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THE PACIFIC WALRUS

A Review of Current Knowledge and Suggested Management Needs

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U. S. Fish and Wildlife Service
Special Scientific Report—Wildlife No. 41

Washington • December 1958

The Library of Congress has cataloged this publication as follows:

Buckley, John Leo, 1920- *comp.*

The Pacific walrus; a review of current knowledge and suggested management needs. Largely from reports by Karl W. Kenyon (and others), Washington, U. S. Dept. of the Interior, U. S. Fish and Wildlife Service, 1958.

iv, 29 p. Illus., map. 27 cm. (U. S. Fish and Wildlife Service. Special scientific report: wildlife, no. 41)

Bibliography: p. 27-20.

1. Walruses. I. Title. (Series)

SK361.A256 no. 41 599.747 59-60430

Library of Congress

The Fish and Wildlife Service series, Special Scientific Report--Wildlife, is cataloged as follows:

U. S. Fish and Wildlife Service.

Special scientific report: wildlife.
(Washington, 19

no. 27 cm. illus.

Supersedes in part the service's Special scientific report.

1. Wild life, Protection of--U. S.

SK361.A256 799 59-60429

Library of Congress

PREFACE

Although there have been no exhaustive studies of the Pacific walrus, there has been considerable work on this species during the 1950's. Studies were initiated independently in 1952 by Francis H. Fay¹ and James W. Brooks.² Brooks' work, centering around Bering Strait but with some observations near Barrow, Alaska, was made available as Special Report Number 1 of the Alaska Cooperative Wildlife Research Unit in 1954. Fay's research was conducted largely at Gambell on St. Lawrence Island, and was presented as a Ph.D. thesis to the University of British Columbia in 1955. Each author has published short sections of the above works in the Transactions of the North American Wildlife Conference.

These two complementary studies served to point up the serious plight of the Pacific walrus, the waste involved in walrus harvest by the Alaskan aboriginals, and the glaring gaps in our knowledge of this species; they also stimulated the initiation, in the spring of 1958, of cooperative studies largely through the efforts of Clarence J. Rhode, Regional Director of the Bureau of Sport Fisheries and Wildlife for Alaska. With finances provided by the Alaska Region, two teams, each consisting of a biologist and an enforcement agent, were assigned to St. Lawrence Island and Little Diomed Island during the walrus hunting season in May and June. In addition, exploratory flights to determine the feasibility of aerial surveys of the population were conducted in the Bering Sea, and later three biologists were sent to the Walrus Islands for several days. The services of Dr. Francis H. Fay were kindly made available by the Arctic Health Research Center of the U.S. Department of Health, Education and Welfare. He and Mr. Averill Thayer, U. S. Game Management Agent of the Bureau of Sport Fisheries and Wildlife, were on St. Lawrence Island. Mr. Karl W. Kenyon, Biologist, and Mr. Stanley S. Fredericksen, U. S. Game Management Agent, both of the Bureau of Sport Fisheries and Wildlife, were the crew on Little Diomed Island. Dr. Fay and Mr. Kenyon were joined during their study on the Walrus Islands by Mr. James W. Brooks of the Alaska Department of Fish and Game. The aerial surveys were conducted by Dr. John L. Buckley, Biologist, Bureau of Sport Fisheries and Wildlife.

Most of the information presented in the following pages is derived from the two major reports by Brooks and Fay, and from the 1958 studies.

1/ Dr. Fay's studies were financed largely by the Arctic Institute of North America.

2/ Mr. Brooks' studies were financed largely by the American Museum of Natural History, The Wildlife Management Institute, American Committee for International Wild Life Protection, and the Alaska Cooperative Wildlife Research Unit.

ABSTRACT

Excessive killing has reduced the Pacific walrus population from an estimated 200,000 to approximately 45,000 in the last 100 years. The decline is continuing. Present hunting methods result in the loss of half of the walruses killed; and only half of those retrieved are fully used. Suggestions for further investigations are included.

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INTRODUCTION

Two subspecies of walrus, that together have a circumpolar distribution in the Arctic, are recognized in current literature. They are the Atlantic walrus and the Pacific walrus.

The Atlantic walrus, O. r. rosmarus, now occurs sparsely from the Canadian Archipelago eastward to Greenland, Spitzbergen, and the Laptev Sea. It formerly ranged in some numbers south as far as the Gulf of St. Lawrence, but because of greatly reduced populations, now is seldom found south of Hudson Bay (Dunbar, 1956). Overexploitation in the historic past has greatly reduced populations of both subspecies, with the Atlantic walrus suffering the greater depletion. Concern over the plight of the latter subspecies is evident from the papers presented at the Fifth Technical Meeting of the International Union for the Protection of Nature by Vibe concerning Greenland and Dunbar for Canada (Vibe, 1956; Dunbar, 1956). Kleynenberg (1957) expresses the concern of the U.S.S.R. over populations of both races in Russian waters. The steps taken by the respective nations for protection of the walrus are also outlined in the above papers. Further discussion of this subspecies is omitted from this paper.

The Pacific walrus, Odobenus rosmarus divergens occurs in the waters adjacent to Alaska and the Chukotsk Peninsula, from Barrow on the east to the East Siberian Sea on the west. Only the Pacific walrus occurs in waters adjacent to United States territory; it also ranges in international waters and in the territorial waters of the U.S.S.R.

Fay (1957) has documented well, from the fragmentary information available, the history of the exploitation and consequent decline of the Pacific walrus population. Perhaps the following table, adapted from Fay (1957), is the most graphic demonstration of the decline that has occurred.

Table 1. Approximate number of Pacific walruses harvested annually within historic times and the minimum size of populations from which they could have been drawn (from Fay, 1957).

Term	Harvest	Mid-term Population
1650-1790	5,000 - 6,000	200,000
1790-1860	10,000 - 15,000	200,000
1860-1880	15,000 - 20,000	150,000
1880-1910	8,000 - 12,000	80,000
1910-1930	5,000 - 7,000	60,000
1930-1950	6,000 - 7,000	60,000
1950-1956	5,000 - 6,000	45,000

Concurrent with the drastic change in numbers has been a pronounced shrinkage of the occupied range and a great curtailment in the number of "hauling grounds" regularly used. Figure 1, adapted from Fay (1957), clearly demonstrates the decrease in summer range. The decrease in hauling grounds used is equally pronounced. Sdobnikov (1956), speaking of the Siberian Coast, says that "On the coast of the Chukotsk Peninsula, out of 33 walrus herds available in the past, only 3 remained in 1954." On the American side, the only hauling ground regularly used is on the Walrus Islands in Bristol Bay. Formerly there were hauling grounds on the Pribilof Islands, near Amak Island, near Port Moller on the Alaska Peninsula (Scammon, 1874), on St. Lawrence Island (Murie, 1936), and near Cape Lisbourne on the Arctic Coast (Bernard, 1925).

The first published evidence of awareness of excessive slaughter and consequent population decline in the Pacific walrus was by Scammon (1874). He says: "Among the numerous enemies of the walrus, it is to be regretted that the whalers are included, they having been driven to the necessity of pursuing them on account of the scarcity of Cetaceans. Already the animals have suffered so great a slaughter at their hands that their numbers have been materially diminished, and they have become wild and shy, making it difficult for the Esquimaux to successfully hunt them, in order to obtain a necessary supply of food. It is stated that there has been much suffering among these harmless people of the far north, on account of this source for supplying themselves with an indispensable article of sustenance being to an alarming extent cut off."

From Scammon's time to the present there have been a number of publications decrying the slaughter and approaching extinction of the Pacific walrus. Unfortunately, these have aroused little public support, and the sporadic actions that have been spurred by the various publications have been inadequate to reverse the downward trend in the walrus population. Significant factors that have served to alter the rate of destruction of the walrus have been as follows:

1. The decline in whaling. Walruses alone were not sufficiently attractive to lure white hunters to the Bering and Chukchi Seas, and with the virtual elimination of whaling in the late 19th century, large-scale commercial exploitation of walruses also ceased.

2. Passage of the "Walrus Act" in 1941. This act accorded the privilege of taking walruses exclusively to Alaskan aboriginals and prohibited the export of raw ivory and of hides from the Territory of Alaska. It made no provision for regulating the harvest, and its prohibition against export of raw ivory was unenforceable.

3. World War II, with the consequent stationing in remote areas of Alaska of significant numbers of men. These men provided a market for both carved and uncarved ivory in proximity to native villages, and thus stimulated the harvest of walruses for ivory. The same trend has continued since the end of the war.

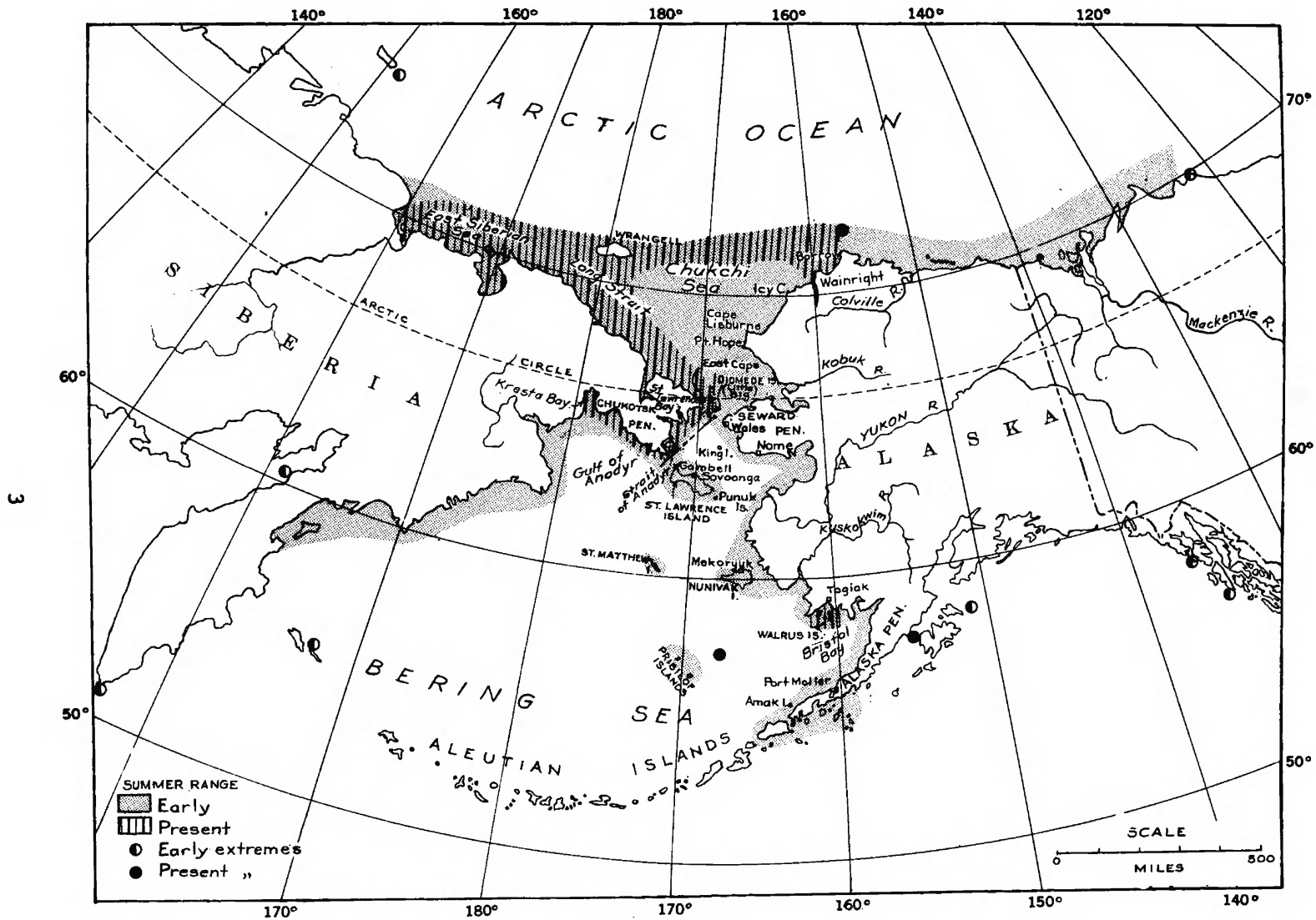


Figure 1.--Present and past summer distribution of the Pacific walrus (adapted from Fay, 1957).

4. Amendment of the "Walrus Act" in 1956, to permit the export of hides, and the taking of bull walruses by white hunters. It does not permit restriction on killing walruses for food by Eskimos; neither does it give control of U. S. Nationals beyond the territorial waters of the United States. 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 that a walrus was not killed for food even though it was not eaten. The only successful prosecutions for violations of the Act to date were of five Eskimos for killing walruses other than for food on the Walrus Islands in October 1958.

PRESENT KNOWLEDGE OF THE PACIFIC WALRUS

Certain aspects of the walruses' biology, and of human use patterns, are fairly well understood. Other aspects, such as current population status, require further studies and will be discussed in a subsequent section.

Description

The general appearance of the Pacific walrus is well known (Figure 2). The prominent tusks, which are modified canine teeth, are perhaps its most obvious distinguishing feature. The tusks of males may be up to 30 inches long and may weigh 9 pounds or more; tusks of females are somewhat shorter, slenderer, and lighter in weight. Large bull walruses may weigh more than $1\frac{1}{2}$ tons, three from the Walrus Islands weighed 3,432 pounds, 3,203 pounds, and 2,895 pounds, respectively, (Kenyon, 1958a) and are up to 12 feet long. Females are about two-thirds as large as males.

Migrations and Habitat

Both Brooks (1954) and Fay (1955) describe the migration of the Pacific walrus. The descriptions are very similar: the general pattern is one of movement northward in the spring and early summer and southward during the fall and winter. The animals follow the southern edge of the ice pack and thus always have an area to haul out on immediately above a rich source of food. Certain groups, usually of males, haul out on shore, as in the Walrus Islands in Bristol Bay³ on the American side and at two or three hauling grounds on the Chukotsk Peninsula on the Siberian side. Occasionally, especially in the course of southward migration in the fall, walruses of both sexes and all ages haul out on land. The Diomed Islands in the Bering Strait are among the places frequented at this time of year.

During the months of January and February, and even until mid-March, most of the walrus population can be found loosely aggregated in a broad undulating band extending across Bering Sea from Bristol Bay on the Alaskan side to the Gulf of Anadyr on the Siberian side. The walruses occupy an area which is perhaps 150 to 200 miles wide in January but slowly increases in width until it may reach 300 miles by late February. Within this zone, walruses are concentrated on the north sides of islands and peninsulas and at the southern edge of the more or less solid ice pack.

During March the pattern remains much the same but there is a definite tendency for some small herds to move northward, especially in the Strait of Anadyr. Some walruses also are reported north of St. Lawrence Island by pilots flying from Gambell on St. Lawrence Island to Nome on the Seward Peninsula.

3/ Place names mentioned in the text are shown in figure 1, page 3.



Figure 2.--Male walrus on the Walrus Islands. (Photo by Kenyon)

In April the northern movement becomes more purposeful. According to Fay (1955), the advance guard is wholly males, usually in groups of 2 to 10 individuals. He further states, on the basis of information provided to him by Ryder (*in litt.*), that the southernmost extremes of range have also been recorded at this time, presumably as a result of southward drift of isolated floes of ice.

By May the major northward movement is well under way, including the females and young. At this time the combination of weather factors is such that the major drift of ice is northward. By the end of the month movement through Bering Strait is well under way. Fay (1955) states that the animals passing through the Strait of Anadyr are principally females accompanied by juveniles and newborn young, but that there are a few adult bulls among them. To the north of St. Lawrence Island, within 15 miles of the Island, the population is nearly all bulls. Passage of large groups of walrus through the Bering Strait begins during this month, with passage beginning on the west side; walrus herds are seldom evident to the east of the Diomed Islands until after the middle of May. This pattern

of movement through Bering Strait is probably a result of hydrographic conditions which bring about the breakup of the western side of the Strait earlier than the eastern side. It seems likely to Fay (1955) that the earliest group through the Bering Strait is from Siberian waters and that the later group on the eastern side comes from Alaskan waters. According to Brooks (1954), the first animals appearing at King Island, Diomede, and Wales are juveniles, and adult females with young. They are followed later by a mixture of adults and immatures of both sexes, and finally by a few old bulls. By the end of May some walruses appear as far north as Point Hope and Icy Cape on the Alaskan Coast. During this time two concentrations of bull walruses are found, well to the south of the remaining herd. One of these is in the Walrus Islands in Bristol Bay; the other, in the Gulf of Anadyr near Kresta Bay.

During June, the sea south and east of St. Lawrence Island becomes ice-free but much ice still remains along the Siberian Coast. The last of the migrating herds are passing both ends of St. Lawrence Island, those to the west being females for the most part, and those to the east and north being males. By the second week in June essentially all have passed King Island, and by the third week most have passed through eastern Bering Strait. Migration through the western side of Bering Strait is completed by the end of the month, although stragglers have been seen in the Strait during July. There is some evidence that the preponderance of the walrus herd migrates through the west side of the Strait. By the end of June large herds are reported near Wrangell Island and Long Strait, on the Siberian side of the Chukchi Sea, and occasionally large herds are seen near shore in the vicinity of Point Hope, Alaska.

July and August bring the end of the northward movement in the Chukchi Sea. Most of the migrants, especially the females and young, have progressed northwestward from Bering Strait. On the Alaskan side, inshore records are common from Icy Cape northeastward to Barrow; most of the Barrow group are bulls. Ice continues to move northward and walruses then are seldom seen near shore. On the Siberian side, ice remains near shore from Kresta Bay to St. Lawrence Bay. When the ice finally melts, the animals move to hauling grounds on shore (Nikulin, 1947). In Alaskan waters a group of bulls remains near the Walrus Islands. In earlier times, resident herds, also bulls, occupied areas on the Pribilof and St. Matthew Islands, and the Penuk Islands near St. Lawrence Island. Formerly there were hauling grounds for both sexes near Point Hope on the Alaskan side, which were occupied during July, August, and September.

In September the northernmost records of walruses have been made at the edge of the ice pack. Late in September, movement to the south begins, and occasionally the vanguard of this southward movement reaches Bering Strait. During October, new ice begins to form, north of about 70° north latitude, and strong northerly winds tend to push the old ice southward.

During November and December, southward movement is the general pattern, but it seems far less purposeful than spring movement. Walrus usually appear in the vicinity of St. Lawrence Island late in November. Ordinarily the bulls appear first followed by groups of both sexes, mostly cows, in early December. By late December most have passed St. Lawrence Island and the winter ice pack is well formed. The regular wintering pattern is established by mid-January.

In summing up the migration pattern, it appears that movements are largely active, with the females' movements more directed than the males'. Walrus movements parallel ice movements, but if necessary the animals swim, and even swim against the prevailing direction of ice movements. Fay believes that the range reduction of recent times is hardly attributable to climatic change, a view in which Dunbar (1956) concurs in relation to the Atlantic walrus.

Food Habits

Walrus' food habits, at least qualitatively, are reasonably well known. Essentially all authors agree that molluscs supply the bulk of the walrus' food. Brooks (1954) noted in addition some echinoderms, annelids, sipunculoid worms, priapuloids, and arthropods; none of these groups occurred in significant amounts in the diet, however. Occasional individual walrus are said to feed on seals, but again, such feeding is of little consequence in terms of the food intake of the entire population.

The amount of food required by walrus is not well known. According to Fay (1955), a captive 6-month-old individual was fed approximately 20 pounds of solids plus 3 or 4 of liquids daily; an older individual (2½ years), when it weighed 1,200 pounds, consumed approximately 60 pounds of food a day (Spackman, 1958). Stomachs of animals killed by Eskimo hunters have been found with over 100 pounds of food. On the other hand, Brooks (1954) found that 60 of 71 bull walrus' stomachs examined by him at Barrow during August were empty. These rather fragmentary data suggest that at certain seasons the bulls fast or that feeding is infrequent, but that rather large amounts are ingested when the animals do feed.

Walrus are evidently capable of feeding at depths as great as 50 fathoms (Fay, 1955), but the majority of the foraging is at 30 fathoms or less. There is no reason to believe that walrus suffer from want of food, except perhaps in unusual circumstances such as when they may be trapped by ice in a restricted area. The range that they occupy is enormous, and almost uniformly shallow and productive; furthermore, the same area within historic times supported a population four or five times as great as at present.

The young apparently nurse for approximately 18 months or more although captive young walrus are able to subsist on solid food by the time they are 6 months old.

Age Determination and Growth

Fay (1955) summarizes present knowledge on age determination of walruses. In general, the methods depend on polymodal distribution of measurements, of which the tusk measurements separated by sexes are best. The age data presented in the following sections are based almost entirely on Fay's presumed age - tusk length relations. There are two other methods suitable for use on bull walruses. The first of these is a crude indication of age based on baculum size. The other, which Fay believes is very satisfactory, depends on cementum rings in the molariform teeth. He finds the formation of 2 rings each year in bulls up to 4 years of age and a single ring beyond this age. This same method, but with different interpretation, was described earlier by Brooks (1954). There is some question still as to appropriate interpretation of cementum rings which cannot be resolved completely until such time as known age walruses are available.

The principal difficulty in using Fay's age - tusk length relationships, especially for females, is that a fairly high percentage of measurements exceed those which he lists in his table. He finds a maximum tusk length from the gum line along the anterior curve of the tusk to the tip of 18-3/8 inches at ages 28 and 29 for females. Quite a number of tusks from subsequent samples exceed 20 inches in length. According to Fay, tusk growth no longer keeps up with wear after age 28. Variability of this sort is certainly to be expected, since tusk length is a measure of two factors--one of growth and the other of wear. Even though growth may be fairly constant between individuals, wear could be expected to vary considerably, depending upon bottom conditions with which the individual animals are in contact in their process of feeding. Regardless of such inconsistencies, the method seems usable as an indicator of relative age.

Population Dynamics

Reproduction

Fay (1955) reports that some males are sexually mature at the age of 5 years and that most males are sexually mature between 6 and 8 years of age. Most females, according to him, reach sexual maturity at age four.

The main breeding season extends from March through May, and copulation takes place during northward migrations. Copulation is probably almost always on the ice although one or two observations indicate its possible occurrence in the water. Breeding apparently is promiscuous, tending toward polygamy. The gestation period is approximately 13 months and births take place from April to June with the peak in mid-May. Birth is on the ice and is very rapid, lasting only a few minutes. Multiple births are rare, but Nikulin (1954) gives several records of twin fetuses. Females apparently breed in alternate years at most, and

each third year after approximately age 10. Brooks (1954) and Fay (1955) report, respectively, crude annual birth rates (calves per adult female) of 33 percent and 39 percent. These rates tend to support the triennial breeding.

At birth, the young are approximately 4 feet long and are capable of swimming immediately. A calf depends on the female for an exclusively milk diet for at least 18 months, and it is not at all unusual to find cows accompanied by 2-year-old calves. There is an extremely close tie between mother and calf, and if one is killed the other remains in the vicinity as long as possible. Calves deprived of their mothers before being weaned are assumed by natives to be adopted by another female. No evidence of adoption has been presented, and such adoption is so unlikely as to be of no importance to the population; that is, virtually all calves deprived of their mothers die.

Mortality

Mortality among walruses is probably almost entirely caused by human depredations. Undoubtedly some walruses, especially calves, are killed by killer whales, occasionally some are killed by polar bears, and walruses of all ages occasionally may be crushed by ice. There is no indication of food shortage and consequent malnutrition. None of these agencies is considered of importance at the present time. The details of human harvest will be presented in a later section. At this point, however, the fact of mortality and not the agency of mortality is of primary concern.

Fay (1955) has constructed a "catch curve" of male walruses taken near Gambell and Savoonga on St. Lawrence Island in the spring of 1953. His data consist of 155 bulls older than calves, and his ages are based on cementum layers in the teeth. The approximate survivorship curve that he interpolates has a slope of 0.12 and can be interpreted as an average annual mortality rate of 12 percent.

The data on which the curve is based were from walruses taken by Eskimo hunters. Because bull walruses are hunted primarily for their ivory rather than for meat, there is a rather constant selection toward the older age classes which have the largest ivory tusks. Thus, the slope of the survival curve probably tends to be underestimated, and the mortality rate estimated is thus too low.

The "catch curves" for females are based on even fewer animals than those for the males. In addition, the method of aging is based entirely on tusk length, and thus probably is less accurate than is the case with the males. However, for ages 4 to 15 inclusive, where the aging method seems the most satisfactory, the slopes of the survivorship curves give estimates of 15 percent mortality in 1953 and 16 percent in 1958. Data for 1953 are from Brooks (1954) and for 1958 from Kenyon; both sets are from Little Diomedé Island. Combining the data for both years yields an estimate of 15 percent, which is greater than that for

the males. Furthermore, the descending phase of the "catch curve" is concave, and thus would ordinarily be interpreted as representing increasing hunting pressure. Since we know that hunting pressure has remained about constant for the past several years, we can conclude that it represents instead a decreasing stock of animals.

Population Status

The total population of the Pacific walrus is not known. The best estimates, however, are on the order of 45,000 (Brooks, 1954; Fay, 1955, 1957). Of this number, approximately 2,000 to 2,500 are bulls that remain much of the year near the Walrus Islands in Bristol Bay. Aerial surveys during early May 1958, revealed about 5,000 walruses in the Bering Sea, most of which were located north of St. Lawrence Island (Buckley, 1958; Fay, 1958). Kenyon (1958b) estimates that 5,000 to 10,000 passed through Bering Strait on the American side. Thus, something less than one-third of the estimated total population is believed to occur in waters available to the United States for hunting.

In addition to the direct estimates of population, there are some indirect methods that may be used to estimate the condition of the population. The most important of these is the insight into age distribution provided by the same data used in computing the "catch curves." On this basis, 56 percent of the female population is of breeding age and capable of breeding. This unusually high proportion of adults is in itself indicative of a declining population.

Fay's (1955) figures show a productivity rate of 0.39 calves per adult female per year. Combining this with the fact that 56 percent of the females are mature yields a total recruitment of 22 percent for the female population. Assuming an equal sex ratio, the recruitment becomes 11 percent per year for the population as a whole. There is every reason to believe that the sex ratio is not unity; rather, there appears to be a substantial excess of males. This apparent excess of males probably results in part from a preponderance of males at birth $\frac{120}{100}$ males : 100 females, according to Fay (1955), and in part from selective hunting of females by the Diomedea and King Island Eskimos. If there is an excess of males in the population, the recruitment rate is even lower than that computed above.

None of the data at hand are conclusive; however, all of the fragments of information available point to the same conclusion--a decreasing population. To review briefly the evidence for decrease:

1. There has been a decrease in occupied range, and in the number of hauling grounds used.
2. The "catch curve" of females is concave on the right-hand leg; assuming equal hunting pressure, it can be explained as the result of a decreasing population.

3. Mortality (estimated at 12 percent for males and 15 percent for females) exceeds recruitment (11 percent) on the basis of the small samples available.

4. The tusk lengths reported by Freimann (1940) exhibit a higher proportion of old animals than the more recent ones of Brooks (1954) and Fay (1955). This suggests a declining population, when interpreted in the light of selective hunting.

5. The total annual kill is estimated at 10,500 (see "Harvest"), which is 23 percent of the estimated population, and more than twice the estimated annual recruitment of 11 percent. The annual kill in Alaskan waters is estimated at 2,200, which is 22 percent of the maximum number estimated to have passed through the eastern side of Bering Strait.

WALRUS USE AND WASTE

Value of the Walrus

Scammon (1874) describes the usefulness of the walruses to the Eskimo of the Bering and Chukchi seacoasts as follows: "To the natives of the coasts where the walrus frequents, the animal is of indispensable value. The flesh supplies them with food; the ivory tusks are made into implements used in the chase, and for other domestic purposes, as well as affording a valuable article of barter; and the skin furnishes the material for covering their summer habitations, planking for their baidarras, harness for their dog-teams, and lines for their fishing-gear." Walruses are still used for all of these purposes, and in addition the intestines are made into rain parkas, the stomach contents are eaten, and the bacula are sold as curios. But the relative importance of the various parts of the walruses to the Eskimos is changed considerably. Today, the ivory tusks are of first interest to the Eskimos, and much waste results from their hunting the animals primarily for ivory.

It is undoubtedly true that the walrus furnishes the basis for subsistence at several Alaskan villages. While acknowledging that walrus meat for dog food and human consumption is of great importance, we will consider here the monetary value of walrus products other than meat.

The greatest incentive to walrus harvest throughout Alaska is the value of the ivory tusks. Fay (1958) at Gambell estimates that the carved ivory from each adult walrus now brings an average of \$125 -- he further states that "This figure could conceivably be doubled if only the most experienced and capable carvers did the work, for there is an enormous waste of monetary potential in the carvings of novices and second-rate craftsmen." Very little ivory leaves Gambell in the "raw" state.

Kenyon (1958b) at Little Diomedé, on the other hand, finds that a sizable proportion of the ivory taken is sold raw -- much of it traded over the bars in Nome for liquor-by-the-drink. The better carvers usually retain enough ivory to meet the anticipated demand for carving during the ensuing year; however, in 1954, 200 pounds of ivory were shipped in to Little Diomedé for carving, a necessity largely brought about by improvident sale of raw ivory. The usual price of the raw ivory is \$2 a pound; when carved it is worth several times as much.

A second potential source of revenue is from sale of hides. Some female hides are sold locally, after being split (figures 3, 4, and 5), for boat coverings. Prices vary from \$15 to \$50 per hide; relatively few hides are sold. Hides of large bulls are in demand by the jewelry industry for use in buffing silver, and are worth approximately \$150 a hide, f.o.b. Seattle. Two hides were sold at Gambell in 1957, but none before or since (Fay, 1958). At Gambell, where the preponderance of the harvest is adult females and juveniles of both sexes, most hides are cut into sections with the underlying blubber and some of the meat attached. "These slabs, 4-8 inches thick and weighing 75-150 pounds (average about 110) are known as 'mungona.' (Figures 6 and 7). Each is folded over and laced into a so-called 'meatball' with the skin on the outside, and it is stored in an underground pit. These meatballs are used principally for dogfood throughout the summer, fall, and winter. About 8 are obtainable from an average adult female walrus and 10 from a male." (Fay, 1958). At other villages, some hides are used for food, but such use is inconsequential.

The third potential source of revenue is through furnishing facilities and guide service for trophy hunters, who are allowed one bull walrus a year on a special license. One trophy hunter spent approximately \$500 at Little Diomedé in the spring of 1958, and another somewhat less at Savoonga in the spring of 1957. There has been practically no other trophy hunting since it was legalized by the amended "Walrus Act" in 1956; only four licenses were sold in 1957 and six in 1958.

To sum up, walrus are necessary for food at several villages, but the number required to provide food is somewhat less than the number currently taken. The potential value of an adult male walrus, fully utilized exclusive of food, is on the order of \$300; of a female, \$150. Present use yields a return to the village on the order of \$125 at Gambell and \$50 at Little Diomedé.

Harvest

Fay (1958) has estimated the annual kill of Pacific walrus for the period 1950 through 1958. His figures include the actual harvest plus the number sunk and one-half the number wounded. The details of this estimate by villages are shown in table 2. The basis he used for extrapolating the loss figures is the information he has gathered on this subject at St. Lawrence Island. To the Alaskan total kill of 2,200



Figure 3.--Scraping hair and epidermis from walrus hide in preparation for splitting the hide. The hide has been stored in a warm place until the epidermis would "slip." (Photo by Thayer)



Figure 4.--Walrus hide stretched and ready for splitting. (Photo by Thayer)



Figure 5.--Eskimo woman at Gambell splitting walrus hide for use as a boat covering. (Photo by Thayer)



Figure 6.--Eskimo hunter (dressed in walrus-intestine parka) preparing walrus for storage. Pieces of hide measuring about 2 by 3 feet, with blubber and a thin layer of meat attached, are folded and sewed together with walrus hide rope. (Photo by Thayer)



Figure 7.--A completed mungona, or meatball, ready for storage in underground meat hole. (Photo by Thayer)

animals estimated by Fay must be added the annual kill in Siberia. Krypton (1956) states that the annual harvest in Siberia is 4,000 to 6,000. Assuming 5,000 to be the average, and applying the 60 percent figure derived for Gambell (assuming complete utilization of calves), the total loss in Siberian waters is approximately 3,300 and the total annual kill then becomes 8,300. Thus, the total annual kill of Pacific walrus in both Alaskan and Siberian waters is estimated at 10,500 plus or minus about 2,000.

It will be noted that the estimated total kill for Alaska is 2,200 but that only 1,100, or 50 percent, of those killed were retrieved. The factors that are involved in this phenomenal waste are the substance of the following paragraphs.

Hunting Methods and Equipment

The great bulk of walrus harvest in Alaska takes place during the spring, although a few animals are killed in every month of the year. The preponderance of the harvest is made by the people of St. Lawrence Island, King Island, and Little Diomedé Island during March, April, May, and June. At this time the walrus are on their northward migration and are closely associated with floating ice. Herds vary from two or three individuals to groups of 100 or more on an individual floe.

During the period that the walrus are available one or more boats from each village pursue the animals on every day when the weather

Table 2. Estimated average number of Pacific walruses killed annually^a since 1950 in Alaska. (Adapted from Fay, 1958)

Village	Harvest	Loss	Total Killed ^b
Barrow	35	25	60
Diomedede	250	320	570
Wales	35	45	80
King Island	250	320	570
Nome	35	30	65
Gambell	170	95	265
Savoonga	200	155	355
Mekoryuk	25	25	50
Togiak	50	35	85
All others	50	50	100
TOTALS	1,100		2,200

a/ There is marked fluctuation from year to year in the harvest of walruses, caused largely by the availability of walruses and by weather conditions. For example, since 1950 the estimated harvest for different years at Barrow has varied from 0 to 105, at Diomedede from 130 to 507, and at Gambell from 70 to 275.

b/ The annual kill is considered to include the harvest plus the number sunk and one-half the number wounded. It has been calculated by applying the proportions of retrieved, sunk, and wounded animals observed at Gambell to the average harvest figures for each locality. In addition, taking account of the use patterns of the various villages and the proportions of females harvested, an amount equal to about one-half of the number of females killed has been added for calves that are orphaned and subsequently die. An exception was made for Gambell, where most orphaned calves are utilized, and are thus included in the harvest.

is clear enough and ice-free enough to permit hunting. For example, during the period 1952 to 1958 at Gambell on St. Lawrence Island, hunting took place on 84 of 217 days according to Fay (1958). This is an average of one day of hunting for each 2.6 calendar days during the spring migration. Data from Diomedede provided by Kenyon for 1958 indicate hunting on one of each 1.8 calendar days. No information is available on hunting at other locations.

Almost all walrus hunting at Gambell, Savoonga, King Island, and Diomedede is done from boats during the spring season. The boats, known as umiaks, used in these locations are walrus skin covered from about 20 to 32 feet long, and are powered by an outboard motor set at the stern or in a well near the stern of the boat (figure 8). At Savoonga and Gambell the boats are also equipped with sails, and at all locations are on occasion propelled by paddles. At Point Barrow hunting is done from wooden inboard launches.

Each boat is equipped with one, or more often two, outboard motors, one of which is used as a spare. In addition, each boat carries two or three, or occasionally more, harpoons, each attached to a seal skin float by a rawhide line made of walrus calf skin. At Gambell the harpoons are of steel or brass; at Diomedede many are still of bone or ivory with metal tips (figure 9). The average boat crew consists of five or six people at Gambell and up to 10 at Little Diomedede.

Each man is equipped with a rifle and ammunition. Almost all available calibers are represented. At Gambell the predominant types are .222, .220, .270, 30-30, and 30-06. At Little Diomedede about the same weapons are used, and are listed by Fredericksen (1958) in the following order of popularity: 30-30, 25-35, 30-06, .308, .222, and the 22 Hornet. Kenyon (1958b) has the following additional comments to make: "Gun sights of various home manufacture, some loose and held in position with paper, splinters, etc, were not uncommon.... Rust and corrosion had damaged many firearms. Between hunts, guns are sometimes left stored (uncoiled and with adhering salt spray) under the boats. Jamming was not unusual."

The following description, quoted from Kenyon (1958b) refers to Little Diomedede, but is almost equally applicable to Gambell, Savoonga, King Island, and Wales:

"When leads begin to open near the south end of Little Diomedede in May the skin boats are hauled over the shore ice from the village to a location near open water. When pack ice closes in the hunters keep lookouts posted on the cliffs to watch for walrus and/or open leads. When open water is available the boats cruise as far as possible. Usually only a mile or two when fields of pack ice are numerous. Frequent steps are made, so that binoculars may be used from vantage points on the ice to search for game and open water (figure 10). In order to return to the shore ice, the boat must



Figure 8.--Skin boat or umiak threading its way through ice floes during a walrus hunt near Gambell. (Photo by Thayer)

often be hauled over fields of floating ice. Meat is unloaded and hauled back to the village on sleds while some of the hunters sleep, either on the rocks or in the boats. After the shore ice goes out the boats land on the rocks in front of the village.

"Eskimo walrus hunts have been described by numerous writers. Those quoted here amply express our own observations. Albert Heinrich describes Little Diomedea 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 (figure 11)...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.... 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.'

"Spencer (1953), writing of a hunt by Barrow Eskimos, states: '... "sentinels" bawl out a warning and make for the water. Precisely at this moment, the men fire shot after shot into the packed bodies and the slaughter begins.... Many of the animals, wounded, make for the water and dive. Others, more badly injured, may be unable to submerge and so can be picked off in the water. Those remaining on the ice can be readily dispatched. From a herd of as many as thirty-five walrus, five to ten, rarely more, may be taken...butchering begins... other men may seek to harpoon the remaining wounded.' "



Figure 9.--Bone harpoon head with iron tip, used at Little Diomede. The harpoon head is lashed to an ivory foreshaft, which is set in a whale-bone base. (Photo by Kenyon)

Dunbar's (1956) discussion of walrus hunting by Canadian Eskimos applies equally well to hunting at Little Diomede.

"... the introduction of the rifle has, amongst other things, had the effect of making increasing numbers of Eskimos 'trigger-happy',.... 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."



Figure 10.--Lookouts on a pressure ridge of a large ice floe searching the horizon for walrus or other game. (Photo by Kenyon)



Figure 11.--The shooting has started and the walrus are alarmed. (Photo by Thayer)

Estimates were made during the spring of 1958 of the number of shots fired per walrus taken. At Diomedes Island 360 shots were fired at 70 walruses and 60 of these were killed. Of the 60, 23 were retrieved and the other 37 sunk. On those occasions when large groups of walruses are attacked the number of shots per animal is reduced. Eliminating the one such group from the Diomedes figures yields an average of 37 shots per walrus killed. At Gambell, according to Thayer (1958), of 36 walruses attacked by hunters, 24 were shot and 12 of these recovered. The average number of shots fired was 8.8 shots per walrus retrieved and 4.4 shots per walrus hit.

The cost of harvesting a walrus, exclusive of the hunters' time, is estimated at \$15 to \$20.

Waste

Fay (1958) reports on waste during hunting at Gambell. During the spring of 1958 when he was accompanying hunting parties, 82 walruses were shot at and hit; 34 of the adults and juveniles hit by rifle fire were wounded and their ultimate fate is unknown. "Probably at least half of these eventually died from loss of blood and wound infections for very few animals with healed wounds have ever been taken at Gambell." (Fay, 1958). Of the 48 killed, 6 sank before they could be retrieved and the remaining 42; that is, 51 percent of the total animals shot, were secured and butchered. These figures do not include calves because they are almost always secured regardless of the fate of their mothers. Fay (1958) further provides information on the recovery of walruses on ice versus those shot in the water. Twenty-nine of 53 animals shot on the ice were retrieved as compared to only 17 of 37 shot in the water. This represents 55 percent recovery of animals on the ice and 46 percent of those in the water. Of animals shot in the water Brooks (1954) noted that adult males and juveniles of either sex almost always sink whereas adult females often float.

Kenyon provides similar information for 1958 hunting at Diomedes. He says: "Of 141 adult walruses known killed, 85 (60 percent) were taken and 56 (40 percent) were lost. On 10 trips, when records were kept by non-native observers, the following figures were obtained: total kill 55, total taken 26 (47 percent);.... If calves are included (on the assumption that orphaned calves will die), the total animals known killed is 245, the take 117 (48 percent) and the loss 128 (52 percent)." (Kenyon, 1958b).

Thayer (1958), Fredericksen (1958), and Kenyon (1958b) all comment on the failure of Eskimo hunters to retrieve dead walruses. In their opinion, loss could be greatly reduced if the hunters would harpoon the animals as soon as they are dead, but the Eskimos' fear of having wounded walruses attack the boat often results in delay until they are sure the animal is dead. In Thayer's words "If the Eskimo hunters would get on the ball and promptly secure a dead floating walrus with a harpoon and seal skin float rather than milling around and endlessly discussing the situation, many walruses that are lost would be saved."

Another measure of the magnitude of the waste involved in walrus hunting is the number of carcasses that wash ashore north of Bering Strait. During July 1958, a survey of the beaches from Wales north to Point Franklin revealed 68 walrus carcasses, most of which were headless or tuskless. Presumably the tusks were salvaged from many after they washed ashore. Ice cover along the beach prevented counts north of Point Franklin. The situation is not new or unusual; over a thousand walrus carcasses, two-thirds without tusks, were noted between Cape Lisburne and Wainright Inlet in 1923 by Bernard (1925).

Observers on both St. Lawrence Island and Diomedede indicate that there is a strong selection for adult females. Fay (1958) lists the order of preference as follows: (1) Large adult females with newborn young; (2) any adult female with newborn young; (3) large adult females without young; (4) adult females without young; (5) large adult males; (6) any adult male; and (7) juveniles of either sex. He continues, "The newborn young are particularly desired for their hide and tender meat, but the juveniles are considered to have the least desirable hides, ivory, and meat and they are seldom taken except when struck by a stray bullet or when nothing else is available. Adult males provide an abundance of high quality meat, skin, and blubber for dogfood, but their great size, toughness and tendency to sink when killed are of negative value in the Gambell hunters' order of selection." Essentially the same preference is exhibited at Diomedede but is most operative when large numbers of animals are available. When only a few are present, any animal is taken.

In addition to the waste of animals that takes place by wounding animals or from dead walruses sinking without recovery, there is further waste of the animals retrieved. It is safe to say that there is no waste of ivory of those animals recovered. However, the desirability of the ivory leads to the practice of "head hunting" for ivory alone, and thus brings about an enormous waste of meat and hides. "Head hunting" has been virtually eliminated at Gambell (Fay, 1958), but is prevalent at King Island and Little Diomedede. Fay's data indicate that 47 percent of the live weight of walruses taken was used and that 56 percent of what he considered the usable weight was used. Kenyon provides similar information. On the basis of 107 walruses at Diomedede he found 28 percent utilization of the 75,000 pounds of meat that were available. He considered an animal as used if it was brought to the village, although not all of this meat was ultimately actually used. As to hides, he found that 30 of the 107 hides of adults were used.

Soviet regulations, according to Kleynenberg (1957), categorically forbid the killing of cows with calves, or of walruses in the water. Kenyon (1958b) presents evidence that hunting by Siberians is somewhat more directed than among Alaskan Eskimos, with a crew chief in each boat, who determines what walruses will be shot and who will shoot. Furthermore, the utilization of animals harvested is far more complete under Soviet direction than under the highly individual and unorganized mode of operation prevailing among Alaskan Eskimos.

To sum up the waste involved in walrus hunting: of each 100 walruses killed only about 50 are recovered and of these, the number rather completely used varies from as high as 30 at Gambell to less than 20 at Little Diomede. It seems safe to assume that less than one-fourth of the walruses actually killed are entirely used, and that even the ivory (the most desired part of the walrus) is recovered from only half of those killed.

HIGHLIGHTS OF IMPORTANCE TO MANAGEMENT

Certain items presented in this report are of special significance for application to management. These are:

1. The Pacific walrus population has declined from an estimated 200,000 in the mid-nineteenth century to an estimated 45,000 at present.
2. Mortality in the population is essentially all from human exploitation. Food supplies are believed to be adequate to support much higher populations than now exist.
3. The estimated annual kill in Alaskan waters is 2,200; only about 1,100 are actually recovered, and the other 1,100 are lost. In Siberian waters the kill is estimated at 8,300. Thus, the total kill is estimated at 10,500, or 23 percent of the estimated total population.
4. The annual recruitment is on the order of 11 percent. Thus, mortality is estimated at more than twice the recruitment, and the population is continuing to decline. Other evidence confirms this decline.
5. In addition to the waste of half of the walruses killed through non-recovery, there is additional waste of approximately half of those walruses recovered.
6. The Pacific walrus population occurs in international waters, as well as territorial waters of the U.S.S.R. and the U.S. Thus, international cooperation is necessary to effectively census the population and to regulate the harvest.
7. Walruses are harvested for human food, dogfood, hides for boat coverings, and for ivory. Females and young are preferred for food.
8. Hunting for ivory alone is practiced at many locations. The most practicable way to discourage this hunting is to remove the incentive. This could be done by prohibiting the sale of raw ivory.

9. Hides of mature male walruses are worth approximately \$150 f.o.b. Seattle. Very few hides have reached the market since export became legal in 1956. Encouraging sale of suitable hides would result in greater value being received from the animals killed.

10. Trophy hunting by whites results in a greater value of the individual walrus killed. It also reduces the amount of time that can be spent on other walrus hunting by the Eskimos acting as guides, and thus reduces the kill.

11. The only hauling ground regularly used by walruses in Alaska is in the Walrus Islands in Bristol Bay. The walruses there should be given complete protection.

NEEDED KNOWLEDGE OF THE PACIFIC WALRUS

The additional knowledge needed to effectively manage the Pacific walrus is categorized in the following outline:

1. Population level and distribution:
 - a. Total numbers and distribution, in both U.S. and U.S.S.R. waters.
 - b. Sex and age composition. Distribution by sexes and ages in time and space. For example, during what part of the year are the Walrus Islands used by walrus, and where do these animals spend the rest of their time? What segregations occur seasonally, if any?
 - c. Factors affecting distribution, such as ice location and drift, ice formation in the fall, southern limit of ice in winter, etc.
2. Biology:
 - a. Improved methods of age-determination, as an aid to solving b and c.
 - b. Recruitment:
 - 1). Sex ratio, at birth and at succeeding ages.
 - 2). Segments of the population involved in breeding, and breeding behavior. Geographic location of breeding.
 - 3). Minimum breeding age, by sexes.

- 4). Age-specific fecundity and fertility rates.
- c. Mortality:
 - 1). Mortality rates.
 - 2). Agency.
3. Harvest:
 - a. Distribution - seasonally and geographically, by sexes and ages.
 - b. Utilization - for food, ivory, hides:
 - 1). How many are needed, by age and sex, by villages?
 - 2). What proportion of food spoils or is otherwise wasted?
 - 3). How much ivory is actually carved in each village, and how much is sold "raw?"

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