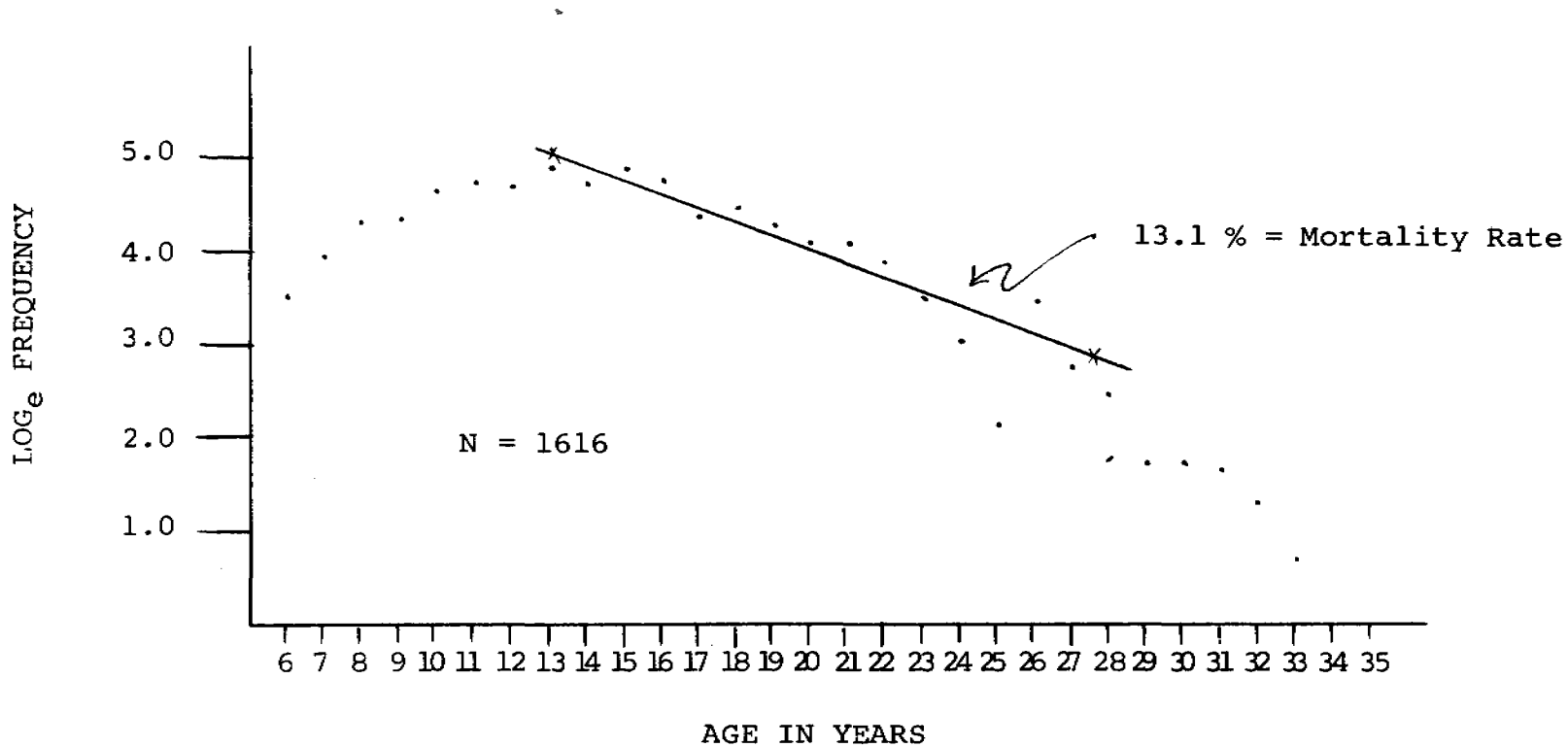


Fig. 2 Catch curve and derived mortality rate for male walrus taken during 1953, 1956, 1957 (data supplied by F. H. Fay), and 1959 through 1962. Age was determined on the basis of the number of cementum layers observed in sectioned canine teeth, and catch curve analysis follows the methods outlined by Ricker (1948, 1958).