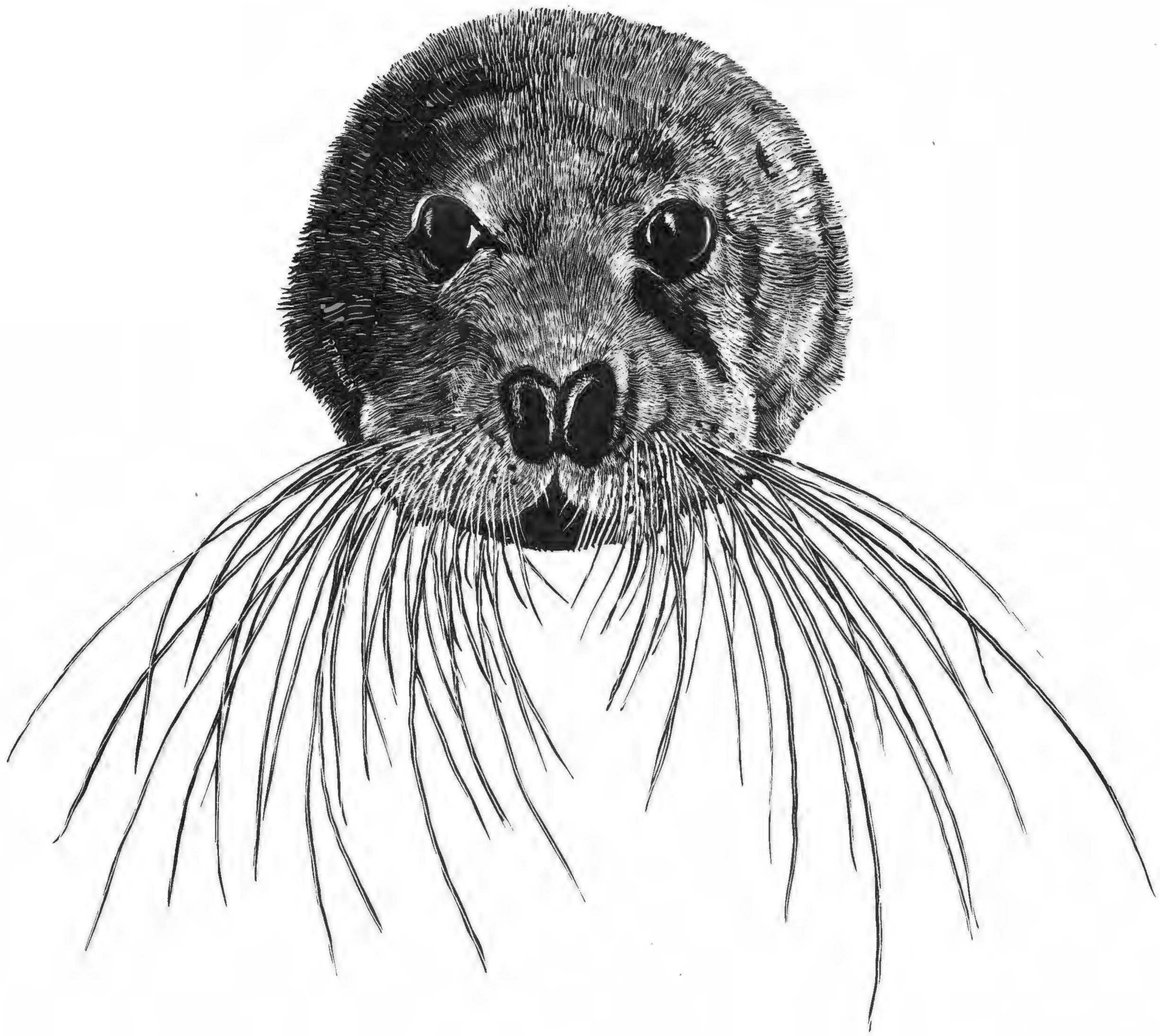


THE

PACIFIC BEARDED SEAL

ALASKA DEPARTMENT OF FISH AND GAME

Juneau, Alaska

STATE OF ALASKA
DEPARTMENT OF FISH AND GAME
JUNEAU, ALASKA

STATE OF ALASKA
Walter J. Hickel, Governor

DEPARTMENT OF FISH AND GAME
Walter Kirkness, Commissioner

DIVISION OF GAME
James W. Brooks, Director
Don H. Strode, Federal Aid Coordinator

THE PACIFIC BEARDED SEAL

by

John J. Burns

Federal Aid in Wildlife Restoration Project Report covering investigations completed by December 31, 1966. Volume VIII: Projects W-6-R and W-14-R.

Cover by: R. T. Wallen

July, 1967

TABLE OF CONTENTS

Page

LIST OF ILLUSTRATIONS

THE PACIFIC BEARDED SEAL

ABSTRACT

A study of bearded seals in the eastern Bering and Chukchi Seas was initiated in 1962, when increased exploitation of these seals was apparently just beginning. This report is based on information obtained from 671 seals, and field observation of numerous others.

Age determinations are based on the number of growth ridges observed on claws from the fore flippers. Teeth are frequently worn down to the gums by age seven, and are often lost by age ten. Seals increase in size from about 37 kg and 131 cm at birth, to 85 kg and 147 cm at the end of the brief nursing period. At physical maturity they are approximately 234 cm long. There is considerable individual and seasonal variation in weight, ranging in some cases from 277 kg during the summer to more than 360 kg during the winter and early spring. Food is mainly crabs, shrimp, clams, decapods, isopods, sponges and other bottom dwelling invertebrates and fishes. There is a period of reduced feeding activity during late spring and early summer, but this is not as marked as in other phocids. Pregnant females remain in better condition than other adults during this period. The sex ratio in all age groups approximates 1:1. Females sometimes begin ovulating by age three, but are not capable of becoming pregnant until five or six. Males become sexually mature between six and seven years. The main breeding period is from mid-April to mid-May. Implantation occurs during late July and early August, after a delay of about 2 1/2 months. Birth occurs primarily during late April. The pregnancy rate in mature females is between 80 and 85 per cent, and the rate of reproduction in the population as a whole is estimated at between 22 and 25 per cent. These seals are generally unsociable, and frequently fight during the rut. Males produce a distinct and specific sound during the breeding season, which is probably part of the courtship behavior. It appears that neither the abundance of prey species, nor water depth affects the distribution of these seals throughout the area underlain by the Bering-Chukchi Platform. Seasonal movements and distribution patterns are primarily the result of ice conditions, although there is a general movement away from the coast during early winter. This coincides with an influx of mature ringed seals. Adult bearded seals are almost always found in association with ice, although juvenile seals often remain in ice free areas. The annual harvest of bearded seals in Alaska is about 3,400; and the total kill is probably between 7,000 and 9,000. Hunting loss can be decreased to offset exploitation if the latter increases significantly.

INTRODUCTION

The seals inhabiting coastal waters of Alaska can be divided into two broad categories. These are the "eared seals" (Family OTARIIDAE) including fur seals and sea lions, and the "earless seals," or hair seals (Family PHOCIDAE) which includes the bearded, ringed, ribbon, harbor, and an occasional elephant seal.

The Pacific bearded seal (Erignathus barbatus nauticus) is the largest of the phocid seals normally occurring in Alaskan waters. It inhabits the area north of the Aleutian Islands where sea and shore ice form during the winter. This seal is an almost completely aquatic animal which, in this area, rarely frequents land, and in general, only seasonally comes out on the ice. They are usually sparsely distributed throughout their circumpolar range, although groups of 50 to 100 are occasionally seen. They are not gregarious to the degree that fur seals and sea lions are.

Scheffer (1958) indicates that they are ". . . more or less resident, moving casually and not in regular migration." However, the majority of bearded seals in the Bering and Chukchi Seas do move with the seasonally advancing and retreating sea ice, and are strongly migratory, moving north each spring and south each fall. A small number of bearded seals apparently do not migrate. These include some juveniles which remain along the coast after the ice is gone, occasionally frequenting bays, brackish water estuaries and river mouths. Also, seals remaining in the northern Chukchi Sea and Arctic Ocean do not have to move far to remain near ice.

There are two subspecies of bearded seals presently recognized in the literature. These are E. b. barbatus (occurring in the eastern Arctic and sub-arctic), whose range is considered to include the suitable habitat from the Laptev Sea westward to the central Canadian Arctic Archipelago; and E. b. nauticus (occurring in the western Arctic and sub-arctic), which occurs from the central Canadian Arctic Archipelago westward to the Laptev Sea (Scheffer, op. cit.). The eastern and western limits of distribution for the two subspecies are very uncertain, and in actuality probably do not exist. At the presently recognized western limit (Laptev Sea) there is no barrier to the movement of bearded seals in either direction. However, any major inter-mixing of the two forms (this could most easily occur during the late summer) would be after the breeding season. As Scheffer (op. cit., p. 109) indicates, in spite of the close relationship between the two forms it is probably desirable at this time to retain the separate names, in view of their firm establishment in systematic literature.

Because of their large size, high quality meat and blubber, and strong, durable skin, the bearded seal (Eskimo terms--mukluk or oogruk) has always been important in the economy of the coastal Eskimos. These seals are still an important item in the comparatively new subsistence-wage earning economy of the present day. In addition to supplying food and raw material for the home manufacture of such items as rope, boot soles, boat coverings, and harnesses, the raw pelts now have a commercial value. In Alaska the commercial value of seal skins has greatly increased, especially since 1962. Skins of young bearded seals which had little or no commercial value prior to 1962 are now worth as much as $20.00. The number of seal scalps submitted to the State of Alaska for bounty has greatly increased, indicating increased hunting effort. Soviet hunters from eastern Siberia are also taking advantage of the presently high prices, and have increased their hunting effort on this commonly shared resource. Exploitation of all the seals in this area has been increasing since 1961, and it appears that this trend will continue.

Recent reports from hunters, as well as sightings of Soviet hunters and their equipment indicate that in addition to the subsistence hunting carried on by the Siberian natives, organized commercial seal hunting is being conducted. The commercial sealers are using mother ships from which five to eight smaller hunting boats operate. The number of such fleets in operation is unknown. Bearded seals seem to be the most sought after seal in the northern Bering Sea-Bering Strait area (Tikhomirov, 1964; Krylov, et al, 1964).

At present there is little information available concerning the various aspects of bearded seal life history, and nothing which would indicate the possible effects of increased exploitation. Rational exploitation of these seals for commercial purposes, and to feed a rapidly increasing human population, demands that particular aspects of the biology of these seals be clearly understood.

Starting in 1962, the Alaska Department of Fish and Game initiated a study of the bearded seal, the objectives of which were to learn the magnitude of the Alaskan harvest; determine the factors affecting abundance, distribution and seasonal movements; and to add to the present body of knowledge concerning general life history, growth rates, reproductive physiology, and ecology. Where applicable, comparisons have been made with the results of studies conducted in other areas.

Field work for the Alaskan studies has been conducted concurrently with investigations of other marine mammals, particularly of the Pacific walrus.

The most productive hunting for both walrus and bearded seals occurs during the spring and summer (April through August) when boats can be employed. Within this period productive hunting is progressively later at the more northerly hunting sites, due to the later break-up of sea ice. The number of bearded seals taken by hunters is directly affected by the abundance and availability of walrus. When walrus are not available, or the harvest is insufficient to supply the needs of hunters, more effort is devoted to the taking of bearded seals, and vice versa.

During the spring hunting seasons of 1962, 1963, 1965, and 1966 walrus were sufficiently available to hunters, and they did not take bearded seals in any large numbers. However, the 1964 spring season was very poor as far as walrus hunting was concerned. In an attempt to fulfill requirements for skins, food, and oil, the hunters at several villages turned to the hunting of bearded seals. It was during the spring and summer of 1964 that much of the material for this report was obtained.

Previous Contributions to the Knowledge of Bearded Seals

As a result of intensified commercial hunting of whales during the 19th century, and several expeditions to the poorly known northern areas, naturalists were provided with the incentive and the means to investigate the forms of life found there. As a result, numerous books, scientific papers and articles appeared during the 1900's, dealing with marine mammals. Since live bearded seals were seldom seen in any numbers by naturalists, comments concerning these seals dealt mainly with descriptions of appearance, location of occurrence, and records of the harvests made by residents of the areas visited. Very little information concerning the biology of these seals was published.

A few of the more informative papers include those written by Beechey (1831), Kumlien (1879), Allen (1880), Murdoch (1885) and Healy (1887, 1889). Allen's (op. cit.) monograph dealing with the taxonomy and general life history of all North American pinnipeds was probably the most complete work done during that time.

Most of the pertinent publications during the first two decades of this century continued to deal with the pinnipeds in a general way only. Later, as was the case with the Pacific walrus, *Odobenus rosmarus divergens*, Soviet biologists took the lead in initiating basic biological and ecological investigations. Notable contributions to our knowledge of seals, including bearded seals, were published by Chapsky (1938) and Sleptsov (1943, 1949).

It was not until quite recently that any intensive investigations of bearded seals were reported. And even then, as in earlier studies, most of the important recent publications deal primarily with the species of seals that occur in greatest abundance. Among the few publications of particular importance from the standpoint of a knowledge of bearded seals, are those of Scheffer (op. cit.), McLaren (1958), Kenyon (1962), Burns (1965), Johnson, *et al* (1966) and Tikhomirov (1966).

Much of the literature presents differing views concerning age at maturity, the time of breeding, the frequency of pupping, wariness, population movements and general abundance. In regard to these, some of the conflicting reports probably arise from the fact that in some locations these seals are strongly migratory, while in other areas they are not; they are usually rather sparsely distributed, but during certain seasons, and under favorable conditions they will congregate in relatively large groups; and their wariness or reaction to the presence of man is highly variable. During the winter months, most bearded seals will become alarmed at the slightest sound of an approaching boat, or at the movements of a hunter on the ice. Yet during the fall and late spring seasons I have watched seals closely approach a boat after being shot at, apparently to investigate the cause of disturbance, or remain stationary, intently peering at me over the edge of an ice floe.

Introduction

Much of the confusion regarding various aspects of reproduction apparently arose because different methods for determining age have been employed, the occurrence of delayed implantation of embryos was overlooked by some investigators, and in some instances apparently inadequate samples of female reproductive tracts were obtained. The publication by McLaren (op. cit.) is probably the most helpful with regard to growth and reproduction of bearded seals.

METHODS AND MATERIALS

Field work has been conducted in Alaska during spring and early summer at several widely scattered villages, most of which are in the northern Bering Sea-Bering Strait area. These villages include Gambell, Savoonga and Northeast Cape on St. Lawrence Island, King Island, Little Diomede Island, Wales and Nome. During August, 1964 and July, 1965 work was conducted in northern Alaska at the villages of Wainwright and Barrow. Figure 1 shows the location of sites where field work was conducted, as well as the distribution of bearded seals.

As far as possible, field work was undertaken throughout the year. The limited amount of specimen material acquired during late fall and winter was taken primarily from the vicinity of Nome. Unfortunately, an adequate sample of material from this period of the year has yet to be obtained.

During the winter months bearded seals are only sparsely distributed along the coast, and hunters take relatively few. For the most part, investigations conducted by other workers have been discontinued during the late fall, winter and early spring.

At the present time we are endeavoring to acquire this needed material in order to insure more accurate and complete knowledge of the ecology and life history of these animals.

Weather and ice conditions, as well as differences in the way seals are handled by hunters from the various villages in Alaska, determine how much specimen material can be obtained from the seals that are killed. Hunters in the Bering Strait area usually butcher the bearded seals at or near the place where they are killed, making it impossible to obtain a series of weights and measurements from adult seals. However, a large amount of specimens including reproductive tracts, skulls, claws, stomachs and notations of date, sex and pertinent comments were obtained.

Body weights and measurements were obtained from sub-adult seals in the Bering Strait area, and from adult animals taken at Barrow and Wainwright.

At Wainwright the most productive hunting period is during July and August. At that time the extensive shore ice has usually moved off, allowing the hunters to bring the large seals (and walrus) to the beach with little trouble. These animals were weighed intact using a tractor equipped with a hydraulic lift, or a small Caterpillar crane (Figure 2).

Most of the body measurements taken were those outlined by McLaren (1958b). However, there were some additions, and a few minor changes. The measurements used in this study are as follows:

Zoological length - measured over curvature of body from tip of nose to end of tail, with head and neck in a natural position.

Fig. 1. Location map showing position of some of major hunting sites and the southern limit of the normal effective winter range of bearded seals (ıııııııı). During some winters the sea ice, and bearded seals, move further south.

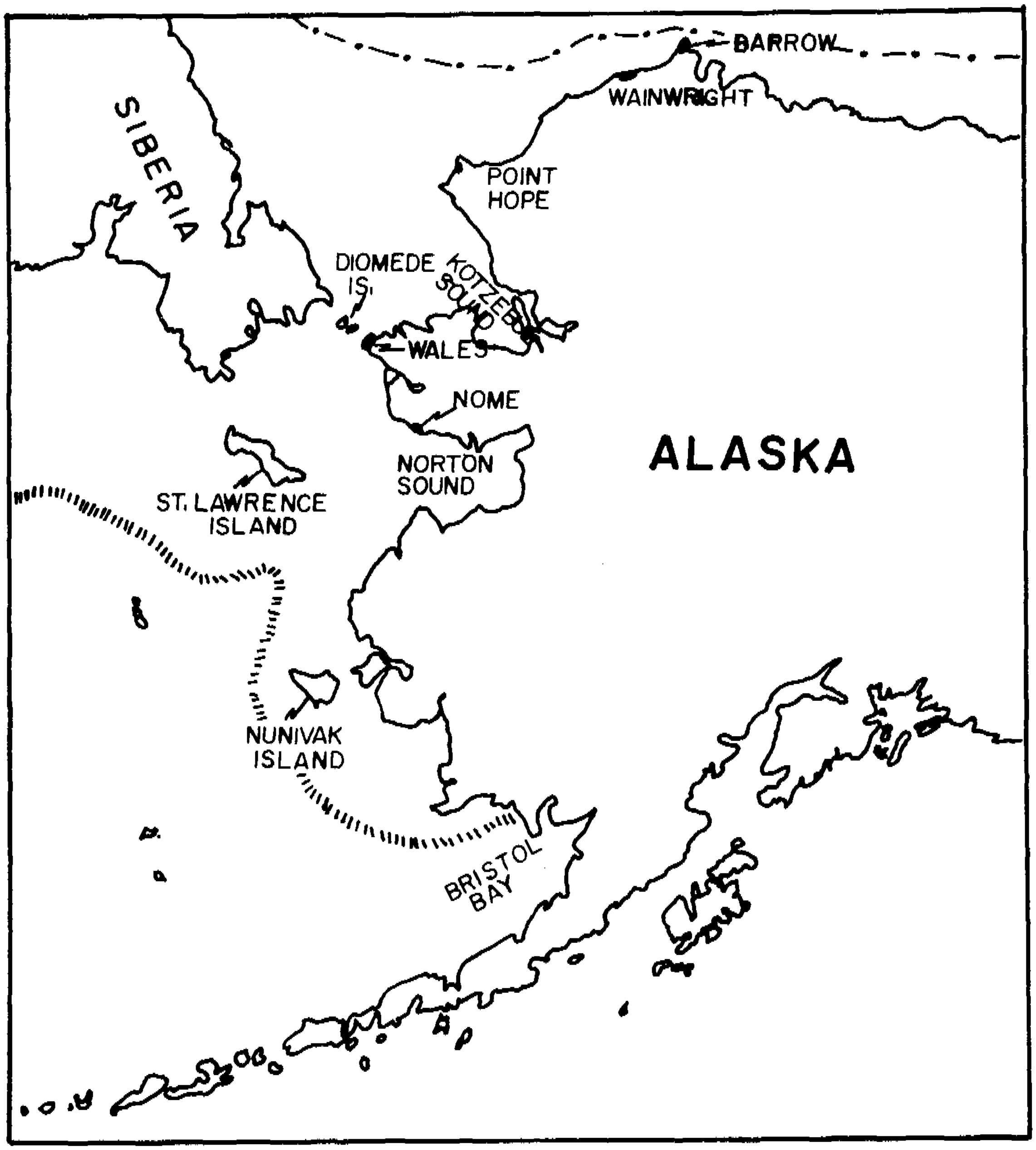


Fig. 2. Weighing a whole bearded seal. All of these seals were weighed intact, using either a tractor equipped with a hydraulic lift, or a Caterpillar crane. August 8, 1964.

Standard length - measured along a straight line on a flat surface, from tip of nose to end of tail with head and neck in a natural position.

Tail length - measured from the externally visible base of the tail to the end of the tail.

Girth - taken around the body immediately behind the fore flippers.

Auxiliary Girth - the largest circumference around the abdomen. This measurement usually exceeded girth.

Navel to anus - the distance along the curvature of the body from the center of the umbilical scar to the anterior notch of the anus in males, and to the vestibule of the female.

Penis to anus - measured along body contour from the center of the penile orifice to the anterior notch of the anus.

Fore flipper length - the distance along the anterior border of the forelimb, from axilla to tip of longest digit (not claw).

Fore flipper width - the straight line distance from the tips of the first and last digits (not claws) of the spread flipper.

Hind flipper length - measured from the level of the astragalus bone, along the inner edge of the extended flipper, to the level of the longest digit.

Hind flipper width - the straight line distance from the tips of the first and last digits (not claws) of the spread flipper.

Weight - taken with a 500 or a 2,000 pound capacity scale.

Measurements of the same animal, taken by different persons often varied widely. For this reason, hunters were requested to furnish only the zoological length and girth of the seals they killed. It was found that these measurements did not vary appreciably when several people measured the same animal. Tables showing complete series of measurements are composed solely of the author's data.

Field numbers used by this writer are a combination of letters and numerals indicating the location, number of the animal and the year of capture. Thus, W-10-64 would designate specimen number 10, collected at Wainwright in 1964. Vital information including the date of capture was recorded on field data forms. This method proved very satisfactory as work was conducted at only a few sites, during successive years. Examples of field numbers used are as follows: N-00-62, Nome; W-00-64, Wainwright.

The digits of the fore flippers were allowed to rot, and the claws extracted (as suggested by McLaren, 1958b). Reproductive materials, except bacula, were preserved in 10 per cent formalin. Skulls and lower jaws were cleaned by Dermestes beetles.

The method of aging seals by examining sectioned canine teeth is not applicable to bearded seals, as in many cases the teeth are almost completely worn down or missing. In this study, all estimated ages of seals are based on examination of claws.

The presence of growth ridges on claws of harp seals (Pagophilus groenlandicus) has been mentioned by Plekanov (1933). Doutt (1942) also discusses the presence of bands on the claws from the fore flippers of the ringed seal (Phoca hispida), the ribbon seal (Histriophoca fasciata) and the bearded seal. Laws (1953) mentions the use of claws for determining the age of young elephant seals (Mirounga leonina). However, wear of the claws in elephant seals is so great that they are useful only on animals up to four or five years old. McLaren (1958a,b) describes in detail the method of age determination employed in this study. In young seals up to three years of age I have found a direct correlation between age as determined from claws, and age estimated from general appearance in the field. An experienced observer can estimate the age of bearded seals, from general appearance, up to three or four years of age. There was also an excellent correlation between estimated age and relative (or advancing) age as determined by ossification of skull sutures.

All claws were soaked in a solution of 50 per cent alcohol and xylol for at least two days prior to examination. Age determinations were made while the claws were still wet. Soaking greatly increased the contrast, and made the growth ridges, or rings, more distinct.

As with bearded seals in the eastern Canadian Arctic, the light bands on the claws of our specimens are laid down during the summer, and the ridges are formed during the late winter and spring. Formation of a ridge is probably associated with decreasing feeding activity during March through June. Claws from pups of the year, taken from the time they are born (late April) until February, do not show any rings. However, by May a ring is obvious.

Although claws were collected from all animals examined, a large portion of the material collected prior to 1965 was destroyed by fire.

Female reproductive tracts collected during the spring were examined in the field for recent placental scars, and only the ovaries were preserved for later examination. Those collected during July and August were tied off at the cervix, and distended by injecting with 10 per cent formaldehyde. The entire reproductive tract was then placed in formaldehyde. Ovaries were cut into sections of one to two mm thickness, and examined for corpora lutea, corpora albicantia and follicles. Ovary dimensions and weights were recorded. The size, position and number of corpora albicantia, corpora lutea and larger follicles were diagrammed and noted on individual cards, along with the animal's age, reproductive condition (as observed in the field) and other miscellaneous data. A small series of ovaries was saved for later histological examination.

Cleaned bacula were weighed an measured.

Testes were measured and weighed (with and without the epididinous attached) to provide an estimate of volume. The equation used for determining volume was: $v = 4/3 \pi a^2b$, where $a = 1/2$ width, and $b = 1/2$ length (see Brenner, 1964). Histological sections of a selected series of testes from 63 seals were commercially prepared. Testes samples were stained with hematoxylin-eosin, and cut into sections 8 - 10 μ in thickness.

A small series of seal stomachs was collected at Savoonga during May and June, and at Wainwright during July and August. The total volume of stomach contents was recorded, as was the volume and per cent of the main items in each stomach.

Extensive field observation, reports from hunters, and bounty record forms provided most of the information concerning general movements, migration timing, seasonal distribution and characteristics of the annual harvests.

To date, information and/or specimen material has been obtained from 671 bearded seals. Dr. F. H. Fay, Arctic Health Research Center, Anchorage, Alaska, also supplied data and some specimen material from an additional 116 animals. Throughout this report, discrepancies in sample sizes are due to lack of various parts; as for instance when hunters saved only claws and a notation of date and sex of the seals. The actual sample size is mentioned in connection with each topic of discussion.

PHYSICAL CHARACTERS

General

Adult bearded seals are quite variable in color, some being a tawny-brown, some silver-grey, and some dark brown. They are usually slightly darker on the dorsal side. Unlike the other northern phocids, the adults have neither spots nor bands.

They are by far the largest of our northern seals, often weighing in excess of 350 kg (770 lbs) during the winter months. The comments included in Allen's (*op. cit.*) account--that the weight of males in "full flesh" varies from 13 to 15 cwt--appear to be gross over-estimations. Johnson, *et al* (*op. cit.*) recorded the weight of an adult female supporting a term foetus as 793 lbs (about 361 kg). No allowance was made for blood or body spilled. During the summer months large seals will weigh as much as 600 lbs (273 kg).

As is indicated by the seasonal differences in weights mentioned above, there is a seasonal change in feeding activity. However, during the period of decreased feeding activity, these seals do not completely fast as is the case with some of the other seals. Pregnant females taken during August were in much better condition and therefore heavier, than other bearded seals taken at the time, and they probably continue their normal feeding throughout the early summer.

Bearded seals can be easily distinguished from other seals in the water by the way they swim and dive. They most commonly swim with both head and part of the back exposed. When diving, they almost always raise their backs and hind flippers out of the water, arching downward head first.

By comparison, ringed, ribbon and harbor seals usually swim with only the heads exposed, and submerge by "sliding backwards" beneath the surface. However, sometimes harbor seals will roll on their flanks, slapping the water with their front flippers. These differences can be illustrated schematically as indicated.

BEARDED RINGED

Upon close examination it can be seen that the bearded seal derived its common name from the presence of numerous, comparatively long whiskers (mystacial vibrissae). The third digit of the fore flippers is the longest, giving the distal edge of the flipper a slightly rounded appearance. In the other phocids of this area, the first digit is the longest. The fore claws of bearded seals are strong and heavy. Claws on the hind flippers appear rudimentary, with the fleshy part of the flipper extending beyond the claws. The third digit of the hind flipper is the shortest; digits one and five, and two and four are of equal length with the former being slightly longer. In adults, hind flipper length is approximately 43 cm (17 in.), and width when fully extended is as much as 61 cm (24 in.). They are powerful swimmers and command the respect of hunters using harpoons. The hind flippers provide all the power for locomotion, fore flippers being held against the body except when turning, banking or coming to a stop. As in all other phocids, the hind limbs cannot be rotated forward.

Unlike other phocids which have two mammary teats, the bearded seals have four. This is a characteristic shared with the monk seals, genus *Monachus*.

When born, bearded seal pups weigh approximately 35 kg, and are about 130 cm long. Color shortly after birth is usually silvery or bluish-grey (occasionally dark brown). Many pups have large, irregular, brown spots. In some newborn pups, the large white areas found on the crown of the head and along the back are obvious.

Dentition

The permanent teeth present in young bearded seals are larger than those of ringed or ribbon seals. However, tooth wear is rapid, and the teeth of bearded seals are usually worn down, or missing, by the time the animals are nine years old.

The typical dental formula of young bearded seals is the same as that of other phocids, and can be summarized as follows:

$$\mathrm{i}\ \frac{3}{2}\ \mathrm{c}\ \frac{1}{1}\ \mathrm{pc}\ \frac{5}{5} = 17 \times 2 = 34$$

Variations from this typical formula are not uncommon, and those which have been observed include absence of the first (medial) upper incisor, presence of a sixth upper postcanine, and presence of a supernumerary third lower postcanine. The dentition observed in bearded seals, showing the common irregularities, is as follows:

$$\mathrm{i}\ \frac{1\ (0)\text{-}2\text{-}3}{0\ \text{-}2\text{-}3}\ \mathrm{c}\ \frac{1}{1}\ \mathrm{pc}\ \frac{1\text{-}2\text{-}3\text{-}4\text{-}5\text{-}(6)}{1\text{-}2\text{-}3\text{-}(3)\text{-}4\text{-}5\text{-}(0)} = 32 - 36$$

The incisors, canines and first postcanines are single rooted. However, in several instances the upper and lower first postcanines show distinct longitudinal grooves on both the lingual and buccal surfaces of the root. Postcanines 2-5 (also 6 when it occurs) are strongly double rooted, each root being in a separate part of the alveolus. In one instance PC 3 had three roots.

When the jaws are closed the canines and postcanines are usually interlocked, with each lower tooth just forward and medial to the corresponding upper tooth. The relative size of postcanines (from smallest to largest) is 1-5-2-3-4.

As in other phocids of this area, the upper incisors increase in size from medial to lateral (PC 1 to PC 3). The lower incisors are much smaller and the size order is reversed (the lateral one being larger than the medial). The upper canines are two to three times heavier than their lower counterparts, and approximately 1 1/2 times as long.

At birth the young bearded seals have a complete set of permanent teeth, and usually all but postcanines 1 and 2 are erupted. All the teeth are erupted within a few days of birth.

Quite obviously the deciduous or milk teeth are lost *in utero*, but the exact timing of deciduous tooth development and loss has not been thoroughly investigated.

Three approximately mid-term foetuses which I have examined, show that the deciduous dentition is the same as that observed in other phocids of northwestern Alaska:

$$i\ \frac{3}{2}\ c\ \frac{1}{1}\ pc\ \frac{3}{3} = 26$$

Tooth Wear

The situation with regard to tooth wear, and eventual loss, is an interesting one for many reasons. Bearded seals are predominantly benthic feeders utilizing among other things considerable quantities of clams, crabs and shrimp. Walrus are also benthic feeders which eat mainly clams. It is a commonly held belief that the walrus utilize their tusks in digging up the clams they eat. However, I think that the walrus tusks are used mainly for display, to assist in locomotion (climbing on ice and land), and for defense and offense. The importance of these functions is probably in the order mentioned. A point which indicates that the walrus tusks may not be important for obtaining clams, is that adult bearded seals with no teeth at all effectively prey upon clams. Judging by the appearance of ingested clam parts (mostly siphons and feet) they tear them from the clams in the same manner as does the walrus--by strong suction.

The phenomenon of excessive wear and eventual loss of teeth in older bearded seals is probably the result of evolutionary degeneration in tooth structure (strong well-developed teeth are not required to catch and hold slow moving or sedentary prey) and the fact that excessive wear results from utilizing the abrasive benthic invertebrates, as well as from ingesting relatively large quantities of sand.

The rate of tooth wear varies in individual animals. However, skulls or lower jaws collected from over 600 bearded seals provide a general indication of tooth wear. The progression of tooth wear in seals of different ages is shown in Figure 3.

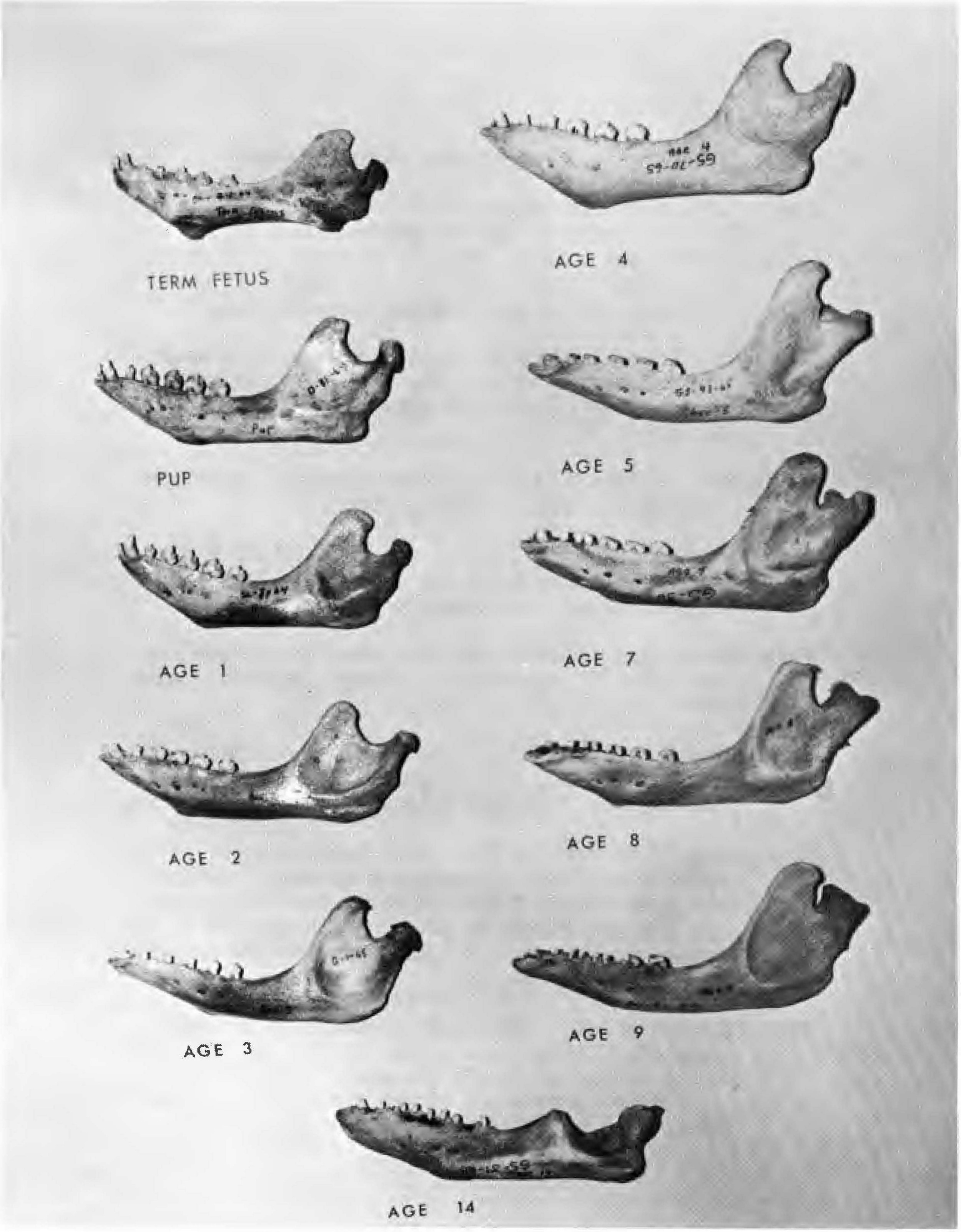


Fig. 3. Tooth wear in Pacific bearded seals from Alaska. By three years of age the teeth are well worn, and by age nine the mouth appears toothless as the gums cover the remaining tooth portions.

The general progression of tooth wear is as follows:

Pups - all teeth are erupted within a few days of birth. By five weeks of age the sharp crowns of the incisors and canines begin to show signs of wear. Postcanines usually tri-cuspate; however, postcanines 4 and 5 are frequently quadri-cuspate.

One year - lingual surfaces of all teeth show considerable wear. In some animals the incisors, canines, and postcanines 1 through 3 show heavy wear on the crowns.

Two years - crowns of all teeth are rounded. Wear most apparent on incisors and canines.

Three years - incisors, canines and postcanines 1 through 3 worn down almost to the gum line. Original cusps on postcanine 4 no longer obvious.

Five years - postcanine 4 now worn down to the gum line and crown of postcanine 5 almost completely worn away.

Seven years - crowns of all teeth except postcanine 5 completely worn down to gum line. In some cases postcanines 2 through 4 have only roots remaining.

Nine years - the rate of tooth wear has decreased as remaining portions of teeth are protected within the gums. Very little if any parts of the teeth are obvious above the gums. Mouth appears to be essentially toothless. Most postcanines persisting only as roots.

Ten years and older - some teeth (especially incisors) completely lost. All others persisting only as roots protected within the gums. In animals fifteen or more years of age the alveoli of missing teeth are filled by bone tissue.

GROWTH AND AGE

The length which bearded seals attain is fairly well known primarily as the result of work by McLaren (1958a). Several other authors including Allen (op. cit.), Kenyon (op. cit.), and Johnson et al (op. cit.) have recorded some information on weights and lengths, but these have not been correlated with age.

Most of our data concerning lengths and weights has been obtained during the months of April through September. Although weights are considered in the following discussion, it should be kept in mind that the weight of bearded seals is subject to extreme seasonal variation. Some adult bearded seals apparently lose as much as 30 per cent of their weight between January (at which time they are the heaviest) and July. Most of this loss can be attributed to reduction in the blubber layer. Correlations of length and age are probably more meaningful from the standpoint of determining growth, although information concerning weights is meaningful for sub-adult seals, and for determining such things as potential yields.

Development of the Pup

For bearded seals in the Bering Strait area, the birth period occurs mainly between April 15 and May 5. The peak period is around April 14. Pups are able to swim within a few days of birth, and Eskimo hunters indicate that they are sometimes born in the water. I have no observations of birth.

The average weight at birth--obtained from 13 full term foetuses--is 33.6 kg (74 lbs); and the average length is 131.3 cm (51.7 in.). They are very lean.

No recorded information is available concerning the length of time that bearded seal pups are dependent upon their dams, or about growth during the first few months of life. From all indications, the nursing period is very short, lasting somewhere between 12 and 18 days (Burns, 1965). This conclusion is supported by several facts. Independent weaned pups of the year are observed as early as April 25, and are common after the first week of May. The latest date on which a pup was observed in assocation with an adult female at Gambell, Savoonga, King Island or Little Diomede Island, since 1962, was on May 12. Dr. Francis Fay (personal communication) states that he has observed a mother and pup on May 17.

By the end of this brief nursing period the average weight of 11 newly independent pups taken prior to May 20 was 85 kg (187 lbs). The average length of 48 newly independent pups, also taken prior to May 20, was 147.3 cm (58 in.). Most of the gain in weight is due to a great increase in the thickness of the blubber layer, and not to any appreciable increase in body length.

As an example, one new-born pup weighed 38.6 kg (85 lbs), and was 141 cm (55 1/2 in.) long. A newly independent pup weighed 65.9 kg, and was also 141 cm in length. The difference in weight is reflected in the measurements of girth, which were 71.8 cm and 92.3 cm respectively.

The relatively large size of pups at birth, and the rapid growth rate (which is common in most seals), enables them to become quite large in a very short period of time. By the time they are weaned, most pups have attained approximately 63 per cent of their adult length.

It appears that the size of seal pups at the time of birth (percentage of adult female weight), and length of the nursing period are related in that the proportionately larger pups are nursed for a shorter period of time. Most of the pinnipeds have a nursing period of rather definite duration (i.e. Weddell seal--Mansfield, 1958; elephant seal--Laws, 1953; harp seal--Sivertsen, 1941; monk seal--Kenyon and Rice, 1959; walrus--Brooks, 1953; Fay, 1955; Burns, 1964). The nursing period in the ringed seal varies, usually ending when the birth lair is destroyed (except at very high latitudes: McLaren, 1958b). In the vicinity of Nome, the nursing period of the ringed seal is from 4 to 6 weeks.

Table 1 presents comparative information about birth weights, weights at the time of weaning, duration of the lactation period, and increase in the size of pups of several pinnipeds.

Several authors have pointed out that the milk of lactating female seals has a very high fat content. In the grey seal it was found to be as much as 53 per cent (Amoroso and Matthews, 1951), and it averaged 46 per cent in fur seals (Wilke, 1958).

The production of rich milk by the mother seals, in combination with large new-born pups, and their very rapid weight increase during the nursing period is indicative of a heavy physical drain on lactating female bearded seals. This is borne out by the emaciated condition of females at or near the time that pups are weaned. A brief nursing period is advantageous for both the pups and females in that the new-born, free-swimming young, gain strength rapidly and are able to keep up with their dams, and the females are not subjected to the prolonged physical drain imposed by the production of large quantities of rich milk.

After their first burst of growth, the pups gain very little weight for several months after weaning, although there is a slight increase in length. The length increase is not associated with a corresponding increase in girth as can be seen in Table 2. An index of seal condition (girth/length x 100) is also presented. Sivertsen (1941, p. 117) refers to Smirnov (1927, p. 23) who used the formula (maximum girth x 100/total length) as an index of condition. Smirnov points out that as the length is exclusively dependent on the size of the animal, the girth is dependent upon both the size and the degree of fatness. Size enters into both the numerator and denominator, and therefore introduces an automatic correction for the size of the animal.

Table 1. Comparison of Birth Weights, Weights When Weaned, Adult Weights, Duration of Nursing Period, and Growth Increment of the Pups of Several Pinnipeds.

Species	Weight at Birth (lbs)	Wt. When Weaned (lbs)	Adult Wt. Female (lbs)	Comparative Weight of Pup (%)		Nursing Period	Increase During Nursing Period
				At Birth	When Weaned		
Walrus	85 (73-150)	750	1,600-2,000	4.3-5.3	41.9	18 mos.	8.8x
Weddell Seal[1]	64	250	600-650[2]	9.8	41.6	5-6 wks.	3.9x
Elephant Seal[3]	100	375	1,600	6.3	23.4	3-4 wks.	3.8x
Ringed Seal	10	27	150	6.7	18.0	4-6 wks.	2.7x
Harp Seal[4]	26	73	246	10.6	29.7	10-12 days	2.8x
Monk Seal[5]	37.5	133	575	6.5	23.1	5 wks.	3.5x
Bearded Seal	74	187	575-600	12.3-12.9	31.2	12-18 days	2.5x

(1) Data (except for adult weight) taken from Mansfield (1958).

(2) Estimated by this writer on the basis of body measurements presented by Mansfield (op. cit.).

(3) Data from Laws (1953a).

(4) Data from Sivertsen (1941).

(5) Data from Kenyon and Rice (1959).

Table 2. Size of Bearded Seal Pups of the Year, from 20 April to 4 November.

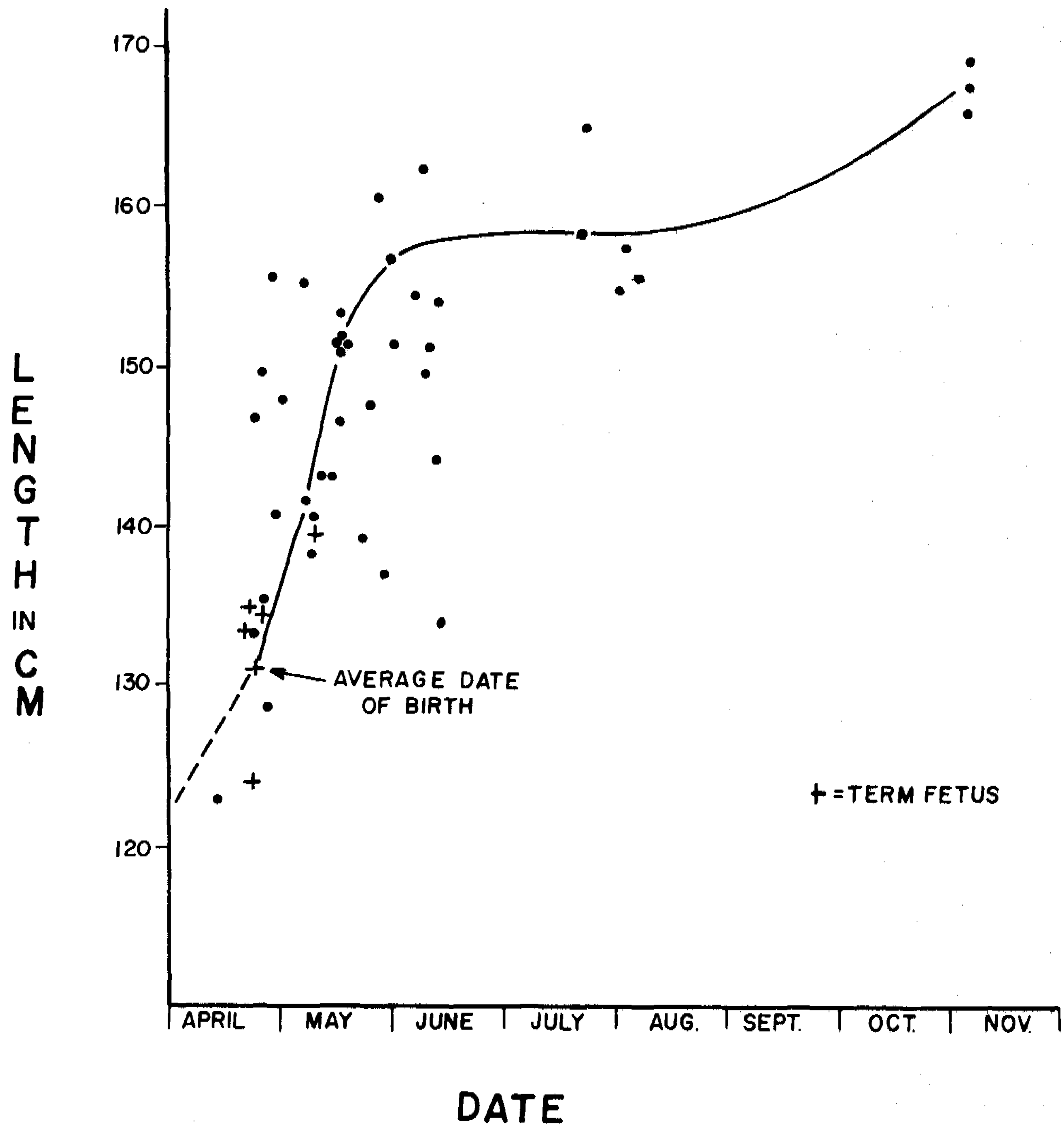
Date	Spec. No.	Sex	Weight (kg)	Length (cm)	Girth (cm)	Index of Condition
20 April	G-11-63	F	36.3	128.5	57.2	44.7
20 April	G-13-65	M	24.5	121.9	60.7	49.8
24 April	G-19-65	M	46.5	133.4	80.0	60.0
26 April	G-20-65	M	37.3	135.3	75.6	55.9
2 May	G-17-64	F	--	154.9	124.5	80.4
4 May	M 1474 [1]	M	30.4	127.5	--	--
6 May	G-19-64	F	--	135.9	71.1	52.3
6 May	G-20-64	M	--	142.3	71.1	50.0
6 May	G-32-65	M	65.9	150.5	91.4	60.7
6 May	G-34-65	F	--	140.3	85.1	60.7
10 May	G-45-65	F	65.9	141.0	95.3	67.6
13 May	G-54-65	F	--	147.3	109.2	74.1
17 May	D-1-64	F	--	154.9	99.1	64.0
17 May	D-2-64	M	--	147.3	106.7	72.4
20 May	G-57-65	M	70.5	150.5	101.6	67.5
27 May	D-106-63	M	--	157.5	101.6	64.5
4 June	G-56-64	M	--	157.6	119.4	75.8
12 June	G-119-64	F	--	170.2	108.0	63.5
16 June	D-26-64	M	--	175.3	119.4	68.1
20 July	W-3-65	M	81.8	158.1	100.3	63.4
20 July	W-5-65	M	85.0	165.0	99.1	60.1
2 August	W-59-65	F	--	154.3	96.5	62.5
6 August	W-6-64	M	97.5	157.5	100.3	63.7
8 August	W-8-64	M	115.6	175.3	104.1	59.4
9 August	W-23-64	F	86.2	154.9	94.0	60.7
4 Sept.	SL-2-64	M	97.5	167.6	106.7	63.7
4 Sept.	SL-3-64	M	106.6	170.2	110.5	64.9
3 Nov.	N-8-66	F	88.5	165.1	100.3	60.8

[1] Data from Johnson, et al, op. cit.

I have used girth (distance around the body immediately behind the fore-flippers) rather than auxiliary girth (greatest distance around the body) for several reasons. Measurements of girth of the same animal, taken by different people, do not vary as much as do measurements of auxiliary girth. This is because the girth measurements are always taken at the same level around the seal's body. Also, girth indicates only size and degree of fatness, whereas, auxiliary girth is affected by such factors as bloating, especially in warm weather (they begin to bloat shortly after death and it is often several hours before the seal can be processed), stage of pregnancy, etc.

Growth of first year pups, from April to November, is shown in Figure 4.

Fig. 4. Growth of bearded seal pups during the first few months of life as indicated by 47 seals from western Alaska.



Growth After the First Few Months

The adult size of bearded seals varies greatly between individual animals. Information on the progressive age-length relationship of bearded seals from the eastern Canadian Arctic is presented by McLaren (1958a); and records (not including age) of a few individual animals from Alaska are presented by Kenyon (op. cit.), and Johnson et al (op. cit.).

McLaren (op. cit., p. 220) graphically shows the age-length relationship of 59 seals, and states that the average length of 25 full grown adults, older than nine years of age, was about 235 cm (92.5 in.). The average lengths of 77 reproductively mature males, and 74 mature females taken during this study were 217.7 cm (85.7 in.) and 224.5 cm (88.4 in.) respectively. This is in close agreement with the findings of Johnson, et al, (op. cit.) who reported the average lengths of 20 adult males and 20 adult females to be 216.0 and 222.5 cm respectively. Bearded seals are usually reproductively active before completing their growth.

The slightly longer length of females--an average of 3.1 per cent greater than males--is also obvious in comparisons of skull length, although not to the same extent. The average condylobasal length of 5 adult females was 227.0 mm and that of 8 adult males was 222.7 mm: a difference of only 1.9 per cent.

The relationship of length to age is shown in Figure 5. On the average, lengths of 37 Alaskan bearded seals older than newly weaned pups were as follows: one year 170.2 cm, two years 187.5 cm, four years 209.0 cm, six years 223.5 cm, eight years 228.6 cm, ten years and older 233.7 cm.

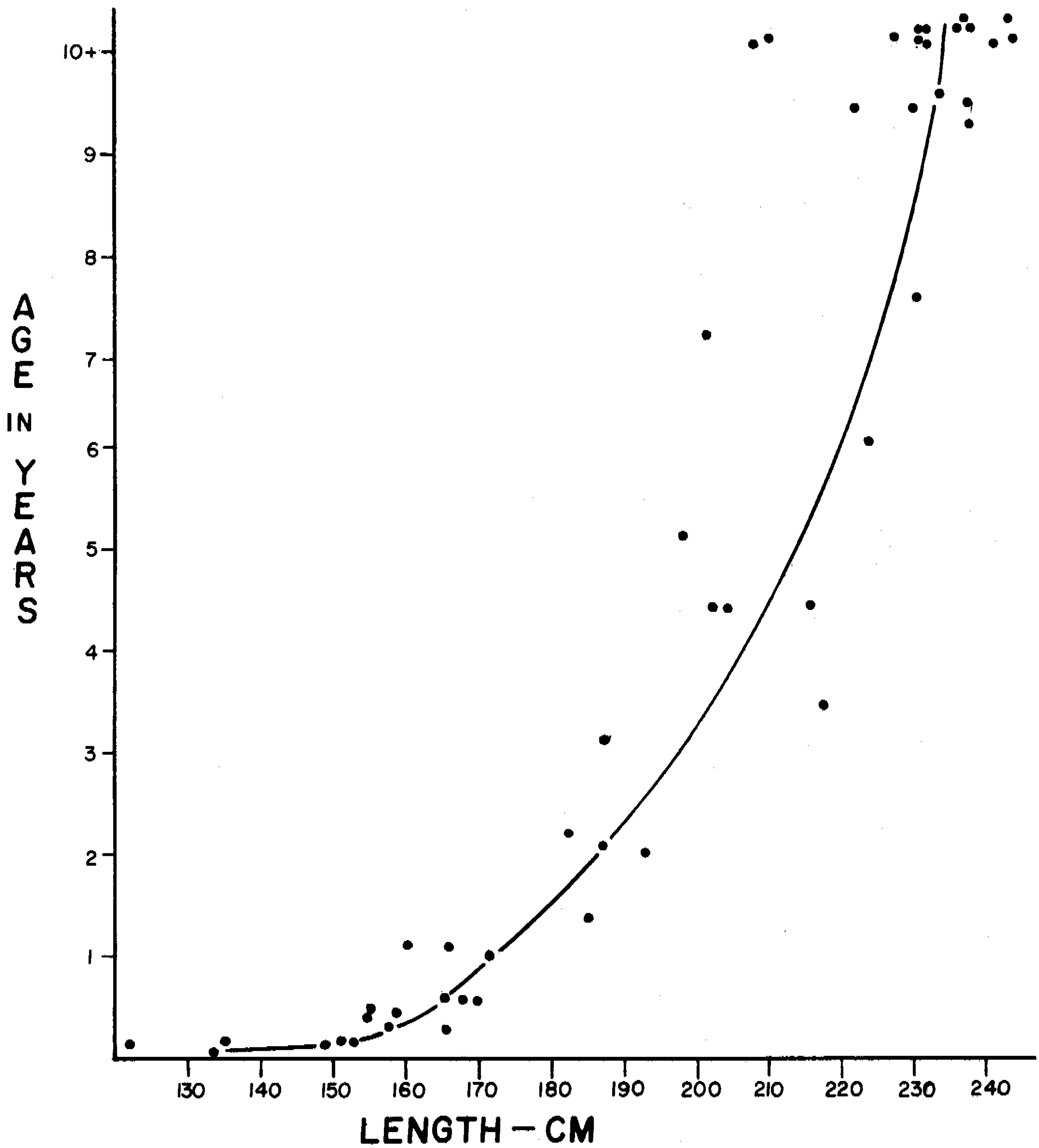
More information is available for a comparison of the body length and weight relationship. Figure 6 is a scattergram illustrating this relationship in 57 seals from Alaska.

I was able to obtain weights from 11 reproductively mature males, and 14 reproductively mature females taken during the months of June, July and August. Weights of the females ranged from 186.4 to 277.3 kg ($\bar{x}$ = 228.6 kg); and the males ranged from 209.1 to 265.9 kg ($\bar{x}$ = 244.4 kg). At this time of the year the seals are not in prime condition. My observations of the condition of large seals during January and February indicates that many of them most certainly weigh in excess of 700 pounds. Johnson, et al (op. cit.) recorded the weight of one pregnant female, taken on April 8, (pregnancy near term) as 793 lbs (no allowance for blood and body fluids spilled).

Development of the Baculum

Since male bearded seals possess an os penis bone, and because development of this bone is associated with advancing age, it is helpful to know something about the development of this bone in relation to the age of the seal from which it was taken.

Fig. 5. The age-length relationship as indicated by 47 bearded seals from western Alaska. Growth of pups during the first few months of life is shown in Fig. 4.



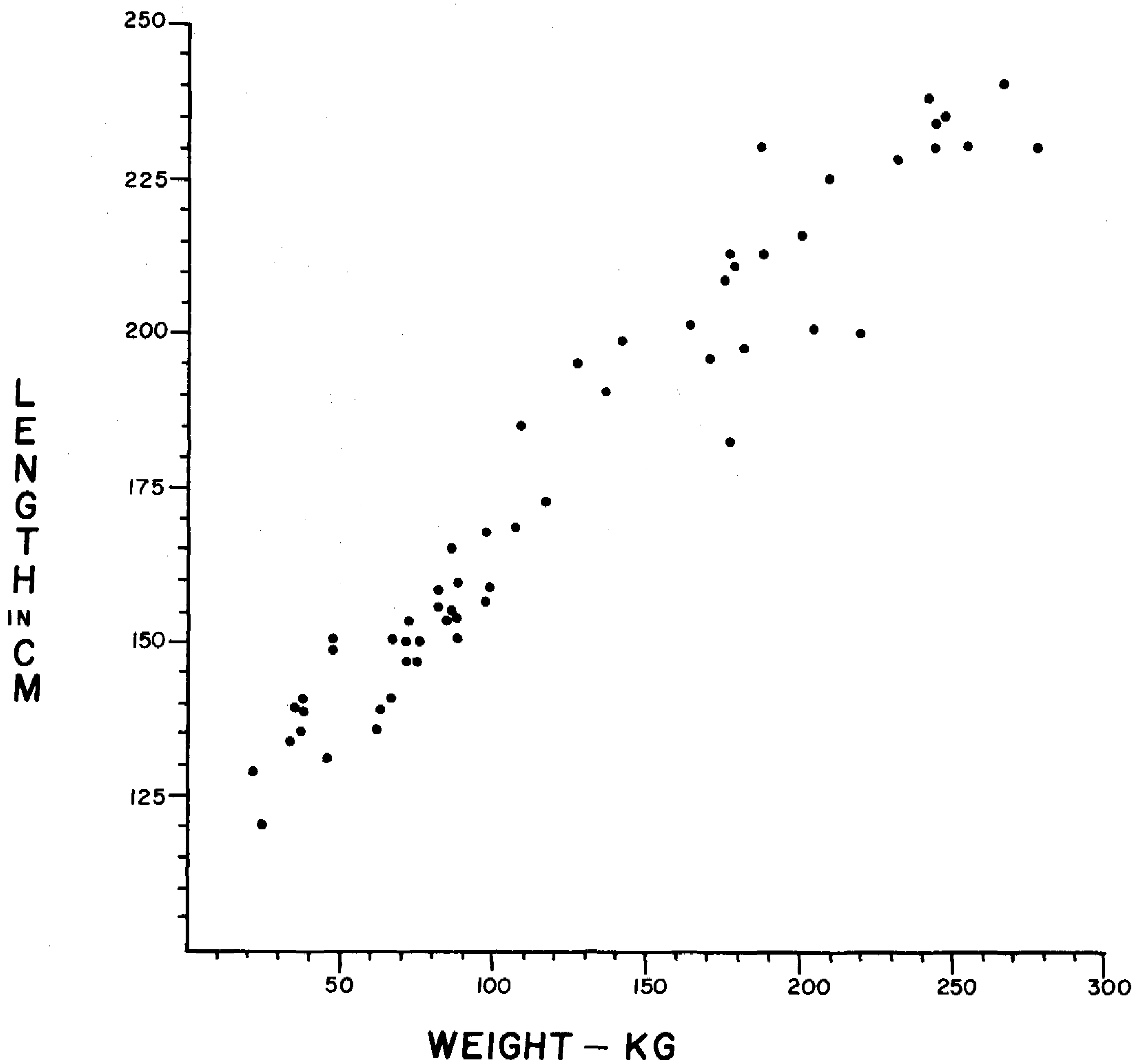


Fig. 6. Length-weight relationships in 57 bearded seals taken from April through August, in western Alaska. Extreme variation in weight is associated with the period of reduced feeding activity in some seals.

Information obtained from 70 male seals from which both bacula and claws (used for age determinations) were obtained, shows that in pups, the average baculum length is 42 mm: the average baculum weight is 0.7 g. There is a slow increase in length and weight up to the fourth or fifth year of life. In nine seals in their fifth year I found the average length was 83 mm, and the average weight was 7.0 g. Between ages five and seven, rapid growth takes place (associated with the onset of reproductive activity). The average baculum length and weight in four seals seven years of age, or in their eighth year of life, is 122 mm and 26.4 g. Growth of the baculum proceeds at a decreasing rate in older seals. The baculum size in 13 bearded seals more than 14 years of age is 156 mm, with an average weight of 65.1 g. There is a much greater variation in weight (and thickness) than in length, and it appears that baculum length is a much better indicator of relative age than is weight.

The progressive increase in length of bacula is shown in Figure 7.

Development of the os penis bone--increase in length, thickness, density, and weight--in weasels (Wright, 1950) and other mustelids is stimulated by increased production of androgens during the breeding season. It is assumed that the same factors are operative in pinnipeds.

Scheffer and Kenyon (1963) presented information on the baculum size in 20 species of pinnipeds including the bearded seal. They indicated (based on one adult specimen) that baculum length in Erignathus was 6.63 per cent of the body length. This was very close to the value of 6.50 per cent observed in 20 adult seals in my sample.

No attempt was made to calculate relative weight due to the extreme seasonal variation in body weight, and the individual variation in both body and baculum weight.

Based on field observation it appears that these seals probably copulate in the water.

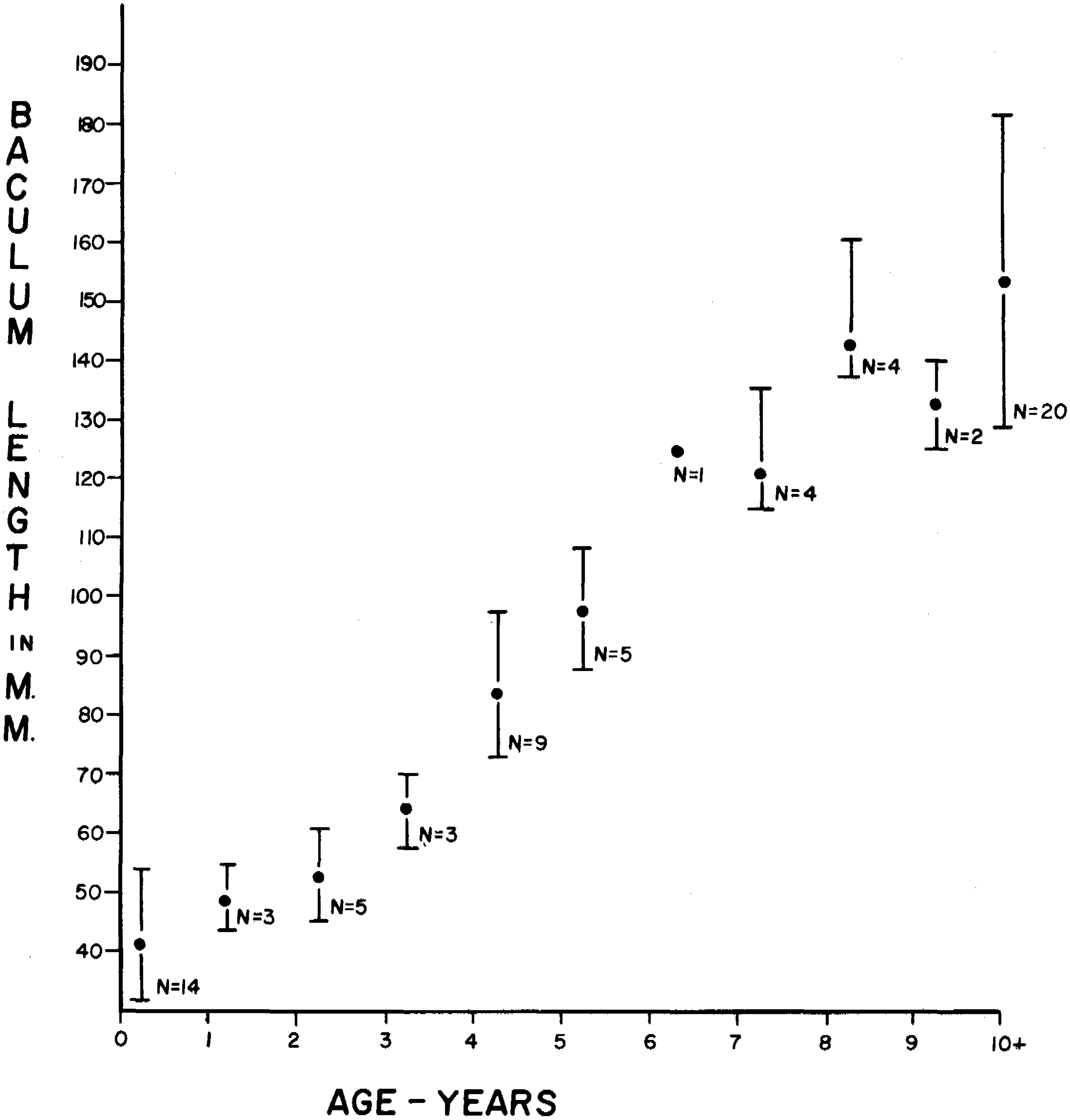


Fig. 7. Increase of baculum length with advancing age in 70 bearded seals from the Bering Strait area. The means, ranges and sample size are indicated.

FOOD HABITS

Two recent papers, those of Kenyon (op. cit.), and Johnson, et al (op. cit.), present information on the food habits of bearded seals in the eastern Bering and Chukchi Seas. Their reports show that these seals are almost entirely benthic feeders that utilize primarily the smaller, more sedentary invertebrates and fish found in the area. At the present time there is no competition between these seals and man, as far as commercially important fish and shellfish resources are concerned.

During this study numerous seal stomachs were examined in the field, but only 23 were collected; nine from Wainwright, 13 from Gambell, and one from Nome. None were collected at the sites where Kenyon and Johnson obtained material. Only those stomachs containing food were saved.

Information obtained from these stomachs, as well as findings reported by Kenyon (op. cit.) who obtained 17 stomachs from the vicinity of Little Diomede Island, and Johnson, et al (op. cit.) who obtained 164 stomachs from Point Hope and Kivalina, provide a very good indication of the main food items utilized by bearded seals throughout a large portion of their range along the Alaskan coast.

Detailed lists of the various food species identified are presented by Johnson, et al (op. cit.). For the purposes of this report, the relative importance of the various types of food (i.e. crabs, shrimp, fish, clams, etc.) will be discussed except for specific mention of primary food items, and those of interest.

A general breakdown of food types, by month (based largely on the work of Johnson, et al [op. cit.]) is presented below:

	Point Hope and Kivalina (from Johnson, et al, 1966)	Nome, Gambell and Wainwright
Nov.	shrimp, 60%	--
Dec.	--	--
Jan.	shrimp, 85%	--
Feb.	shrimp, 52%; fish, 24%	--
Mar.	hermit crabs, 56%; shrimp, 25%	--
Apr.	shrimp, 51%; crabs, 14%	--

	Point Hope and Kivalina	Nome, Gambell and Wainwright
May	shrimp, 27%; crabs, 24%; unidentified decapods, 23%	crabs, 57%; shrimp, 12%; fish, 11%; sponges, 3%
June	clams, 38%; crabs, 24%; shrimp, 13%	--
July	--	clams, 43%; shrimp, 28%; crabs, 3%
Aug.	--	clams, 25%; crabs, 19%; isopods, 19%; shrimp, 4%

The largest volume of food found in a single stomach that we examined was 2,800 ml, and the average volume contained in the 23 stomachs collected was 854 ml, including sand, pebbles, parasites and food items.

All of the fishes found in the stomachs we examined were benthic types including primarily the saffron cod (Eleginus gracilis), Arctic cod (Boreogadus saida)--the latter apparently assuming greater importance further north--and various sculpins (Myoxocephalus spp.). The latter was the fish taken most frequently: in one stomach containing 450 ml of food we found 135 ml of sculpins.

Kenyon (op. cit.) pointed out that although Paralithodes platypus (a close relative of the king crab) is of common occurrence in the vicinity of Little Diomede Island, the bearded seals did not utilize them. Apparently this is true throughout the northern Bering Sea area where both P. platypus and P. camtschatica (the king crab) are present but not eaten in any large numbers by bearded seals. The exception is probably when the crabs are moulting, and in the soft shell stage. One abdomen from a female crab of the genus Paralithodes (apparently shedding) was found.

The crabs most commonly utilized were Hyas coarctatus alutaceus (rock crabs) and hermit crabs, primarily Pagurus spp. The smaller crabs are eaten whole, while only the legs and abdomens (including eggs of the females which are of common occurrence in the seal stomachs) are eaten from the larger individuals.

There appears to be a definite seasonal preference in the utilization of clams. Several species are abundant in the Bering and Chukchi Seas, and are utilized extensively by walrus, throughout the year. However, it appears that bearded seals do not utilize clams in any quantities except during the summer months. As yet I have no information concerning feeding habits during September and October.

As a point of speculation, this seasonal preference may be the result of seasonal changes in the palatability of the clams themselves. From personal experience with the clam fishery in New England, I have found that during the months in which longer periods of daylight prevail, and marked seasonal increases in plankton occur, clams often become almost unpalatable for humans. It may be a change in the taste of clams that make them more preferred by bearded seals during the summer. Another possibility is that the other prey species are not as available during this period, although this seems unlikely in view of the sedentary habits of most of them.

The clams most commonly included in stomach contents were Serripes groenlandicus, Spisula sp., and Clinocardium (probably ciliatum). Shells or shell fragments of Velutina sp., Hiatella arctica, Zirfaea pilsbryi and Astarte sp. have been found. It seems highly probable that the shells of these small clams were ingested accidentally as are the numerous small pebbles found in many stomachs.

Numerous operculae of whelks were found in the stomach of one seal taken at Wainwright. These were from whelks of the genus Buccinium. Some small snail shells--probably ingested accidentally--were found in several stomachs. These were tentatively identified as including Nautica aleutica, Trichotropis borealis, and Tachyrhynachus sp.

The shrimps most commonly utilized were Sclerocrangon boreas, Pandalus hysinotus, P. goniurus, Argis sp., Lebbeus groenlandicus, and Eualus spp.

Numerous isopods were found in the stomach of one young seal taken at Wainwright. The isopods accounted for 150 ml in a stomach containing 204 ml of food. Several other stomachs collected in the same area contained small numbers of amphipods and isopods. Various annelid worms, and other items of this type were also found, but none were identified.

Although bearded seals utilize a wide variety of food items, a relatively small number comprise the bulk of the diet.

PARASITES

The parasite fauna of bearded seals is very impressive, mainly from the standpoint of the quantity of individuals found in some seals. The stomachs of most bearded seals in our sample contained the nematode Porrocaecum decipiens; in volume, up to 150 ml of these roundworms have been found in a single stomach.

King (1964, p. 134-5) provides a list of the parasites found in the various species of phocid seals. In addition to the nematode mentioned above, she lists Contracaecum osculatum, and Trichinella spiralis as also occurring in bearded seals. Other parasites which she lists as occurring in bearded seals are: Corynosoma strumosum, C. semerme, C. validum, C. hadweni, all of which are in the Phylum Acanthocephala. Parasites of the Phylum Platyhelminthes (flat worms) include the cestodes Diphyllobothrium lanceolatum, D. cordatum, D. hians, D. schistochilos, D. latum, D. macrocephalum, Diplogonoporous tetrapterus, Pyramicocephalus phocarum, Polypocephalus tortus, and the following trematodes: Orthosplanchnus fraterculus, O. arcticus, and Opisthorchis tenuicollis. Ectoparasites listed include a louse of the order Anoplura; Echinophthirius horridus.

Dr. Francis H. Fay (personal communication) indicated that the most common parasites of bearded seals in the Bering Sea include Pyramicocpehalus phocarum, Diphyllobothrium cordatum, and D. lanceolatum, all of which are cestodes commonly found in the small intestine. According to Dr. Fay, the most common trematode in the liver (bile ducts and gall bladder) is Orthosplanchnus fraterculus.

Parasites that I found in the stomachs included P. decipiens (very common), D. lanceolatum, D. tetrapterus, and Corynosoma sp. (probably validum). My studies did not include a detailed analysis of the parasites found in bearded seals, other than those encountered during examination of stomachs for identification of food items utilized.

Examination of seals for ectoparasites has, for the most part, been relatively unproductive. I have found lice, presumably Echinophthirius horridus, on only two out of approximately 230 seals.

There is some indication, based on the occurrence of various kinds of food in seal stomachs, and the incidence of the parasite Porrcaecum decipiens, that certain types of food may help to remove some of these roundworms from the stomach. The largest volume of these worms were found in empty stomachs, or in those containing a variety of food items including shrimp, clams, fish and various other items except crabs. In those animals whose stomachs contained any volume of crabs, the incidence of stomach worms was significantly less, and in several cases only a few worms were found. It is probable that some of the worms are removed by the mechanical grinding of the crab shells, as many of the small crabs are swallowed intact.

Parasites

No stomach parasites were found in nursing seal pups (those in which the stomachs contained only milk).

Additional information concerning the parasites of bearded seals, and other marine mammals, may be found in Deliamure's (1955) "Helminthofauna of Marine Mammals of the World In the Light of Their Ecology and Phylogeny" (in Russian).

REPRODUCTION

To begin a discussion of reproduction it is probably most desirable to confirm the period during which the breeding or rutting season, and the birth period occur. There has been some difference of opinion regarding the former point, particularly among Soviet investigators. Thus, although Chapsky (1938) recognized the occurrence of delayed implantation in bearded seals, Sleptsov (1949) indicated that a period of latent or arrested embryonic growth did not actually occur, and therefore felt that breeding occurred in the summer.

McLaren (1958a) reviewed Sleptsov's conclusions in light of his own findings and determined that in bearded seals of the eastern Canadian Arctic, "The males are going out of rut in June, and are probably most potent in mid-May." Unfortunately he apparently had no material from adult males taken during March, April or early May. Kumlien (1879) stated that the breeding season is in the forepart of May.

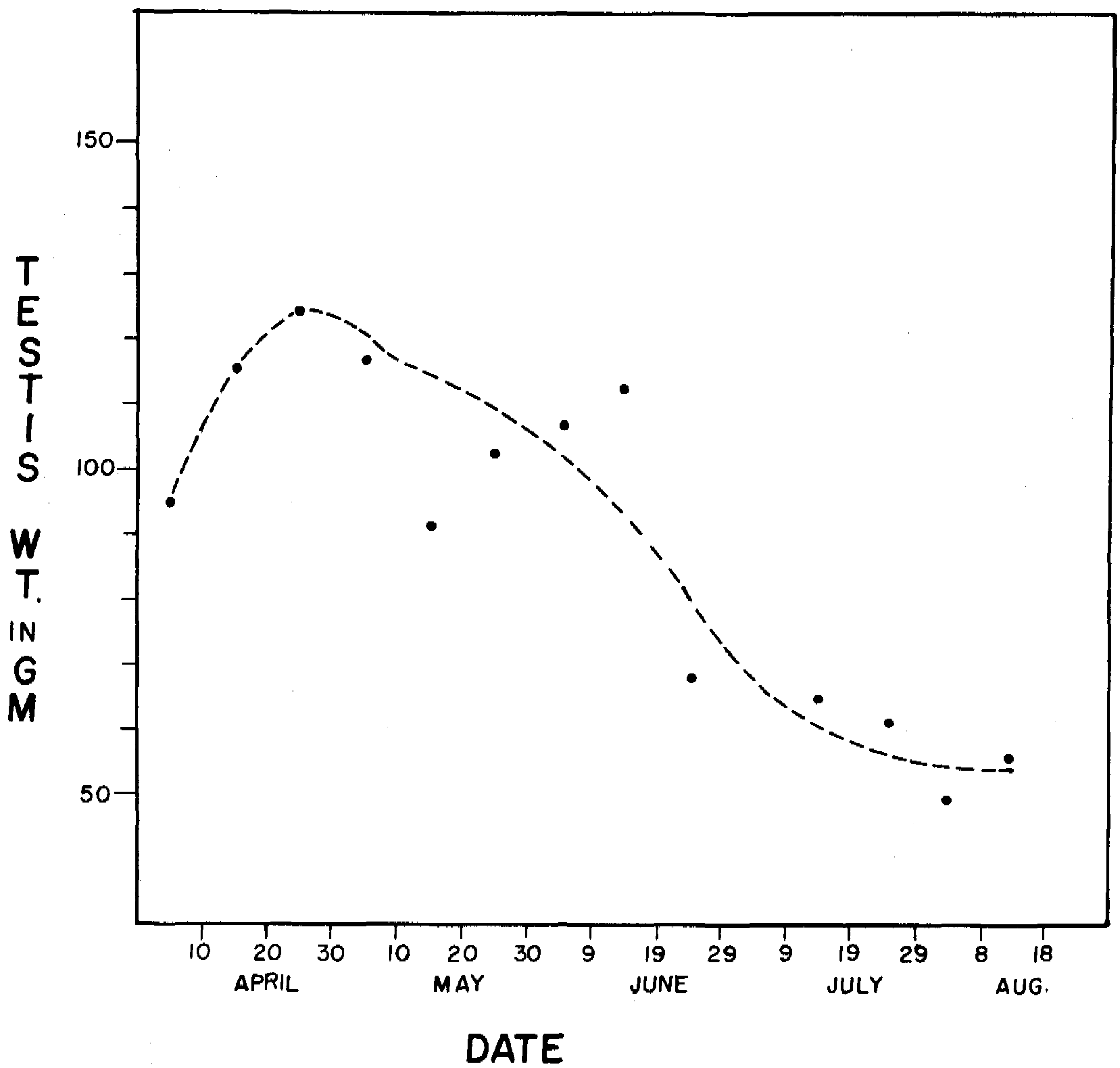
Specimens collected from the Bering Strait region during March through June, and from northern Alaska during July and August indicate that the peak period of breeding activity occurs from about mid-April to mid-May.

The breeding period can be determined on the basis of several things such as behavior of mature males (see section on Behavior), changes in testicle and seminiferous tubule size, and by histological examination of testicle and epididymus sections to determine the presence of maturing spermatids and spermatozoa. By analogy, in females the breeding season can be determined by the presence of mature follicles, or the presence of proliferating or completely formed corpora lutea of the pre-implantation stage of pregnancy.

From my material it appears that the males are in breeding condition for a longer period of time than females, as evidenced by the occurrence of spermatozoa or maturing spermatids in a series of 65 pairs of testes collected from March through June. However, the peak of breeding period, based on changes in testicle weight, size, seminiferous tubule diameter, and presence and relative abundance of spermatozoa in the epididymis, occurs from mid-April to mid-May. This was also found to be true in bearded seals of the eastern Canadian Arctic (McLaren, 1958a) and the southern Bering and Okhotsk Seas (Tikhomirov, op. cit.). Both of these authors graphically illustrated various changes in testicle size. As Backhouse and Hewer (1964) pointed out, ". . . a good register of spermatogenic activity can be obtained from the gross testis weight . . ." Figure 8 shows the changes in testicle weight of 66 bearded seals, seven years of age or older, taken from April through August.

Although some males are probably potentially capable of fertilization during a period from March to June, the earliest date that a recently impregnated female was taken, was on April 13. The latest date that a multiparous female containing a mature follicle was taken, was May 23. In this case only multiparous females were considered because nulliparous animals frequently ovulate outside of the normal breeding period (McLaren, 1958b; Craig, 1964).

Fig. 8. Seasonal changes in testicle weight of 66 Alaskan bearded seals, seven years of age or older, from April through August.



Another indication of the breeding season, based on ovarian analysis, is the occurrence of proliferating corpora lutea in the early stages of formation; in other words, shortly after conception. These are corpora lutea that are only sparsely filled with granulosa cells, and contain large, fluid-filled cavities. A scar on the surface of the ovary (the eruption site) was usually present.

Ovaries containing corpora lutea in the early stages of formation were obtained from 16 females taken between May 8 and 25. By June 3 the fluid-filled cavity is greatly reduced, and by June 12 it is usually absent.

Craig (op. cit.) found that in fur seals the corpus luteum is compactly filled, as the result of progressive luteinization, sometime during the month following ovulation. My sample consisted of ovaries from 133 reproductively mature females.

These dates for the breeding period in multiparous females (April 13 to May 23) bracket the indicated peak breeding period in males. Tikhomirov's (1966) conclusion that ovulation occurs at the termination of lactation is correct in that no one has reported ovulation in seals that are still lactating.

Tikhomirov (op. cit.) indicated that ovulation in the bearded seal may be spontaneous (independent of coitus) based on the presence of unshed ova, even though sperm cells were found in the vagina.

Field observation indicates that these seals are polygamous, forming pairs only for a brief period. The males do not have harems as do the fur seals and sea lions.

Implantation, Gestation and the Birth Period

In Alaskan waters, implantation of bearded seal foetuses occurs during late July and early August. On the basis of the small range in size of 13 foetuses collected between July 27 and August 15, I feel that in most cases implantation occurs over a relatively short period of time.

Delayed implantation (probably characteristic of all pinnipeds) occurs in other groups of animals, particularly the Mustelidae. Photo-period directly affects the duration of the dormant period, suggesting that activation of the pituitary gland is involved (Asdell, 1946). Variation in the gestation period within the same species of animal is probably the result of differences in the duration of arrested development. Thus, despite sometimes wide variation in the time of breeding, the time of implantation and whelping are more closely grouped.

Tikhomirov (1966) stated that the end of June is the time at which implantation begins in all of the phocid seals of the North Pacific, and that the main period is in the second part of July. Implantation in June and early July may occur in seals of the Okhotsk and southern Bering Sea (where apparently Tikhomirov obtained his material), but in the waters off northern Alaska, where most of our adult bearded and ringed seals are during the summer, implantation occurs mainly during the last week of July and the first two weeks of August, in the bearded seals. Implantation in the ringed seals starts about two weeks later. This agrees with findings concerning these seals in the eastern Canadian Arctic (McLaren, 1958a, 1958b).

Two multiparous females taken at Barrow on July 16 were still in the pre-implantation stage. Animals taken at Wainwright between July 27 and August 18 supported foetuses ranging from newly implanted to one 35 mm in crown-rump length. Two females showing a ringed swelling of the uterine horn, but not having implanted foetuses, were taken on July 31. Newly implanted foetuses were recovered on August 2, 5 and 8.

The time between breeding and implantation is approximately 2 1/2 months. Placental attachment is usually about 2/3 of the way down the uterine horn (from the anterior end), and the placenta is zonary.

Figure 9 shows the progressive increase in size of foetuses, from implantation to birth.

Comparison of data from both Alaska and the eastern Canadian Arctic (the latter reported by McLaren, 1958a) indicates that foetal development is similar in both _E. b. nauticus_ and _E. b. barbatus_.

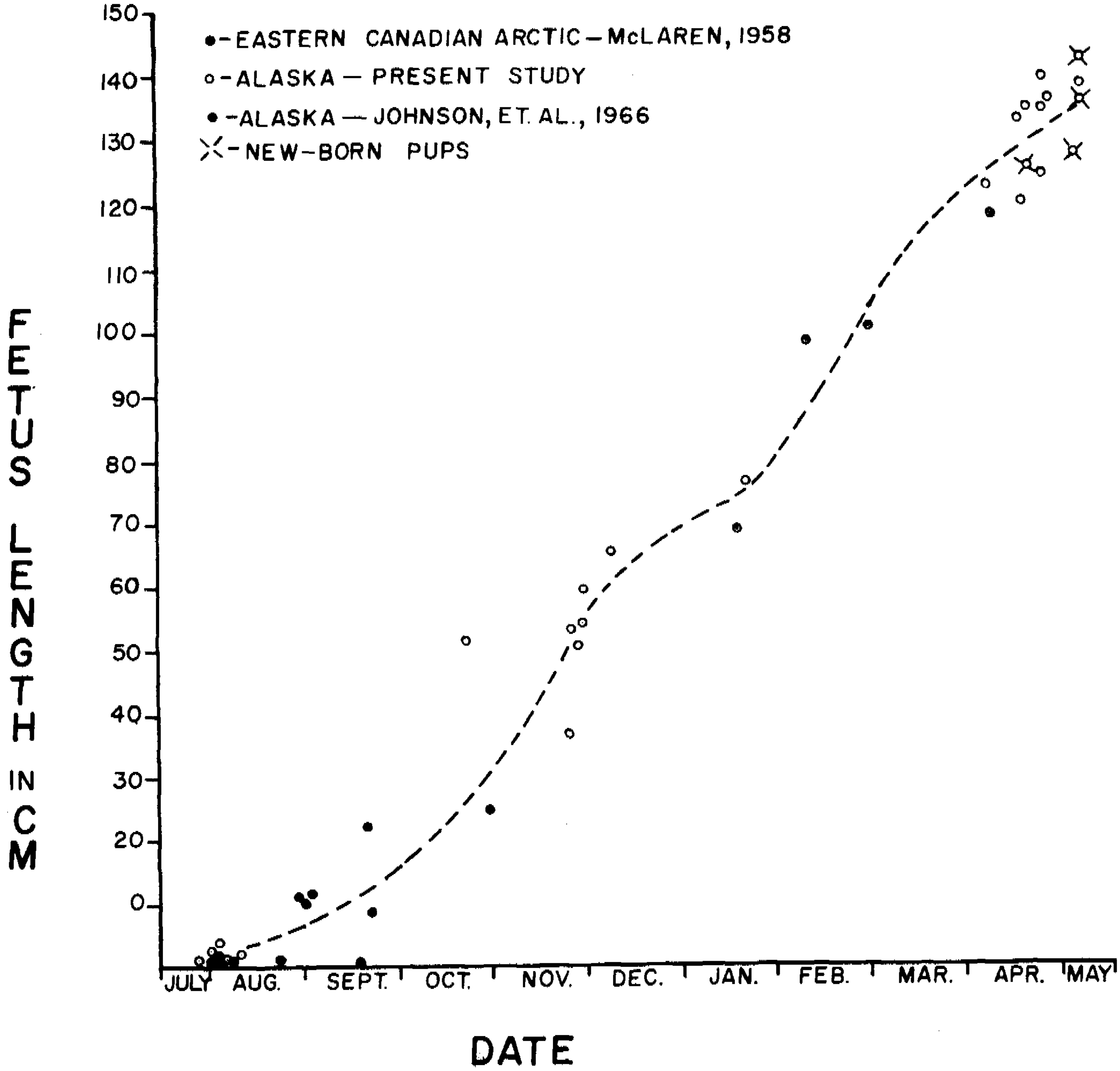
During my studies, birth of pups in the Bering Strait area occurred from mid-March through the first week of May, with the peak of births occurring between April 20 and 25. This is approximately ten days to two weeks later than the main period indicated by Tikhomirov (1966). The difference may be due to the fact that all of my material was obtained from more northerly latitudes (mainly near 65° 45' N). As pointed out by McLaren (1958a), variation in the timing of birth may be related to latitude. He refers to Mohr (1952) who considered the birth season to be earlier in the areas off northern Europe and Newfoundland, than in the higher Arctic seas. Earlier pupping seasons in more southerly areas are also suggested by Sleptsov (1943).

General comments concerning the time of pupping in bearded seals north of Bering Strait, and information presented by Johnson, _et al_ (_op. cit._) indicates that pupping in this region also occurs mainly in late April.

As pointed out in a previous section, pups weigh approximately 35 kg, and are about 130 cm long at birth. However, some pups are markedly smaller. At this time it appears that the smaller females may bear smaller pups; but as yet we have not accumulated enough data to say this with much confidence.

By late April, the seasonal retreat of the pack ice is well under way. Although the ice is not moving rapidly, it is usually broken up and areas of open water are numerous. Seals with young (the pups go into the water shortly after birth) are not forced to swim long distances under closely packed ice. Also, the pups are weaned at what appears to be the most favorable time of year from the standpoints of weather, ice, and probably feeding conditions during the first few months of independent life.

Fig. 9. Growth of bearded seal fetuses from implantation to birth as indicated by 45 specimens from Alaska and Canada. Sources of information are indicated.



Tikhomirov (1966) feels that the main pupping period coincides with the time of maximum ice extension--when the greatest stability is attained.

Age at Sexual Maturity

Females are often considered to have attained sexual maturity when the first ovulation occurs. In many animals this is not true (i.e. humans), and it does not appear to be the case with bearded seals. In my sample as well as in the one obtained by Tikhomirov (op. cit.), some female bearded seals three years of age, or in their fourth year of life, had begun to show signs of the annual reproductive cycle. This included only increased follicular activity in some three year old animals, while in others it included development and shedding of an ovum, and formation of a small corpus luteum. However, all of the three year olds that I examined were sexually immature on the basis of appearance and size of uteri, ovary size, and ovary weight. In my sample, no females younger than five years of age had successfully implanted a foetus or exhibited indications of previous pregnancies, based on the appearance of uteri. None younger than six were accompanied by new-born pups (these females would have been bred at five years of age).

In a small sample of eight females five years old, five were sexually mature (capable of breeding for the first time) and three were definitely not capable of reproduction. The average weight of both ovaries in the mature animals was 16.7 g while in the immature animals it was 5.2 g. The high average ovary weight for the sexually mature five year old females was affected somewhat by the unusually large size and heavy weight in one animal (28.7 g) containing a mature follicle 26 x 22 mm. Excluding this female, the average weight of ovaries in mature five year old animals was 14.4 g.

Ovary weight continues to increase throughout the reproductive life of the animal. The increase is caused by continued follicular activity and formation of corpora lutea and corpora albicantia with each successive ovulation. Bearded seals may remain reproductively active throughout their life span (judged to be about 20 to 25 years); no "senile" ovaries, containing neither a corpus luteum nor maturing follicles, are included in my sample.

It appears that probably 55 to 65 per cent of the females become sexually mature at five years, and the remainder at age six. The period from three to five--and in some animals six--years of age can be considered one of adolescense in which they undergo certain phases of the annual reproductive cycle, but are not capable of becoming pregnant. Fisher (1954) comments on follicular activity in immature harp seals, and Craig (op. cit.) mentions that the ovaries of nulliparous female fur seals approaching maturity contain follicles, and in some cases corpora lutea or corpora albicantia from previous unfertilized ovulations. This has also been noted in Fin whales (Wheeler, 1930), and Blue whales (Laurie, 1937).

Length of the smallest female which was pregnant for the first time was 213.4 cm (84 in.). Hence it can be postulated that females begin breeding after attaining at least 92 per cent of the average length at physical maturity. This closely coincides with the findings of McLaren (1958a).

The genitalia of late foetal and new-born female bearded seals exhibit a high degree of activity (Burns, 1965), a phenomenon noted in other seals by Harrison and Matthews (1949), and by Craig (op. cit.) in northern fur seals. Hypertrophy of the female gonads in term and new-born young of humans, elephants and horses has been recorded, but it does not occur in the guinea pig, cow, or monkey (Parkes, 1954). Hypertrophy has been attributed to the production of progesterone and estrogen by the placenta after the corpus luteum ceases its secretory function. Ovary weight decreases rapidly after birth.

Specimens collected from males during the breeding season are limited, but may shed some light on the question of age at sexual maturity in males. Sexual maturity in males is considered to be attained at the onset of fertility, and evidenced by the presence of spermatozoa in the epididymis.

It was observed that marked seasonal changes occur in the testes of immature males (i.e. changes in seminiferous tubule diameter and seminiferous epithelium). All of 13 males from pups to three years old were sexually immature; four animals four years of age and one five year old were immature; one six year old and two seven year olds were sexually mature.

The rapid increase in baculum size that occurs between the sixth and eighth years of life, and the first appearance of spermatozoa in animals of this age group, indicates that these are the ages at which sexual maturity is attained. It appears that some males achieve sexual maturity at six years of age, and that all are probably fertile by age seven. As Fay (1966) pointed out for the Pacific walrus, in males there is also an extended process of development--the period of adolescence--leading up to the onset of fertility.

I have no information concerning the ability of young, sexually mature males to compete with older males during the rut.

RATE OF REPRODUCTION

The frequency of pupping by female bearded seals is not clearly understood, and there are conflicting views concerning this point. McLaren (1958a) stated that, "Females which have produced a pup forego ovulation until after the male rut, thus establishing a two-year cycle of pup production." This was also the view held by Sleptsov (1949). Tikhomirov (op. cit.) indicates that all of the phocid seals of the North Pacific mate annually. Judging by various comments throughout his paper he is of the opinion that only five to ten per cent of the mature female bearded seals do not successfully breed.

Our findings indicate that most of the mature females do breed during successive years, but the incidence of pregnancy is significantly lower than that indicated by Tikhomirov.

I have used the following methods to determine the incidence of pregnancy and the rate of reproduction in bearded seals of the Bering and Chukchi Seas: 1) interpretation of ovarian analysis; 2) observation of the incidence of foetuses in adult females taken from August through early April; and 3) considering the age composition of the harvest and the incidence of pregnancy.

Results of Ovarian Analysis

In 133 sexually mature females, 111 (83.5 per cent) were judged to be pregnant, and 22 (16.5 per cent) were barren. Classification was based upon the presence or absence of corpora lutea and/or mature follicles.

An inherent danger in this method of determining the proportion of breeding (and non-breeding) females lies in the fact that we do not know what proportion of the conceptions will result in successful births. However, in the specimens taken during June, July and August, most of the unsuccessful breeders can be recognized by the presence of a degenerating corpus luteum. Females in this condition were classed as barren.

Also, there is some error in that animals taken during early May, and classed as barren, might subsequently breed successfully.

These sources of error would tend to cancel each other.

The conclusion that about 83 per cent of the adult females are pregnant each year compares very well with the figure obtained by recording the proportion of females actually supporting foetuses.

The Presence of Foetuses

My sample of females, obtained during the period when all pregnant females will be supporting foetuses (from late August through early April), is relatively small, consisting of 20 animals. The six females reported by Johnson, et al (op. cit., p. 912) can be included. They reported that five of six adult females (83.3 per cent) examined between January and April, were pregnant. In my sample, 17 of 20 (85 per cent) were pregnant.

These figures agree with the pregnancy rate of about 83 per cent obtained by examination of ovaries.

Age Composition and Natality

Estimation of the actual age composition of the seal population must, of necessity, be based on a compromise between the age composition prevailing in our biased sample, and careful consideration of the sources of bias in order to correctly make allowances for them. The main source of error is over-representation of pups in the spring and summer harvests, the period when most of our material was obtained. This bias is greater during certain periods of the year, particularly in the early fall when most of the seals taken are pups. However, the age composition of the fall harvest is not included.

Since the bias is constant, comparisons of the age composition of harvests obtained during different years will prove to be a valuable management tool. A more detailed discussion of the harvest will be included in another section.

In our sample of 390 seals for which ages have been determined, 107 (27.4 per cent) were pups, 178 (45.6 per cent) were six years or older and 105 (27.0 per cent) were between the ages of one and six.

The actual proportion of animals six years and older is probably between 55 and 60 per cent, and females older than six constitute between 27 and 30 per cent of the population.

Under-representation of adults in our sample is the result of disproportionately high hunting losses in these older animals. Females which are lactating, or only recently ceased doing so are in poor condition and are frequently lost before hunters can retrieve them. When females and their pups are killed, quite frequently the pup is retrieved and the female is not. Adult males are also in poor condition and hunting loss is high, as this is the period of reduced feeding activity.

The sex ratio at birth--47 males to 50 females--and throughout the various age groups--256 males to 265 females--can be considered as essentially equal.

Since the incidence of pregnancy in adult females is between 80 and 85 per cent, the rate of reproduction (considering the population as a whole) is estimated at 22 to 25 per cent.

Pregnancy in five year old females would raise the estimated rate of reproduction, and the incidence of unsuccessful conceptions would lower it. All things considered, natality amounting to between 22 and 25 per cent is probably a close approximation of the actual rate of reproduction. In comparison, natality in the Pacific walrus is estimated at 14 to 15 per cent (Burns, 1966).

There are apparently some significant differences in the age of sexual maturity and the rate of reproduction between E. b. nauticus and E. b. barbatus. One of the most probable causes would be differences in the level of exploitation. It is generally known that certain levels of exploitation tend to decrease the age at which sexual maturity is attained, and to increase the rate of reproduction. This has been shown to occur in many animals including some of the baleen whales (Laws, 1962), and the elephant seal (Carrick, et al, 1962). Sergeant (1966) showed that as the result of exploitation, the mean age at sexual maturity in female harp seals off northeastern Newfoundland decreased to four, from five and a half years. In another area--the Gulf of St. Lawrence--the mean age at sexual maturity in females decreased to five, from nearly six years. He also concluded that, "Fertility of the adult females was likely higher in the more heavily exploited populations."

The Pacific bearded seal in the Bering Sea is exploited relatively intensively (as yet not to the point of presenting any management problems), apparently to a greater extent than the Atlantic form. My assumption that exploitation of the Atlantic bearded seal is less intensive is based on various sources of information such as the annual reports of the Norwegian seal harvests, and general comments concerning this seal in the eastern Canadian Arctic (McLaren, 1958a; Mansfield, 1963). McLaren (1962) indicates that the Atlantic bearded seal is not being over-utilized, and that availability to the hunters, and not abundance, is the main factor affecting harvests.

In the Bering and Chukchi Seas there are many villages (most are dependent upon seal hunting) located along the Siberian and Alaskan coasts, as well as on off-shore islands. In addition to the retrieved harvest made by hunters from these villages, there is a very substantial hunting loss which often exceeds 60 per cent. On top of the substantial total kills resulting from the activities of subsistence hunters, there is the organized commercial hunting conducted by the Soviets.

A greater level of exploitation in the Pacific bearded seal must be considered if the various aspects of reproduction are, in fact, different in the eastern and western bearded seals.

The various aspects of exploitation will be discussed at length, in a later section.

BEHAVIOR

Various aspects of bearded seal behavior have been briefly touched upon in preceding sections. Some of the points already mentioned are this seal's habit of swimming with both the head and back exposed (an excellent sketch drawn by Dr. F. H. Fay appears in Plate 23 of Scheffer's 1958 book), and that they raise their hind flippers out of the water when starting to dive. Also, that during the breeding season, the males "sing."

Kumlien (1879), in referring to this seal's habits mentions their basking on floating ice, the fact that they generally remain off-shore (this is especially true during the winter months when ringed seals move toward the shore-fast ice), and that they usually occur singly. He also mentions that the old males frequently fight when they meet on the ice floes, using fore flippers rather than teeth (the latter often missing) as weapons.

The high incidence of scarred seals, of both sexes, indicates that at times they are quite quarrelsome. In most cases, the more popular belief that the distinct claw marks result from encounters with polar bears is probably not true. Seals (including the ringed seal) taken during the spring have more fresh scars than those taken at other times of the year, and it is assumed that increased fighting is associated with the breeding season.

The commercial value of ringed seal skins (except pups) is drastically reduced during the spring because of the prevalence of scars on most pelts.

With the aid of a little imagination, the deep parallel scars inflicted by the strong claws of another bearded seal might resemble those of a polar bear. However, it is a little hard to understand how so many seals could receive scars on their bellies--be on their backs, in the grasp of a bear--and still escape. In my mind there is little doubt that the scars result primarily from fighting with other seals, both in and out of the water. On May 8, 1964 (during the breeding season) I watched two bearded seals while they were engaged in what appeared to be rather violent combat. The thrashing and rolling in the water seemed to explain how wounds could be inflicted on all areas of the body, and at all angles. This particular battle ended when the seals were alarmed by the hunters.

Figure 10 shows the ventral side of a seal bearing many scars. The old scars to the left of the pen are the type often attributed to polar bears.

The general unsociability of bearded seals is apparent when several animals are basking on the same piece of ice. They are most commonly widely dispersed and usually facing away from each other around the edge of the ice floe, or near their respective retreats to the water.

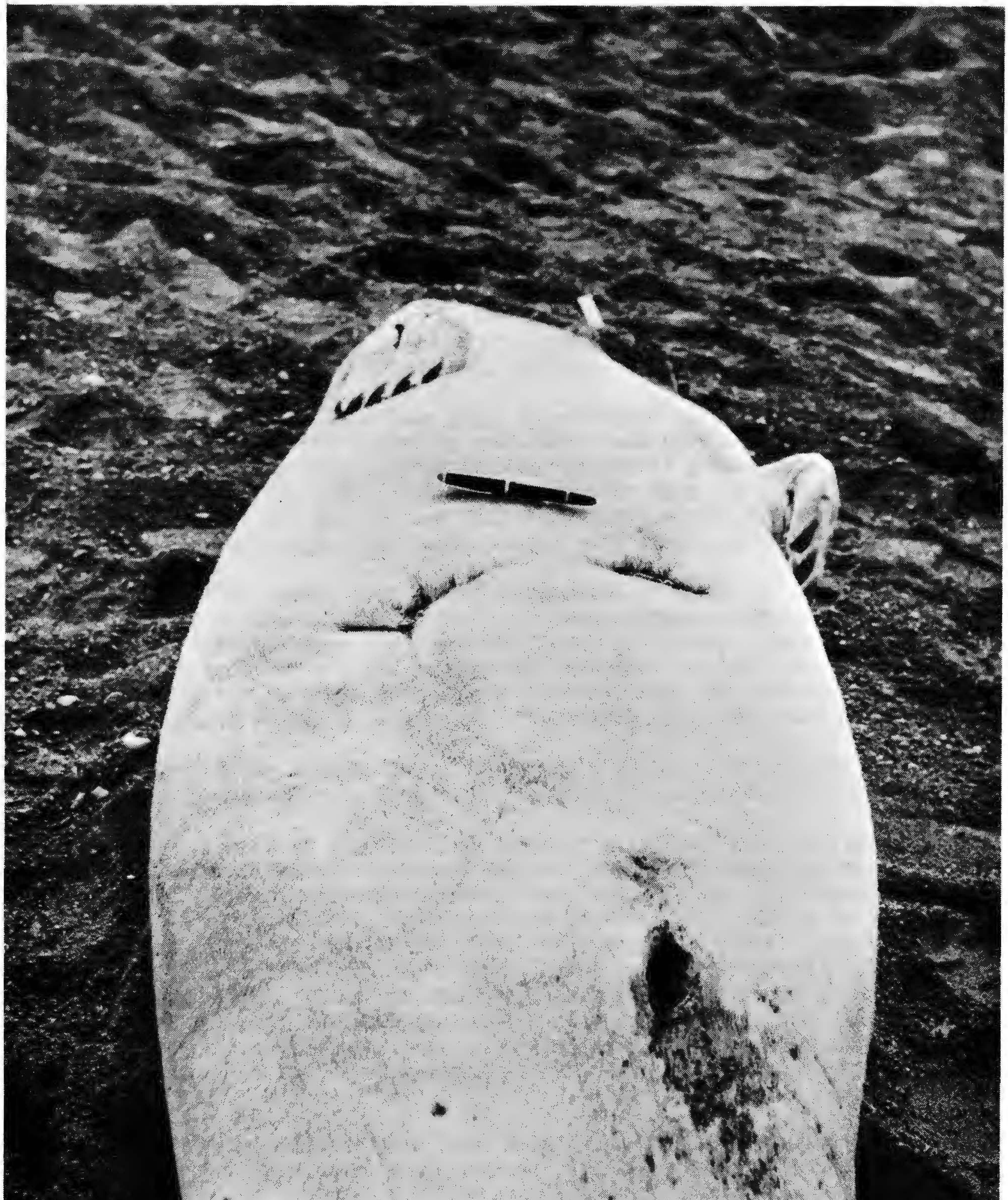


Fig. 10. Ventral side of a female bearded seal showing a recent, deep scar, and several other scars. Those to the left of the pen are the type often attributed to encounters with polar bears. The abdomen has been pierced to prevent bloating. Length of the pen is 13.3 cm.

Alertness or wariness of these seals is quite variable. Persons acquainted with them for only a limited period of time might hold widely divergent opinions depending upon what time of the year the seals were encountered. During the spring when seals are basking, they frequently show little concern at the presence of a boat or man. With a little care on the part of a hunter, they can be approached very closely. One may judge that their senses of sight, smell and hearing are very poor.

In fact, however, these seals seem to possess an acute sense of sight and hearing, and at least a good sense of smell. During the winter, the slightest sound-producing movement of a hunter on the ice will frequently cause these seals to flee, in a splash of water. Also, a hunter must remain well hidden, and if exposed, move very slowly, in order not to alarm a seal. When hunters are waiting near small areas of open water, they always try to place themselves where the wind will not be blowing from the man toward the seal.

An experience which occurred near Nome provided some indication of the bearded seal's sense of smell.

A dog team was tied behind a pressure ridge, next to a lead. All the dogs were curled up and sleeping, and the driver was quite a distance away. I was about 200 yards away from the team, in the other direction. A small bearded seal surfaced about 60 yards out and swam parallel to the ice until it was down wind of the dogs. The seal apparently smelled the dogs, as it raised itself higher in the water, and then dived. It came up several times, down wind of the dogs, but each time it was further away. During the whole time the dogs remained motionless behind the ice ridge.

During late fall when boats are used in the hunt, it is not an uncommon sight to see bearded seals surface several hundred yards from the boat, intently trying to identify the source of disturbance.

Recent work done by Schusterman (1966) indicates that underwater visual acuity is probably good in all pinnipeds, although I suspect it is below average in the walrus.

Unlike some of the other pinnipeds such as the harbor seal in southeastern Alaska, the northern fur seal, and the ringed seal, new-born bearded seal pups move and remain with their dams virtually from the moment they are born. Apparently the pups are born on the exposed ice floes or occasionally in the water. In this respect they are quite like walrus. Another similarity is that both walrus calves and bearded seal pups are dark in color, while the new-born of the other pinnipeds of this area are white when born. White affords protective coloration that probably has selective advantage in those species of seals that periodically leave their offspring unattended on (or in) the ice. However, a dense, white, wooly coat is of little advantage to walrus calves and bearded seal pups as it would be a hindrance to swimming, and white is probably of little protective value in these cases: it may even be a disadvantage to the swimming and relatively deep diving young.

Protection is afforded the bearded seal pups by the strong maternal bond. This is best illustrated by a number of instances in which the female bearded seals remained near a nursing pup (identified as such by the presence of milk in the stomach) which had been killed by hunters. The female will invariably remain near the pup, and in some cases come up on the ice. If shot in the water, lactating females sink very rapidly due to their extreme loss of blubber during the nursing period.

With regard to the production of sound, King (1964) mentions that, "Adult Bearded Seals have been heard whistling to their pups while under water, but they do not apparently make this noise when on land."

During the spring, adult male bearded seals do make a loud, distinct and highly characteristic noise which is best described as a whistle. Locally, these seals are referred to as "singing oogruks" or are designated by the Eskimo name ay-uk-touk.

The earliest date on which a "singing" oogruk was heard was April 9, and the latest date was May 27. Records of the occurrence of these seals have been kept during the past five spring hunting seasons starting in 1962. Mr. Edward Muktoyuk, a former resident of King Island, stated that the time during which these seals "sing" is from April 12 to the end of May. During the past three years Mr. Muktoyuk, as an interested party, has been keeping records of pinnipeds and their activities at King Island.

These seals are easy prey for the hunters as they signal their presence, and usually remain in a localized area, or move very slowly. The sound can be heard from a great distance by putting a boat paddle in the water, and placing the other end against the ear. In this way the hunters can determine the general direction and distance to the seal. Invariably the singing seals are adult males.

In commenting on a recording of these sounds made by Dr. Carlton Ray, of the New York Zoological Society, William Watkins (personal communication) stated that this was the first marine mammal he had noted with a real "frequency modulated" signal. The others have some frequency shifting, "but not as rapidly and continuously varying as in *Erignathus*."

A paper concerning the characteristics of these sounds and their significance, is presently in preparation (Ray and Burns, MS).

The call is repeated over and over. The first part of the "song" begins when the male seal starts a dive. The frequency of the whistle decreases and the whole process is reversed, ending when the seal appears at the surface. Whistling seals observed near and at the surface were swimming in circles, indicating that while under water the seals may be swimming in a spiral. The whistling is not made while the seal's head is above water.

At the present time the correlation (if any) between frequency (which is controlled by the seal) and the depth at which he is swimming, is unclear. That seals are shifting their position underwater is indicated by changes in amplitude of the sound. The seals can initiate any part of the call at will. A long low-frequency moan sometimes precedes that part of the call in which the frequency is increasing, but it is often omitted.

The part of the song most commonly heard without the aid of sound amplifying instruments can be crudely diagrammed as follows:

Waller (1966), in analyzing the three classes of phonations--clicks, whistles, and grunts--produced by spotted porpoises, indicates that clicks represent echolocation and that, "certain whistle patterns concern social interactions and conditions . . ."

In bearded seals the whistling is done by males during the breeding season. The dates when these sounds were first and last heard (April 9 and May 27) support the conclusion that they are in some way connected with courtship behavior. The peak of singing activity is reached during early May.

The sounds are interpreted as a vocal proclamation or advertisement of a receptive male that has established a breeding territory.

Territories of these males are either stationary (i.e. the seal remains in the same location for a period of time: 4 1/2 hours was the maximum observed in Norton Sound, where there was little current at the time), or moving slowly. The moving territories are more common in Bering Strait. Territorial attachment seems to be with an area of open water, rather than with the sea floor or something else. How much water volume is included in a territory is a matter of speculation, but it is probably highly variable. The seals are more stationary in the larger areas of open water. A slow spiral descent and ascent enable the seal to "broadcast" in all directions.

As yet, no female bearded seals that had been proclaiming their willingness to breed (with sound audible to man), have been killed by hunters, and it is doubtful that they "sing" as do the males.

Another sight, although a fairly infrequent one, is that of a bearded seal leaping completely out of the water. The only time I have observed this was when a seal was being pursued with a boat. Of three "jumpers" that were killed, one was a large adult female, one was an adult male, and the third a juvenile male. All three were taken during the spring. Hunters indicate that this has been observed at all seasons of the year.

DISTRIBUTION AND MIGRATION

In the area of the Bering and Chukchi Seas underlain by the Bering-Chukchi Platform, there are probably no places where bearded seals cannot reach the bottom to feed. Also, the abundance of prey species in this area is not an important factor with regard to distribution of these seals.

Quite obviously, the seasonal movements and distribution patterns are primarily the result of ice conditions overlying this platform.

The question of whether bearded seals can make breathing holes in thick sea ice is still a matter of discussion. In the Bering and Chukchi Sea areas they apparently seldom do. This is not to say that they cannot maintain breathing holes which have been started at some time when the ice was thin, or soft. It appears that these seals will remain in an area as long as open water areas prevail, or until their breathing holes are destroyed by shifting ice--then they move to other areas where conditions are more favorable.

Another unknown but apparently important factor with regard to distribution is competition with ringed seals.

Starting in January, there is a large-scale influx of adult ringed seals along the coast. These ringed seals are seeking areas favorable for the bearing of their offspring, and subsequent procreation. Sexually immature ringed seals remain more evenly distributed throughout their winter range, although they tend to congregate in areas where food is abundant.

Concurrent with the influx of ringed seals is an exodus of bearded seals to areas further from shore. The Eskimos feel that the ringed seal is able to appropriate the available breathing holes because of its speed in swimming. This may be part of the reason. However, even where there is no competition for breathing holes the majority of bearded seals also leave the inshore areas where open water prevails.

Due to differences in feeding habits competition for food is apparently not involved. A reason highly suspect for offshore movements of the bearded seals is the unsociability of the animal, and the fact that adult ringed seals are concentrated along the coast where ice conditions favorable for denning are found.

Regardless of the cause of these movements, there is an important shift of ringed seals toward the coast, and of bearded seals away from it.

During the period from January to April the bearded seals are sparsely distributed throughout the Chukchi and northern Bering Sea. The major segment of the population probably occupies the ice covered areas south of a line extending from the southeastern tip of the Chukchi Peninsula, to the south shore of the Seward Peninsula. They are numerous in areas of strong currents and shifting ice--where open water is found.

The great numbers of these seals observed near the southern edge of the ice during the summer months (off northern Alaska), indicates that they are probably most abundant near similar conditions during the winter. In this respect they are somewhat like the walrus.

During these months (January through March) Alaskan hunters take relatively few bearded seals. The spring and fall migrations are the most important single factors affecting availability to hunters, and hunting success.

By early April the northward spring migration has begun, but it is not until the latter part of that month that bearded seals appear in any greatly increased numbers in the Bering Strait area. At this time they also begin to move in closer to the mainland again. By early May the migration is well under way in the Bering Strait area, and it continues until all of the sea ice has passed north (usually in mid-June). These seals, although more numerous than walrus, are more widely distributed and not as socially inclined. An indication of the spring migration timing past St. Lawrence Island, based on hunting success from 1963-1966, is presented in Figure 11. More females appear during the early part of the migration, while the later migrants are predominantly males.

The tendency to remain near the ice is apparently more fixed in adult seals than in the juveniles. Young bearded seals are occasionally taken during the summer months in the ice-free bays, and have been observed several miles up some of the rivers. The periodic occurrence of relatively large numbers of sub-adult seals in Kotzebue Sound, during the ice-free period, has apparently given rise to the belief that a race of dwarf seals inhabits that area. All of the "dwarfs" that I have examined from the area have proven to be sexually immature animals. The reported occurrence of dwarfs was also mentioned by Johnson, et al (op. cit.).

Circumstantial evidence indicated that the immature seals that enter the bays and sounds to bask, remain as long as the ice does. By the time the ice rots in situ, during late June or early July, the pack ice has receded to the vicinity of northern Alaska and many of the young seals remain where they are.

By mid- to late June the main movement of bearded seals past Point Hope is occurring, and by mid-July to early August the seals are numerous near the southern edge of the ice which generally extends west from somewhere between Wainwright and Point Barrow.

Johnson, et al (op. cit.) found that at Point Hope, during June (when the seals are migrating north past that location) there was a "definite preponderance of adults over immature specimens." This was also the situation at Wainwright during July and early August of 1964 and 1965. This is probably because many of the young seals remain further south.

Little is known about the movements of the seals during years when the ice passes north beyond the limit of shallow water. It is assumed that like the walrus, most of them move west, along the northern Siberian Coast, while others no doubt move east along the coast of Alaska and western Canada.

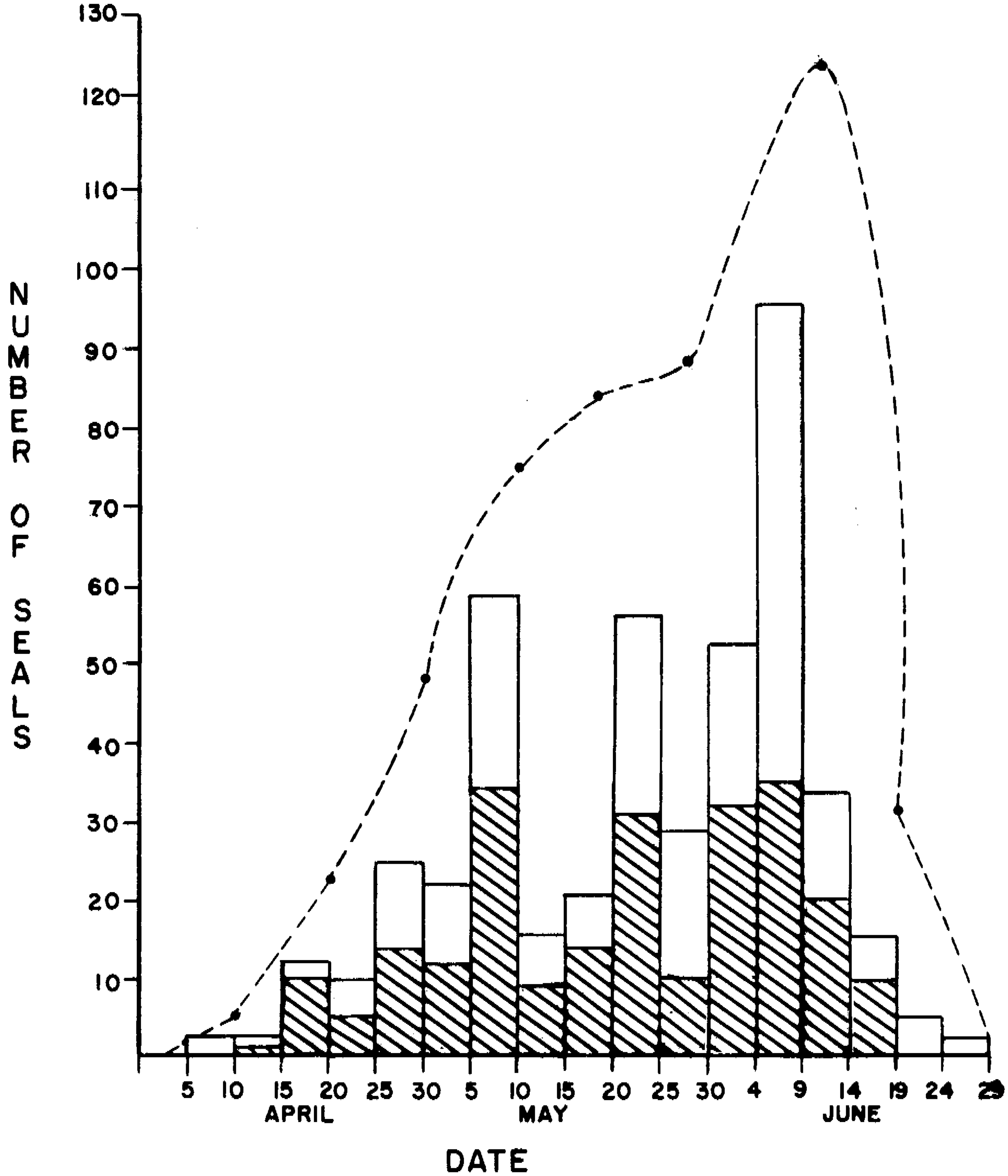


Fig. 11. Spring migration timing of bearded seals past St. Lawrence Island as indicated by recorded hunting success from 1963-1966. The bars indicate harvest by five day intervals, with the female component indicated by stippling. The dots connected by a broken line indicate the harvest by ten day intervals, starting with the period from April 5 to 15. Total sample, 471 seals.

The southward fall migration occurs concurrently with the southward movement of the sea ice. However, this fall movement is not as spectacular as the spring migration because it occurs over a longer period of time. Bearded seals can move south at a slower pace as the extensive sea ice in the Bering Strait area is not completely formed until around January.

Young seals often move south well in advance of the sea ice. At Little Diomede, King and St. Lawrence Islands the immature seals begin to appear in late September, but it is not until late November or early December that the adults appear in any number.

Davies (1958) pointed out a useful distinction between the total range and effective range of groups or species of animals. The total range includes the areas far from an animal's normal habitat where it has occasionally been found. The effective range is the area in which most of the animals usually occur (their usual habitat). The difference between the two is sometimes rather extensive in pinnipeds as they can move great distances from their effective range to a degree not equaled in land mammals.

The effective winter range of bearded seals in the Bering and Chukchi Seas coincides with the maximum extension of the pack ice, and density of animals seems to decrease from south to north.

EXPLOITATION AND POPULATION DYNAMICS

Exploitation of the Pacific bearded seal results from two kinds of hunting activity; that of the subsistence hunters along both the Siberian and Alaskan coasts, and the commercial seal hunting carried on by the Soviets and Japanese. At the present time only the Soviets are working in the middle Bering and Chukchi Seas, while the Japanese hunting is restricted to the area around northern Hokkaido Island.

The effects of Japanese hunting activity on bearded seals of this area are unknown as we have no information concerning the movement of seals between the Okhotsk and southern Bering Seas.

Commercial seal hunting by the Soviets has apparently greatly increased since 1962, and the following quotations provide a valuable insight into the extent, purpose and possible results of this increased pressure.

The first note appeared in Polar Record (1965) and is from two papers by Tikhomirov (1964).

> A Soviet biological party from the Pacific Research Institute of Sea Fisheries and Oceanography . . . has recently studied the seals of Bering Sea, with a view to possible exploitation. The party was aboard the sealer <u>Lakhtak</u> and followed the ice edge northwards from March to early July 1962. Most work was done in the eastern part of the sea, between Bristol Bay and Bering Strait . . .

The note goes on to say:

> The conclusion reached was that there were two hunting areas, east and west of long. 176° W. The western area has been exploited since 1960 by two Soviet sealers. Some 15,000 head a year are taken, mainly Ribbon Seal, and this is thought to be as many as the stock will stand. The eastern area, however, is not exploited, and the suggestion is made that six Soviet sealers should be deployed here in April and May of each year. Three would work the Pribilof Islands region, mainly for Harbour Seal, one the St. Lawrence Island region, for Bearded and Ribbon Seal, and one the St. Matthew Island region, mainly for Ribbon Seal.

Judging from the presence of Soviet seal hunting vessels near St. Lawrence Island during 1965 and 1966, the above recommendations were at least partially adopted. The number of skinless bearded seal carcasses found on the ice by Alaskan hunters indicates that the Soviets are taking mostly skins and blubber.

Bearded Seal Investigations in Alaska

Another note which appeared in Polar Record (1966) from a paper by Krylov, et al (1964), contains the following statements:

> Shore based sealing [by local inhabitants organized in state and collective forms] off Chukotka has been for Walrus (Odobaenus rosmarus divergens), Bearded Seal (Erignathus barbatus) and Ringed Seal (Pusa hispida). . . Since 1961 ship-based sealing has spread also to the Bering Sea . . .
>
> Information on the stocks of these species is scanty, but the following facts are indicative. In the Sea of Okhotsk, the catch of all species dropped by 20 per cent between 1957 and 1962. The catch of Ringed Seal in the same place and period dropped from 6,500 head to 4,000 head per unit effort. A survey of Bearded Seal rookeries on the coast of the Sea of Okhotsk in 1961-62 gave counts which were only a third of the comparable figures for 1936. Both these species are thought to have declined in numbers through over-exploitation.

Another brief note which appeared in the Bureau of Commercial Fisheries, Daily Market Report, for 10 November 1966 deals primarily with the hair seal fishery in the Caspian Sea. However, some of the comments probably apply to the entire Soviet seal fishery. With regard to the Caspian Sea, "Soviets plan to exploit hair seals at an increasing rate and hope to harvest yearly, 130,000 skins by 1980." The article states that skins are sold abroad for use as trim on sport coats, skiing apparel, etc.

All indications seem to point toward increased exploitation of all commercially valuable seal stocks that are not already being over-utilized--the bearded seal of the Bering-Chukchi Sea area included.

In a recent paper (Burns, 1965) I pointed out that in the Bering Sea, the present harvest of walrus closely approaches the maximum sustained yield at the present population level. The bearded seal sustains the next highest rate of exploitation, followed by the harbor seal and the ringed seal.

Information concerning the total annual kill, and the total retrieved harvest of Pacific bearded seals is not available at present. The number of bearded seals taken by Alaskan hunters has been estimated on the basis of information accumulated during my studies. The estimated harvest is based on records accumulated at the major hunting sites, identification of selected samples of seal scalps submitted for bounty, and records kept by various people visiting the villages. The Alaskan harvest is somewhere around 3,400 animals. Table 3 presents a resumé of the harvest by area or village.

Table 3. The Estimated Mean Annual Harvest of Bearded Seals at Hunting Sites in Western and Northern Alaska.*

Village or Area	Bearded Seals	Village or Area	Bearded Seals
Bristol Bay Area	100	Savoonga	275
Kuskokwim Bay Area	225	King Island	75
Mekoryuk	50	Teller	200
Tununak	25	Brevig Mission	200
Hooper Bay	250	Wales	150
Chevak	20	Little Diomede	75
Scammon Bay	15	Shishmaref	300
Stebbins	75	Deering	20
St. Michael	15	Buckland	10
Unalakleet	45	Kotzebue	50
Shaktoolik	45	Noatak	10
Koyuk	100	Kivalina	40
Elim	100	Pt. Hope	200
Golovin	40	Pt. Lay	40
White Mountain	10	Wainwright	250
Nome	60	Barrow	150
Gambell	200		
TOTAL			3,420

* This estimate was obtained from records compiled by Department personnel working at the more successful hunting sites, from information obtained by village residents (teachers, clergymen, VISTA Volunteers and hunters), and by examination of seal scalps submitted to the Nome office for bounty.

Hunting loss is extremely high with bearded seals, as many of the animals sink when killed. Loss through sinking occurs in both sexes throughout the year, but is less frequent in juveniles and pregnant females. Observation of hunting procedures shows that at least half of all the bearded seals killed, are lost. Extreme losses occur during the spring, when men are hunting from the edge of the ice. The seals sink before the men can launch their small boats, or hook them with a hand-thrown retriever. An extreme example of this type of loss occurred at Little Diomede Island on June 3, 1966, when one man killed 14 bearded seals from the edge of the ice, without getting one.

Considering a minimum loss of 50 per cent, the total annual kill of bearded seals made by Alaskan hunters is somewhere around 7,000 animals, and is probably closer to 9,000. The present high hunting loss can be greatly reduced.

As was mentioned in the section on Age Composition and Natality, the age composition of the seal population, as determined through analysis of the harvest, is biased because of the greater availability of young seals. However, I think that this bias is more or less constant.

If exploitation of the Pacific bearded seal continues to increase, it will be well to have comparative data by which we can measure changes in the overall composition of the harvest.

Figure 12 shows the age composition observed in our total sample of 390 seals from which claws were obtained, and the age composition observed in the 1966 spring harvest at Savoonga. The total spring harvest of bearded seals at Savoonga was about 185 animals, and specimens were obtained from 177. This represents our only relatively complete sample obtained at a major hunting site. Prior to 1966, our sampling of the harvest was not random, as we were primarily interested in seals older than pups.

Determining the age composition of the population, and sources of sampling bias, are lines of investigation which deserve further attention: a more complete sampling of the harvest would provide answers.

The great difference between the proportion of pups and one year old seals in the harvest suggests that in spite of biased sampling of these young animals, mortality during the first year of life is probably high.

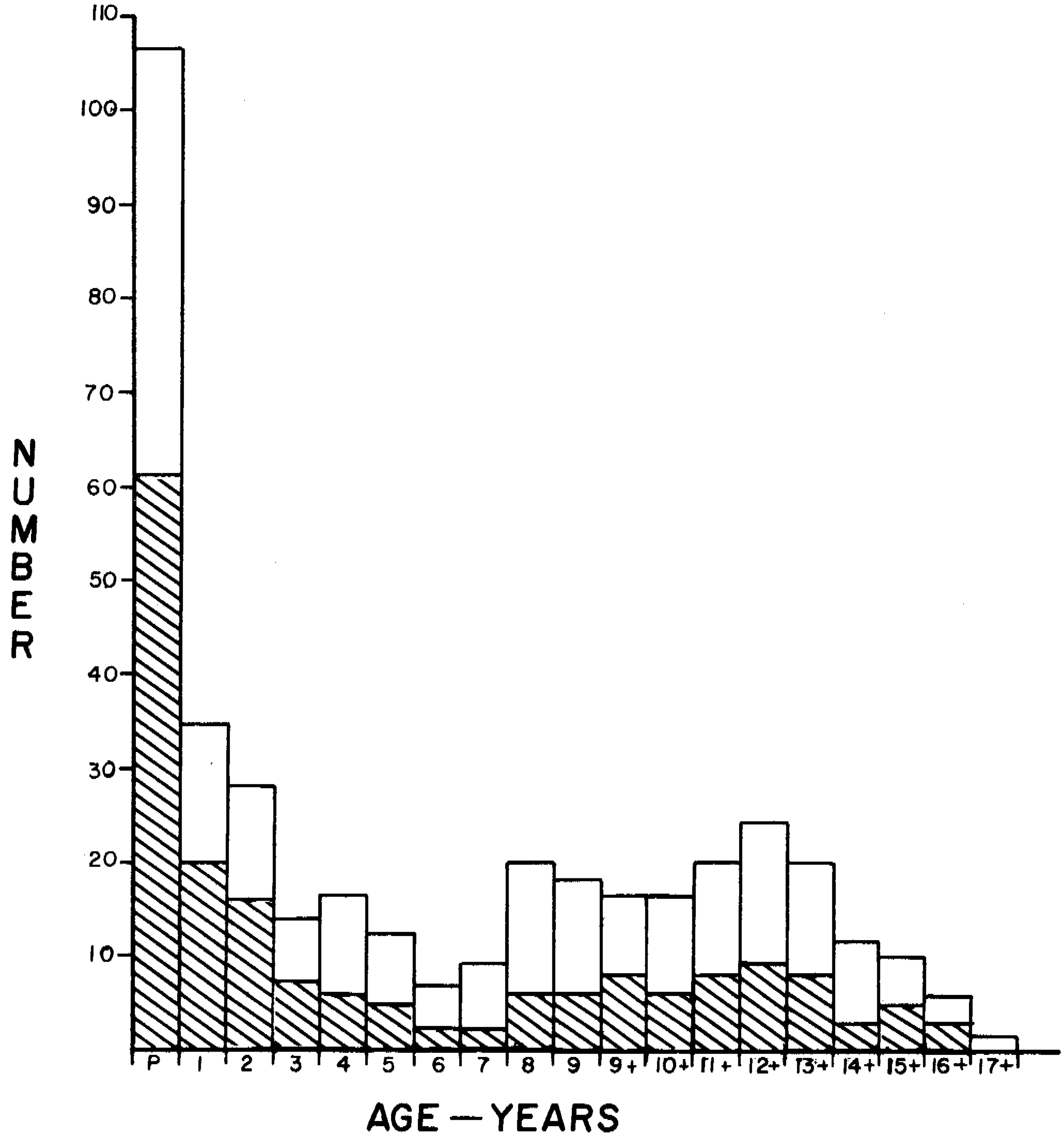


Fig. 12. Age composition of 390 bearded seals taken during the spring hunting seasons from 1964 through 1966 in the Bering Strait area. The stippled area shows the age composition of almost the entire spring harvest of seals, at the village of Savoonga, during 1966.

MANAGEMENT CONSIDERATIONS

At present, bearded seals are abundant throughout their normal range in the eastern Bering and Chukchi Seas. As in the eastern Canadian Arctic (McLaren, 1962) the annual kill is most affected by seasonal availability of the seals.

From all indications, increasing exploitation has as yet not directly affected the harvest taken by Alaskan hunters. It remains to be seen if increasing hunting pressure--a trend which is still in an early stage--will in fact reach a point where the bearded seal population of this region is adversely affected.

Alaskan hunters can greatly reduce the total kill of bearded seals (retrieved harvest + seals killed and not recovered) without reducing the annual harvest. Reduction of hunting loss by improving the presently employed hunting methods would greatly off-set the effects of increased exploitation. However, there is likely to be little concern for improvement of hunting techniques until such time as the hunters can detect a significant reduction in the abundance and availability of bearded seals.

The most significant hunting losses result from shooting seals when the chances for recovering them before they sink are very poor. An extreme example has already been presented.

Employment of careful hunting practices in an attempt to reduce the loss is a system that is both practical and productive.

During May, 1965, after many discussions of ways to reduce the loss normally involved in hunting bearded seals, several hunters from Nome agreed to apply the procedures that were decided upon. During the course of about eight days of hunting, 18 bearded seals were killed and only one was lost.

The simple procedures employed by these men included hunting for seals that were on top of the ice rather than giving chase to swimming seals; also when ice was not present, swimming seals were not killed until they were very close to the boat and could be easily harpooned. The men did not hunt without adequate equipment including harpoons, pokes, boat hooks, and seal hooks: the latter is a hand thrown wooden block containing hooks, and retrieved by an attached line.

Unfortunately, many hunters are inadequately equipped, and thus are unable to recover the seals once they are killed.

By and large, the boat crews--and especially men hunting alone--can handle only a limited number of bearded seals. It is of direct benefit for the hunters to be able to get three or five seals, without killing six or ten.

With regard to evaluating the effects of hunting on the bearded seal population, effort should periodically be devoted to determining changes or trends in the age composition of the harvest at selected sites, particularly on St. Lawrence Island. Villages on this island make significant harvests in a short period of time during the spring, and the age composition is not as biased as in samples obtained from along the coast.

Direct counting of bearded seals by aerial or boat surveys appears to be wholly impractical except for obtaining crude indices of seal abundance in very localized areas. The main problems involved in aerial census procedures are 1) the extensive effective range of the bearded seal in this area; 2) the fact that these seals are more solitary than many other pinnipeds (i.e. harp seals or walrus); 3) that observers can record only those seals visible to them, and it is almost impossible to determine what proportion of the population will be visible at any given time. The number of seals observed on top of the ice is directly affected by atmospheric conditions (even during May and June, the height of the basking season), and the time of day.

As an example, at approximately 8:30 a.m., on June 21, 1966, 27 bearded seals were spotted on top of a piece of ice that was wedged between Big and Little Diomede Islands. The observer (Mr. Aaron Milligrock) was approximately 750 feet up, on the west side of Little Diomede. By 1:00 p.m. only five seals were visible. The piece of ice was approximately 2.6 miles long, and 400 to 500 yards across. It was not moving with the strong current.

Nothing approaching this number of seals was observed out on the moving ice that could be seen to the south of the island. It is quite possible that the seals actively selected the more stable ice between the islands, rather than the floes that were in constant motion, rubbing and bumping against each other in the strong current that prevailed on that particular day. What was observed between the islands may have been an unusual concentration of bearded seals. Expansion or extrapolation of the observed abundance, to include the entire area in which sea ice occurred would have indicated a tremendous number of seals. In some areas along the coast a similar situation prevails when bearded seals haul out on the land-fast ice, but few are observed on the moving ice although they are observed in the water.

Counts of bearded seals made during the course of boat hunting excursions with Eskimo hunters also indicate that direct counts are impractical for anything except an indication of general seasonal abundance. Dr. Carlton Ray (personal communication) indicated that on May 8, 1966 bearded seals appeared to be relatively scarce; yet when he was recording the underwater sounds of male bearded seals, they could be heard everywhere. Granted, his hydrophone could detect the presence of whistling seals within a radius of several miles, but few could be seen by the traveling hunters.

On several occasions, when accompanying the Eskimo hunters in their boats, I "estimated" that more than 95 per cent of the bearded seals in a given area were not detected. Either they were in the water among the loose ice floes, or basking on the rough ice floes where they could not be seen. On such occasions they were easily spotted when we stopped to climb a high pressure ridge and look for them.

Another problem is that extracting meaningful information from a comparison of indices obtained by direct counts during different periods, or subsequent seasons, is extremely difficult because of the problems involved in determining whether the circumstances involved (similar migration timing, weather and ice conditions, time of observation, etc) are similar enough to yield counts which can be validly compared.

At the present time it appears that the only practical procedure for obtaining an estimate of the bearded seal population, and an insight into the effects of exploitation, is through analysis of various characteristics of the harvest in conjunction with accumulated observations, and periodic checks of the various aspects of reproduction.

One very important need is for an exchange of information between American and Soviet investigators in order to determine the magnitude of the total kill of these seals (and the walrus), and comparative estimates of the age and sex composition of the harvest.

If this point can be reached, there is the possibility that, if necessary, the total kill can be manipulated in order to achieve a sustainable harvest.

CONCLUSIONS

1. Some adult Pacific bearded seals attain a weight during the winter in excess of 350 kg, and many weigh more than 270 kg even during the summer months when they are in lean condition.

2. By age nine, most of the teeth are worn down to the gum line, and some are already missing.

3. The average weight of these seals at birth is about 33 kg, and the average length is about 130 cm. By the end of the brief nursing period (12 to 18 days) the average weight of pups increases to some 85 kg, and they have attained approximately 63 per cent of their adult length.

4. At physical maturity, the average length of these seals is about 233 cm. Females are slightly larger than males; a characteristic also observed in skull length.

5. Baculum length is a useful indicator of relative age in males.

6. There is some indication that certain food items may aid in the removal of stomach parasites. Food consists primarily of bottom living invertebrates and fish.

7. The peak breeding period is from mid-April to mid-May, and male seals appear to be in breeding condition for a longer period of time than females. These seals are probably polygamous.

8. Implantation occurs during late July and early August, after a delay of approximately 2 1/2 months. By comparison with the findings of other investigators, the time of breeding and implantation is earlier in areas further south.

9. Birth of pups occurs from mid-March to early May with the peak of births occurring during late April.

10. Some female bearded seals begin to ovulate at three years of age, but reproductive maturity (the ability to successfully conceive) is not attained until age five or six. Males apparently achieve sexual maturity at age six or seven.

11. The incidence of pregnancy in adult females is approximately 85 per cent, based on both ovarian analysis and frequency of foetuses in a limited sample of adults taken from late summer through winter.

12. Our samples consistently show slightly more females than males in the population at birth and throughout the various age groups. The significance of this is unknown, but the difference is so slight, that for practical purposes I have considered the sex ratio to approximate 1:1.

13. The estimated proportion of adult (sexually mature) seals in the population is between 55 and 60 per cent, and the rate of reproduction for the population as a whole is estimated at 22 to 25 per cent.

14. It appears that the age at sexual maturity is lower and the rate of reproduction is higher in the Pacific bearded seal, than in the Atlantic form. This is tentatively attributed to a higher rate of exploitation of the Pacific seals.

15. Distribution and migration of bearded seals in the Bering-Chukchi Sea area is affected primarily by the seasonal advance and retreat of the sea ice. Adult seals are almost always associated with ice although young seals will remain in ice free areas. Hunting success depends mainly upon availability of these seals during the seasonal migrations.

16. There is a significant movement of bearded seals away from the coast during the mid-winter and early spring months. This coincides with an influx of mature ringed seals during the same period.

17. Although the responses of bearded seals to the presence of man are quite variable, these seals seem to possess acute senses of sight and hearing, and at least a good sense of smell.

18. During the breeding season male seals produce a distinct and very specific whistling sound under the water. These sounds are interpreted as a vocal proclamation or advertisement of a receptive male that has established a breeding territory.

19. At the present time, all indications point toward increased exploitation of the seals available in commercial quantities. This exploitation may affect the bearded seals of the Bering and Chukchi Seas. The present harvest by Alaskan hunters is approximately 3,400 bearded seals, and the total kill is estimated at between 7,000 and 9,000 animals.

20. The effects of increased exploitation can be partially off-set by reducing the high hunting loss. This can be accomplished through improvement of the presently employed hunting techniques.

21. It appears that direct census of bearded seals, using either aircraft or boats, is not satisfactory for obtaining population information other than a crude index of relative abundance in localized areas. Population size, status and trends will have to be determined by indirect methods based on material collected from the hunters.

ACKNOWLEDGEMENTS

Throughout the course of this investigation I have received assistance from many people. Dr. Francis Fay, Arctic Health Research Center, Anchorage, Alaska, provided a substantial amount of specimen material, data, field notes, and many interesting and informative discussions. Dr. Max Brewer, Arctic Research Laboratory, Barrow, Alaska, greatly assisted by providing logistic support and facilities at both Barrow and Wainwright. Dr. Ian McLaren, Dalhousie University, Nova Scotia, made age determinations of a series of bearded seal claws sent to him for the purpose of comparing our respective results. Drs. Tetsuo Inukai and Hasashi Abe, University of Hokkaido, Japan, permitted me to examine material collected in the southern Okhotsk Sea.

Assistance during this study was also received from numerous residents of coastal villages throughout northwest Alaska; particularly Albert Iyahuk of Little Diomede Island, Andrew Ekak of Wainwright, Vernon Slwooko and Neal Shanahan of St. Lawrence Island, Edward Muktoyuk of King Island, and Anthony Koezuna of Nome.

I am also indebted to Mr. Alan Courtright, Alaska Department of Fish and Game, Juneau, for his critical review of the manuscript, and the improvements which he made.

LITERATURE CITED

Allen, J. A. 1880. History of North American pinnipeds, a monograph of the walruses, sea lions, sea-bears, and seals of North America. Washington, U. S. Geol. and Geogr. Surv. Terr., Misc. Publ. 12, 16 + 785 p.

Amoroso, E. C., and J. H. Matthews. 1951. The growth of the grey seal (Halichoerus grypus [Fabricius]) from birth to weaning. J. Anat. 85: 427-428.

Asdell, S. A. 1946. Patterns of mammalian reproduction. Comstock Publ. Co., Ithaca, N. Y. 437 pp.

Backhouse, K. M., and H. R. Hewer. 1964. Features of reproduction in the grey seal. Med. and Biol. Illustration. 14(3): 144-150. London.

Beechey, W. F. 1831. Narrative of a voyage to the Pacific and Beerings Strait. v. 1, Colburn and Bentley, London.

Brenner, F. J. 1964. Reproduction of the beaver in Crawford County, Pennsylvania. J. Wildl. Mgmt., 28(4): 743-747.

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

Burns, J. J. 1964. Walrus investigations in Alaska. Fed. Aid Completion Rpt., Alaska Dept. of Fish and Game. (Mimeo)

__________. 1965a. Marine Mammal Report. Fed. Aid Completion Rpt., Alaska Dept. of Fish and Game. v. 6, 45 pp. (Mimeo)

__________. 1965b. Marine mammal investigations in northwestern Alaska. Proc. 45th Conf. W. Assoc. State Game and Fish Comm., pp. 129-133.

__________. 1966. Marine Mammal Report. Fed. Aid Completion Rpt., Alaska Dept. of Fish and Game. v. 7, 47 pp. (Mimeo)

Carrick, R., and S. E. Ingham. 1962. Studies on the southern elephant seal, Mirounga leonina (L.). V: Population dynamics and utilization. Commonwealth Sci. Indus. Res. Org., Wildl. Res. 7(2): 198-206. Canberra, Australia.

Chapsky, K. K. 1938. (Bearded seals [Erignathus barbatus Fabr.] of the Kara and Barents Seas.) Vsesoiuznyi Arkticheskii Institut, 123:7-70. Leningrad.

Craig, Allison M. 1964. Histology of reproduction and the estrus cycle in the female fur seal, Callorhinus ursinus. J. Fish. Res. Bd. Canada, 21(4): 773-811, 5 plates.

Davies, J. L. 1958. Pleistocene geography and the distribution of northern pinnipeds. Ecology, 39(1): 97-113.

Delamure, S. L. 1955. (The helminthofauna of marine mammals of the world in the light of their ecology and phylogeny.) Moscow. 517 pp. (in Russian, orig. not seen)

Directorate of Fisheries. 1960. Institute of Marine Research. Bergen, Norway. Seal Harvest 1959. 18 pp. (in Norwegian)

__________. 1965. Seal Harvest 1964. 19 pp. (in Norwegian)

Doutt, K. J. 1942. A review of the genus Phoca. Annals Carnegie Mus. 29: 61-125.

Fay, F. H. 1955. The Pacific walrus; spatial ecology, life history and population. University of British Columbia Ph. D. Thesis. (Unpubl.)

__________. 1966. Investigations of the Pacific walrus. (Monograph in preparation.)

Fisher, H. D. 1954. Studies on reproduction in the harp seal, Phoca groenlandica Erxleben, in the northwest Atlantic. Fish. Res. Bd. Canada. MS Rpt., no. 588, 109 pp.

Harrison, R. J., and L. H. Matthew. 1949. Subsurface crypts, oogenesis, and the corpus luteum in the seal ovary. Nature, 164: 587-588.

Healy, M. A. 1887. Report of the cruise of the Revenue Marine Steamer CORWIN in the Arctic Ocean in the year 1885. House Ex. Doc. 153. 49th Cong., 1st sess. U. S. Govt. Print. Off., Washington. 102 pp., 42 plates, 2 maps.

__________. 1889. Report of the cruise of the Revenue Marine Steamer CORWIN in the Arctic Ocean in the year 1884. House Misc. Doc. 602. 50th Cong., 1st sess. U. S. Govt. Print. Off., Washington. 128 pp., 40 plates.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson, and M. L. Barbour. 1966. Marine Mammals. In Environment of the Cape Thompson Region, Alaska. U. S. Atomic Energy Commission. pp. 877-924.

Kenyon, K. W. 1962. Notes on the phocid seals at Little Diomede Island, Alaska. J. Wildl. Mgmt., 26(4): 380-387.

Kenyon, K. W., and D. W. Rice. 1959. Life history of the Hawaiian monk seal. Pacific Sci., 13: 215-252.

King, J. E. 1964. Seals of the world. British Mus. (Nat. Hist.). 154 pp.

Krylov, V. I. and others. 1964. Soviet sealing in the North Pacific Ocean. (Abstr.) Polar Record. 13: 342.

Kumlien, L. 1879. Contributions to the natural history of Arctic America, made in connection with the Howgate Polar Expedition, 1877-78. Bull. U. S. Nat. Mus., 15: 1-179.

Laurie, A. H. 1937. The age of female blue whales and the effect of whaling on the stock. Discovery Rpts., Cambridge Univ. Press., 15: 223-284.

Laws, R. M. 1953a. The elephant seal (Mirounga leonina Linn.). I. Growth and age. Falkland Is. Depend. Surv., Sci. Rpt. 8: 1-62, 5 plates.

________. 1953b. The elephant seal (Mirounga leonina Linn.). II. General social and reproductive behavior. Falkland Is. Depend. Surv., Sci. Rpt. Rpt. 13: 1-88, 7 plates.

________. 1962. Some effects of whaling on the southern stocks of baleen whales. In The exploitation of natural animal populations. John Wiley & Sons, New York, pp. 137-158.

Mansfield, A. W. 1958. The breeding behaviour and reproductive cycle of the Weddell seal (Leptonychotes weddelli Lesson). Falkland Is. Depend. Surv., Sci. Rpt., 18: 1-41, 6 plates.

____________. 1963. Seals of Arctic and eastern Canada. Fish. Res. Bd. Canada. Bull. 137: 1-30.

McLaren, I. A. 1958a. Some aspects of growth and reproduction of the bearded seal, Erignathus barbatus (Erxleben). Calanus Series no. 13. J. Fish. Res. Bd., Canada. 15(2): 219-227.

__________. 1958b. The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic. Fish. Res. Bd., Canada, Bull. 118: 1-97.

__________. 1962. Population dynamics and exploitation of seals in the eastern Canadian Arctic. In The exploitation of natural animal populations. John Wiley & Sons, New York. pp. 168-183.

Mohr, E. 1952. Die Robben der Europaischen Gewasser. Monographien der Wildsaugetiere, Verlag Dr. Paul Schops, Frankfurt am Main. 12, 283 pp., 40 plates.

Murdoch, J. 1885. Part IV. Natural History. In Report of the International Polar Expedition to Point Barrow, Alaska. Exec Doc. House of Rep., 2nd Session, 48th Cong. 1884-85. 23(44): 89-200.

Parkes, A. S. 1954. Some aspects of the endocrine environment of the fetus. In The mammalian fetus: physiological aspects of development. Cold Spring Harbor Symposia on Quantitative Biology, 19: 3-8.

Plekhanov, P. 1933. (Determination of the age of seals) Sovetskii Sever., 4(1): 111-114 (in Russian)

Ray, C., J. J. Burns, and W. A. Watkins. Analysis of the underwater calls of Erignathus, and a theory of their significance. (in preparation)

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

Schusterman, R. J. 1966. Visual orientation and discrimination in seals and sea lions. (Abstr.) Ppr. presented at the Washington, D. C. Meet. AAAS. Dec. 26-31, 1966.

Sergeant, D. E. 1966. Reproductive rates of harp seals, Pagophilus groenlandicus (Erxleben). J. Fish. Res. Bd. Canada, 23(5): 757-766.

Sivertsen, E. 1941. On the biology of the harp seal. Hvalradots Skrifter, 26, IX + 166 pp., 11 plates.

Sleptsov, M. M. 1943. (On the biology of reproduction of Pinnipedia of the far east.) Zool. Zhur., 22(2): 109-128. (in Russian)

______________. 1949. (New information on the reproduction of far-eastern pinnipeds.) Isvestiia Tikhovkeanskovo N.-I. Inst. Rybnovo Khoziaistva i Okeanografii, 31: 73-77. (Transl. by Fish. Res. Bd. Canada.)

Smirnov, N. A. 1927. Diagnostical remarks about some seals (Phocidae) of the northern hemisphere. Trømso, Mus. Aarsh. 48 (1925), no. 5, pp. 1-23.

Tikhomirov, E. A. 1964. Seals in the Bering Sea. (Abstr.) Polar Record 12: 748-749.

______________. 1966. (On the reproduction of the seals belonging to the family Phocidae in the North Pacific.) Zool. Zhurnal. 45(2): 275-281. (in Russian)

Waller, D. W. 1966. Phonations of free-ranging spotted porpoises in the eastern Pacific. (Abstr.) Ppr. presented at the Washington, D. C. Meet. AAAS. Dec. 26-31, 1966.

Wheeler, J. F. 1930. The age of fin whales at physical maturity with a note on multiple ovulation. Discovery Rpts., Cambridge Univ. Press. 2: 403-434.

Wilke, F. 1958. Fat content of fur-seal milk. Murrelet, 39(3): 40.

Wright, P. L. 1950. Development of the baculum of the long-tailed weasel. Proc. Soc. Exper. Biol. and Med. 75: 820-822.