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The Natural History and Ecology of the Bearded Seal (*Erignathus barbatus*) and the Ringed Seal (*Phoca hispida*)

Principal Investigators:

John J. Burns and Thomas J. Eley
Marine Mammals Biologists
Alaska Department of Fish and Game
1300 College Road
Fairbanks, Alaska 99701

Assisted by: Kathy Frost, Lloyd Lowry, Glenn Seaman, Robin Lynn, Richard Tremaine, Dan Strickland, Ed Muktoyuk, Diane Preston

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I. Summary of objectives, conclusions, and implications with respect to OCS oil and gas development

Ringed seals, Phoca hispida, and bearded seals, Erignathus barbatus, are major components of the marine mammal fauna of the Bering, Chukchi, and Beaufort Seas. They have been chosen as target species for investigation based upon criteria including their significance in the ecosystem, importance to people residing along the coast, and considerations of timeliness, feasibility, and applicability to OCS requirements. This does not overlook the significance of other marine mammal species of the region, some of which are the subjects of other investigations (i.e. walrus, spotted seals, bowhead whales), and some of which suggest a lower probability of successful achievement of important task objectives (i.e. ribbon seals or grey whales). All of the marine mammal species of the area will be included in certain kinds of analyses such as that of distribution.

The broad objectives of this project are to obtain baseline information about the natural history and ecology of ringed and bearded seals. These species occupy vastly different ecological niches within the ice-dominated marine systems in question.

The ringed seal is a small, widely distributed and very abundant species which mainly occurs in areas of extensive, relatively thick and stable sea ice. It is the only species within our study area that occupies the landfast ice. It is the species taken in largest numbers by Eskimo seal hunters. Ringed seals feed mainly on zooplankton, the smaller shrimp, and demersal fishes.

In marked contrast, bearded seals are the largest of our northern seals. They are also widely distributed, but occur in the drifting ice. They feed almost exclusively on benthic organisms. Annual harvests of bearded seals are much lower than those of ringed seals. However, due to the great difference in size, the amount of usable protein is almost the same. Bearded seals are preferred by coastal residents.

Our intent in selecting these species for investigation was to examine simultaneously the biology of two species which are of significant importance to man, and which depend on vastly different habitats within the marine ecosystem.

The implications with respect to oil and gas development are basically that we will be able to recognize how, when, where, and why certain activities may have proximal or ultimate effects on these two important species. As examples, how does seismic exploration in areas of landfast ice affect ringed seals which breed there? What food organisms are these seals utilizing? Are there differences in the susceptibility of prey species to oil pollution--or, which of the seals is most susceptible to significant indirect effects of oil development? How much disturbance will the seals tolerate? Will they avoid areas of intensive human activity? Are there critical migration routes, etc.? Answers to almost all of the questions concerning the potential effects of oil and gas development on these seals depend on an understanding of their natural history and ecology.

II. Introduction

Bearded and ringed seals constitute two of the five pinniped species associated with the ice-dominated habitat of the Bering, Chukchi, and Beaufort Seas. By virtue of numbers and distribution they are of great significance to coastal residents of northern Alaska and Siberia, providing reliable sources of food and usable byproducts. Their importance as significant, functioning elements of the marine environment is not adequately known. Both species occur throughout the seasonally ice-covered regions. However, differences in habitat requirements (including food habits) result in an ecological partitioning of the marine system in question. Proposed OCS lease areas in the Bering, Chukchi, and Beaufort Seas fall directly within the habitat of these two species.

The primary emphasis of our ecological studies responds to OCSEAP tasks A-1, A-2, and A-3. Information required for accomplishment of objectives A-6 and A-31 is being obtained. Our study (as well as many others) is required in order to eventually achieve objective E-1.

Information required to meet the task objectives includes, but is not limited to, such things as natality, mortality, population size, population structure, trophic relationships, detailed understanding of factors determining density, distribution, seasonal movements, critical habitats, behavior, and other biological processes. Historical events indicate that marine mammals, as intelligent, irritible (in the physiological sense) and ecologically specialized organisms have almost always been adversely affected by the activities of man. The proposed exploitation of outer continental shelf resources poses the real threat of habitat alteration. Adverse impacts can be lessened if there is an adequate understanding of the ecosystem and its component parts and types of perturbation that can be anticipated.

Specific objectives of this project are as follows:

1. Summarization and evaluation of existing literature and available unpublished data on reproduction, distribution, abundance, food habits, and human dependence on bearded and ringed seals in the Bering, Chukchi, and Beaufort Seas.

2. Acquisition of large amounts of specimen material required for an understanding of food habits in these two species.

3. Acquisition of additional data on productivity and growth rates.

4. Acquisition of baseline data on mortality and morbidity (including parasitology, diseases, predation, and human harvest) of ringed and bearded seals.

5. Determination of population structure of bearded and ringed seals as indicated by composition of harvest taken by Eskimo subsistence hunters.

6. Initial assessment of regional differences in density and distribution of ringed and bearded seals in relation to major habitat conditions.

7. Acquisistion of additional information on seasonal migrations.

III. Current state of knowledge

A considerable amount of general background information concerning bearded and ringed seals is presently available and is being summarized under our task objective 1. Almost all of this information relates to general understanding of aspects such as reproduction, age and growth, gross physical characteristics, general seasonal movements, general distribution, and food habits. However, the knowledge presently available remains inadequate for purposes of understanding the dynamic processes of these two species, their impact on and role in the northern environment, and the probable effects of disturbance both to the species themselves and the environment on which they depend.

A. Ringed seals

Ringed seals have a circumpolar distribution in arctic and subarctic seas, and they are the most abundant seal found in the Arctic. Polar bears, arctic foxes, and ringed seals are the only mammals that have been recorded north of 85°N latitude.

In Alaska, ringed seals inhabit the shorefast and moving pack ice of the Bering, Chukchi, and Beaufort Seas. Stragglers have been collected at Unalaska Island in the Aleutian Islands and on the Pribilof Islands.

The general distribution of ringed seals is limited by the distribution and quality of sea ice; however, some ringed seals are seen during ice-free periods in the Bering and Chukchi Seas. Seals appear at various coastal locations with the formation of shorefast ice in the fall and then disappear from these coastal areas in the spring with the ice breakup. Seals which winter in the Bering Sea may appear to move farther and are more widely distributed than adult ringed seals. The density of ringed seals varies greatly with the area and the season, but depends chiefly on the stability of shorefast ice for reproduction.

In addition to man, predators of ringed seals include polar bears (Ursus maritimus) (the chief predator), arctic (Alopex lagopus) and red foxes (Vulpes vulpes), dogs, wolves (Canis lupus), and ravens (Corvus corax).

Females give birth to a single, white-coated pup in ice dens (lairs) on both landfast and drifting pack ice during March and April. The female seals build the lairs on ice pressure ridges or under snow in refrozen leads for protection from predators and severe weather. Lairs are about 10 feet (305cm) long with an entrance from the water located at one end.

There is some evidence that females lacking maternal experience give birth in marginal habitat--drifting pack ice--and may be more subject to polar bear predation. The more experienced females give birth in better habitat, landfast ice, and may have higher reproductive success.

At birth the average weight of pups is 10 pounds (4.5kg) and the average length is about 24 inches (61cm). Females nurse pups for about two months during which the pup doubles its birth weight, to about 20 pounds (9.0kg). This gain is due to an increase in blubber thickness which provides the pup insulation to reduce heat loss to the cold water, air and ice, and provides an energy reserve. Weaning usually takes place at ice breakup.

Most females breed again within a month after the birth of the pup. Implantation of the new fetus is delayed 3-1/2 months and occurs in mid-July or early August. Pregnancy lasts about 11 months. Female ringed seals first ovulate at five or six years of age but successful conception does not appear to take place until the female is seven years old. Males become sexually mature at seven or eight years of age.

Ringed seals have been reported to live to an age of 36 to 40 years in the wild; however, relatively few animals taken in subsistence harvests exceed 10 to 15 years of age.

Until recently the ringed seal has been considered a silent species unlike many of its relatives which produce very melodious and complex "songs." Recent studies have shown that ringed seals do emit several types of vocalization under water and that these vocalizations are not readily audible above water or ice. Although these vocalizations are "heard" all year, if one uses a hydrophone (underwater microphone), the number of vocalizations increases during the breeding season. This may mean that the vocalizations are used to maintain social organization or to defend territories.

The behavior of ringed seals is poorly understood since both males and females spend the greater part of the year beneath the ice in lairs or in the water. From April until ice breakup, ringed seals "haul out" on the shorefast ice on sunny and warm days and undergo a molt (shedding and regrowth of the hairs). Peak of the molt is in May and June. Apparently the warmth and rest are required for rapid regrowth of the hairs.

The primary food of ringed seals in the nearshore western Beaufort Sea during spring and summer is euphausiids. In the Chukchi Sea they appear to feed primarily on shrimps in the summer and fishes (largely arctic cod) in the winter.

B. Bearded seals

Bearded seals are also a circumpolar arctic species. Although they can maintain breathing holes in ice, they appear to do so only rarely and are thus largely excluded from the winter fast ice zone. The winter density of bearded seals in the Beaufort Sea is low (about 0.1 animals/mi^2) with animals found in the flaw zone and nearshore pack ice.

Bearded seal pups are born on top of the ice from late March through May. Pups are capable of swimming shortly after birth and are weaned in 12 to 18 days. Subsequent to pupping, animals breed and molt.

As was the case with ringed seals, a seasonal concentration of animals occurs during summer. However, as they are primarily benthic feeders, few bearded seals remain with the summer pack ice when the southern edge is over deep water. They redistribute south with winter ice formation. The majority of animals winter in the Bering Sea and in the highly fractured ice north of the Bering Strait.

Bearded seals in the Chukchi and Bering Seas feed primarily on shrimps, crabs, and bivalve molluscs. Foods of bearded seals in the Beaufort Sea are presently being investigated (cf. Annual Report RU #232).

IV. Study area

The study area for this project includes the nearshore and offshore waters and ice of Bristol Bay, Bering Sea, Norton Sound, Bering Straits, Kotzebue Sound, Chukchi Sea, Beaufort Sea, and Arctic Ocean. Specific collection localities from which we have attempted to sample during this contract period include Stebbins, Nome, Savoonga, Gambell, Shishmaref, Kotzebue, Point Hope, Cape Lisburne, Point Lay, Wainwright, Barrow, and Barter Island. With the aid of ships and helicopters we have sampled the offshore areas of Bristol Bay, Bering Sea, Norton Sound, Chukchi Sea, Kotzebue Sound, Beaufort Sea, and Arctic Ocean. We have attempted to sample within and adjacent to areas outside the following proposed lease areas: Beaufort Basin, Hope Basin, Norton Basin, Bristol Bay, and Saint George Basin.

V. Sources, methods, and rationale of data collection

A. Ringed and bearded seals are collected as systematically as possible from different geographical areas and habitat types throughout the year. The objective of our sampling program is to detect variations in sex and age distribution, growth rates, reproductive conditions, parasites, and food habits in relation to season, geographic area, and habitat type. Acquisition of the large amounts of specimen material required for an understanding of the natural history and ecology of these two species is continuing at major Eskimo hunting villages. In addition, selective collection by the Principal Investigators is utilized to collect animals under specific environmental, temporal, and behavioral conditions. Selective collection provides additional data that cannot be obtained from the animals taken at the Eskimo hunting sites.

B. Weights and standard measurements are taken, when possible, from animals taken by Eskimo hunters, and from all animals selectively collected. The weights and measurements include: gross weight, hide and blubber weight, curvilinear length, standard length, axillary girth, maximum girth, front and hind flipper lengths and widths, navel to anus length, penis to anus length, tail length, and blubber thickness at the sternum. These data are used to establish fetal, pup, subadult, and adult growth rates, seasonal condition patterns, and to assist in making biomass calculations. In addition to weights and standard measurements, we attempt to obtain: specific location, date and time of collection; habitat and ice type; behavior at time of collection; group size and composition; tidal stage; and water depth.

C. The sex of a specimen is determined by examination of the external genitalia, or reproductive organs in those cases where the intact animal is not presented.

D. The ages of all seals for which claws are available are initially estimated by claw examination. The claw provides a rapid and accurate means of age determination for seals up to six years of age, as growth rings or ridges are formed annually on the claw. After six years the claws are worn such that the initial ring ("constriction of birth") and usually subsequent rings are worn off. For these specimens, a canine tooth is sectioned and stained, using a modification of the Johnson and Lucier (1975) technique. The tooth sections are examined with the aid of a light microscope and the age of the seal is determined by enumerating the dentine or cementum annuli (Smith 1973, Benjaminsen 1973). Age determinations are necessary for development of growth rates, to determine population structure and productivity, and age specific food habits.

E. The analyses of food habits of bearded and ringed seals involve separation and identification of food items and determination of frequency of occurrence and volume of prey species. (See Annual Report for RU #232 for a detailed discussion.)

F. Species productivity is determined through laboratory examination of reproductive tracts and correlation of these data with the age of each specimen.

Testes are weighed to the nearest 0.1 g with and without epididymides. Length and width at the middle of the testes are measured to the nearest millimeter. Testes volume (nearest cc) is determined by water displacement. Bacula are cleaned by boiling, air dried, and then measured (nearest mm) and weighed (nearest 0.1g).

The presence of sperm in the epididymides is used to acertain breeding condition. The epididymides are sliced and a drop of fluid is squeezed onto a slide and examined under 78x or 300x magnification. Sperm presence or absence in the epididymal fluid is quantified as: none found, trace, or abundant.

Ovaries are weighed to the nearest 0.1 g and then cut into 2mm longitudinal sections. The sections are left joined at the base to preserve their relative position. The sections are examined macroscopically for corpora lutea, corpora albicantia, follicles, and ovarian masses or abnormalities. The largest diameter of corpora lutea, corpora albicantia, and largest follicle are measured to the nearest mm. Drawings are made of each ovary for later reference. The presence of absence of a fetus is noted at necropsy.

G. All specimens are examined macroscopically for gross pathological conditions. We attempt to conduct a complete necropsy on each seal selectively collected. Time and conditions do not allow complete necropsies of all the specimens obtained in the various villages but we endeavor to examine, at least partially, as many as possible. The necropsy procedure followed is that outlined in Fay et al. 1976.

H. Samples (about $125 cm^3$) of heart, liver, kidney, skeletal muscle, and skin and blubber are wrapped in aluminum foil, labeled, and frozen. These tissue samples will be provided to other investigators for microbiological, hydrocarbon, pesticide, and heavy metal analyses.

I. Aerial, ship, and ground surveys are being used to determine the distribution and densities of ringed and bearded seals killed by polar bears and arctic foxes. These dead seals are being examined to determine how they were killed, physical condition, and amount consumed by the predator. Specimens are collected for laboratory analyses. In addition, the geographic location, specific habitat (breathing hole, lead, lair, etc.), and ice type are noted. Standard measurements are made on all seals.

Teeth and claws are collected to determine the age of the prey. Reproductive tracts are examined for sex and reproductive condition following standard techniques. Blubber, selected organs and tissues, stomach and digestive tract of prey species are examined for parasites, diseases or pathologic conditions, and food habits, and will be provided to cooperators for analyses for pesticides, heavy metals, and petrochemicals.

Several ecological and behavioral parameters will be investigated to determine factors affecting prey availability and selection and hunting success of predators. For example, polar bears tend to take seals at breathing holes, seals hauled out on the ice, or in lairs; therefore, these factors influence hunting success of bears. The numbers and kinds of seals seen on the ice during surveys will be related to ice conditions, weather, and seal biology data to obtain environmental and natural history correlates to hauling out behavior.

J. Population structure of ringed and bearded seals is assessed through sex and age determination of samples obtained at coastal hunting sites and during the course of selective collection. Eskimo collaborators have been established in various villages, with hopes of obtaining jaws and claws and other specimen material from seals killed by the villagers. The collectors also maintain logs of dates, species, and sexes of kills.

K. Seasonal migration patterns are determined through observations at coastal hunting sites, and from shipboard and aerial surveys.

L. Aerial, shipboard, and ground surveys are used to determine the distribution and densities of pinnipeds in the ice-covered Bering, Chukchi, and Beaufort Seas. These surveys are conducted chiefly in June during the post-reproductive and molting period of ringed and bearded seals, but by the end of this research surveys will have been conducted during every season and will have covered all ice types.

Aerial surveys are flown in both fixed-wing airplanes and helicopters. Aircraft used thus far for surveys have been a Cessna 180, Cessna 195, DeHavilland Twin Otter, and Lockheed P2V (all fixed-wing aircraft) and Bell 205 and 206B helicopters. Survey transects were 0.9 km (0.5 miles) on each side of the aircraft. Transect width was maintained with fixed reference points on the windows and wing struts or floats. Surveys were flown at altitudes of 91.5 meters (300 feet). All seals (by species) and polar bears observed on these flights were enumerated.

Location and distances traveled along flight tracts were determined by standard aerial navigation techniques, by radar fixes from various DEW-Line stations, or with the aid of GNS-500 system (very low frequency, Omega navigation system).

Ground surveys were conducted on shorefast ice near villages or base camps either on foot or on snow machines. Shipboard surveys were conducted from U.S. Coast Guard and N.O.A.A. ships working near the ice edge.

M. Natural history and behavioral observations are obtained from several sources: 1) field observations by the principal investigators, 2) unpublished field observations of other reliable investigators, 3) reports from Eskimos, and 4) observation of captive animals.

The bulk of the natural history and behavioral observations is recorded by the principal or other investigators while they are on the sea ice, or aboard ships, skin boats, or aircraft. These observations are usually made with the aid of field glasses or spotting scopes and are recorded as field notes with appropriate ecological and behavioral conditions.

Because of the amount of time they spend on the ice pursuing marine mammals, Eskimo hunters can provide a wealth of information concerning behavior and natural history. Interview of several hunters may sometimes be required to separate facts from traditional folklore, or information given just to impress or please the interviewer. Rarely has information been given which is intended to mislead the investigators.

VI-VII. Results and Discussion

A. Field activities and specimen collection

Field activities during the reporting year were conducted extensively throughout our study area. These activities included both collection of specimens and surveys of ice habitats and seal densities and distribution. Specimens were obtained at hunting sites in Nome, Savoonga, Gambell, Shishmaref, Point Lay, Wales, Point Hope, Wainwright, and Barrow. Collections offshore, with the aid of ships, boats, or helicopters, were made in Norton Sound and the Bering, Chukchi, and Beaufort Seas. A complete listing of field activities for the reporting year is presented in Table 1.

During reporting year 1977-1978, specimens were obtained from 487 ringed seals and 215 bearded seals (Table 2). Measurements, jaws, claws, stomachs, reproductive tracts, and parasitological material were obtained from most specimens. All specimen material is processed as rapidly as possible.

Of the 487 ringed seals obtained, 246 were males and 235 were females; a 1:1 sex ratio ($P > 0.05$). Similarly 128 bearded seal (90 males and 118 females) were found to have a 1:1 sex ratio ($P > 0.05$).

B. Ringed seal

1. Population characteristics

<u>Sex ratio</u>

A sample of 3,264 postnatal ringed seals obtained by Alaska Department of Fish and Game personnel from 1973 to the present

Table 1. Schedule of field activities, April 1977 - March 1978.

Date	Location	Activity	Personnel
April-March	Fairbanks	Examination of seal specimens and analyses of data	Eley, Burns
April-March	Fairbanks	Data management	Frost, Eley, Burns, Lynn
April	OSS SURVEYOR (southern Bering Sea)	Collection of seal specimens and seal and ice surveys	Burns, Lowry, Frost
April	Barrow	Collection of seal specimens	Eley
May	OSS DISCOVERER (Bering Sea)	Collection of seal specimens	Lowry
May	Point Hope	Collection of seal specimens from native harvest	Seaman
June	Nome	Collection of seal specimens	Frost
June	Wales	Collection of seal specimens from native harvest	Seaman
June	Point Lay to Barter Island	Aerial surveys of seals and ice	Eley, Burns
June	Fairbanks	Preparation of quarterly report	Eley, Burns
July	Shishmaref	Collection of seal specimens	Seaman, Tremaine, Strickland
July	Wainwright	Collection of seal specimens	Seaman
July	Wales	Collection of seal specimens	Seaman, Strickland
August-September	USCGC GLACIER (Beaufort Sea)	Collection of seal specimens and data on regional densities	Burns, Frost
September	Fairbanks	Preparation of quarterly report	Burns, Eley
October-November	Shishmaref	Collection of seal specimens	Tremaine
October	Fairbanks	Attended OCSEAP seabird and marine mammal meeting	Burns, Eley
November	Prudhoe Bay	Collection of seal specimens	Eley, Lowry
November	Barrow	Collection of seal specimens	Eley, Burns
November	Nome	Collection of seal specimens	Frost

Table 1. continued.

Date	Location	Activity	Personnel
December	San Diego	Attended marine mammal biology conference	Burns, Eley
December	Seattle	Attended marine mammals-fisheries interactions conference	Lowry, Burns
December	Fairbanks	Preparation of quarterly report	Eley, Burns
January	Anchorage	Game Division meeting	Burns, Eley
January	Barrow	Beaufort Sea Synthesis meeting	Burns, Eley, Frost
January-February	Shishmaref	Collection of seal specimens	Seaman
January-February	Nome	Collection of seal specimens	Seaman
February-March	Gambell	Collection of seal specimens	Seaman
February-March	Kotzebue	Collection of seal specimens	Seaman
February-March	Fairbanks	Collection of seal specimens	Eley, Burns

Table 2. Seal specimens obtained from April 1977 to March 1978.

Location	Males	Females	Sex Unknown	Total
Barrow				
Ringed seal	13	14	1	28
Bearded seal	4	3	-	7
OSS DISCOVERER				
Ringed seal	2	-	-	2
USCGC GLACIER				
Ringed seal	8	8	-	16
Bearded seal	2	3	-	5
Nome				
Ringed seal	12	17	-	29
Bearded seal	7	1	1	9
Point Hope				
Ringed seal	23	8	-	31
Prudhoe Bay				
Ringed seal	13	10	-	23
Bearded seal	1	1	-	2
Shishmaref				
Ringed seal (July-Sept)	137	147	4	288
Ringed seal (Oct-Dec)	10	7	-	17
Ringed seal (Jan-Feb)	19	15	-	34
Bearded seal (July-Sept)	63	88	-	151
Bearded seal (Oct-Dec)	7	7	-	14
OSS SURVEYOR				
Ringed seal	-	1	-	1
Bearded seal	3	7	0	10
Wainwright				
Bearded seal	-	4	-	4
Wales				
Ringed seal	9	8	1	18
Bearded seal	3	4	6	13
TOTAL				
Ringed seal	246	235	6	487
Bearded seal	90	118	7	215

consisted of 1,626 (49.8%) males and 1,638 (50.2%) females which was a 1:1 sex ratio ($P > 0.05$). An even sex ratio in postnatal ringed seals also has been reported by other investigators (McLaren 1958, Johnson et al. 1966, Smith 1973). Males and females appear in approximately equal proportion throughout the year except during the spring (March and April) when males are more accessible to subsistence hunters. Females are involved in pupping activities and are apparently unavailable to hunters. A 1:1 sex ratio was also found in most age groups (Table 3). The sex ratio of 73 fetal ringed seals (36 males and 37 females) was essentially 1:1. A 1:1 fetal sex ratio has also been reported for ringed seals by other investigators (Johnson et al. 1966, Smith 1973).

Table 3. Sex and age structure of 3,264 ringed seals collected in the Bering, Chukchi, and Beaufort Seas (1973-1977).[1] Most seals were taken by coastal subsistence hunters.

	Males			Females		
Age	Numbers	Percent of all males	Percent of age cohort	Numbers	Percent of all females	Percent of age cohort
Pup	399	24.5	51.2	381	23.3	48.8
1	245	15.1	51.0	235	14.3	49.0
2	150	9.2	54.0	128	7.8	46.0
3	86	5.3	47.0	97	5.9	53.0
4	82	5.0	42.9	109	6.6	57.1
5	95	5.8	46.8	113	6.9	53.2
6	105	6.4	51.2	100	6.1	48.8
7	99	6.1	51.0	85	5.2	49.0
8+	365	22.6	48.3	390	23.9	51.7
Total	1626	100.0	49.8	1638	100.0	50.2

[1] Older age classes will be subdivided in a subsequent analysis as the laboratory processing of teeth, used for determining age, is not completed.

Longevity and mortality

The oldest ringed seal collected during this study was a 29-year-old male. The maximum age for a female was 28 years. Ringed seals in excess of 30 years have been reported from the Canadian Arctic and it has been suggested that ringed seals may attain an age of 40 years (Smith 1973). The majority (93%) of the Alaskan specimens, almost all taken by subsistence hunters, were 11 years old or younger.

Life tables were prepared, following the techniques of Caughley (1966, 1977) to analyze the mortality rate of male and female seals seven years old and younger (Tables 4 and 5). The behavior of ringed seals when hunted appears to be such that no selectivity is possible by the hunter as all that is generally observed is a head sticking out of the water or a seal hauled out on the ice. Discrimination of sex or age is not readily apparent. A collection of seals from a specific area at a certain season is a good indication of what age or sex groups are present. Additionally, collections of seals from a wide geographic area, taken throughout the year, are a good index of the sex and age structure of the population (Fedoseev 1965, Smith 1973).

Table 4. Life table for 1,626 male ringed seals.

Age	# Killed fx	# Killed/1000 dx	# Survivors/1000 lx	Mortality rate (%)	Survival rate (%)
Pup	399	245	1000	24	76
1	245	151	755	20	80
2	150	92	604	15	85
3	86	53	512	10	90
4	82	50	459	11	89
5	95	58	409	14	86
6	105	64	351	18	82
7	99	61	287	21	79
7+	365	-	226	-	-

Table 5. Life table for 1,638 female ringed seals.

Age	# Killed fx	# Killed/1000 dx	# Survivors/1000 lx	Mortality rate (%)	Survival rate (%)
Pup	381	233	1000	23	77
1	235	143	767	19	81
2	128	78	624	12	88
3	97	59	546	11	89
4	109	66	487	14	86
5	113	69	421	16	84
6	100	61	352	17	83
7	85	52	291	18	82
7+	390	-	239	-	-

The mean annual mortality rates for both male and female ringed seals were 20 percent (Tables 4 and 5). Male and female seals had the same range (0-50%) in mortality rates, and the standard deviation of the rate of males (9.66) was not significantly different ($P > 0.05$) from that of females (9.35). The trends in mortality patterns, as exhibited by the life table, were essentially the same in males and females. The mortality rate is high for pups and the rate lowers during the juvenile years (1-7 years). Our sample of seals older than age seven remains to be completely analyzed.

Pathology and parasitology

A considerable amount of material for pathological and parasitological examination has been collected by this project and Research Unit 232. The bulk of this material has been given to Drs. F. H. Fay and R. A. Dieterich and Mr. L. M. Shults (RU #194 - Morbidity and Mortality of Marine Mammals) for examination, analyses, and reporting.

Marine mammal hearts, either obtained from specimens collected by personnel working on RU #230 and 232 or those provided by RU #194, 229, and 243, are examined for marine mammal heartworms, *Dipetalonema* (*Acanthocheilonema*) *spirocauda* (Lidey 1858) Anderson 1959. Examinations are still underway but findings thus far are presented in Table 6. A paper on the status and effects of *Dipetalonema spirocauda* on Alaskan marine mammals is in the early stages of preparation, and will be enclosed as part of a future quarterly report.

Table 6. Examinations for marine mammal heartworms (*Dipetalonema* (*Acanthocheilonema*) *spirocauda*).

Species	Location	Number examined	Number positive	Percent positive
Phoca hispida	Beaufort Sea	16	0	0
Phoca hispida	Barrow	4	1	25.0
Phoca hispida	Point Hope	9	0	0
Phoca hispida	Shishmaref	275	3	1.1
Phoca hispida	Nome	31	3	9.6
Phoca hispida	Bering Sea	3	0	0
Phoca vitulina largha	Shishmaref	20	2	10.0
Phoca vitulina largha	Wales	2	0	0
Phoca vitulina largha	Bering Sea	18	1	5.6
Phoca vitulina richardii	Kodiak	87	15	17.2
Phoca fasciata	Bering Sea	15	0	0
Erignathus barbatus	Beaufort Sea	5	0	0
Erignathus barbatus	Barrow	5	1	20.0
Erignathus barbatus	Wainwright	4	0	0
Erignathus barbatus	Shishmaref	16	0	0
Erignathus barbatus	Nome	6	0	0
Erignathus barbatus	Bering Sea	10	0	0
Odobenus rosmarus	Bering Sea	1	0	0
Eumetopias jubatus	Bering Sea	1	0	0
Eumetopias jubatus	Gulf of Alaska	31	0	0
Delphinapterus leucas	Point Hope	23	0	0

Polar bear predation

Of 71 pinnipeds killed by polar bears examined thus far, 65 (92%) were ringed seals, 5 (7%) were bearded seals, and 1 (1%) was a walrus (Table 7). The 65 ringed seals examined consisted of 34 (52%) males. This bias toward males appears to be due to the fact that most specimens were obtained during March and April when females are involved in birth activities and apparently not readily accessible to bears. The sex composition of ringed seals killed by bears was not significantly different from the sex composition of seals taken by subsistence hunters in nearby villages during the spring (Table 8). Adult ringed seals (older than 6 years of age) were taken most commonly by bears, followed by juveniles (1-6 years old). Pups (less than 1 year old) were the least common age class taken by bears. The five bearded seals killed by bears included two pups and three one-year-olds. The sex ratio approached 1:1. The single walrus was a female calf. It appears that the sex and age composition of seals killed by bears is reflective of availability rather than a selectivity towards an age or sex group. These findings contrast somewhat with those of Stirling and Archibald (1977) who found pups to be important to bears in most years in the western and eastern high Canadian Arctic. Although ringed seals are the most abundant pinniped along the northwestern Alaska coast in spring, and appear as the most abundant seal taken by both bears and Eskimo hunters, it is not known whether bears are selecting ringed seals because of their relative abundance or because of the relative ease of capture as compared to bearded seals and walrus.

Table 8. Comparison of sex and age structure of ringed seals killed by polar bears and native hunters during March - May.

	Sex Composition		Age Composition		
	males(%)	females(%)	adult(%)	juveniles(%)	pups(%)
Bears	24(79)	9(21)	23(56)	16(39)	2(5)
Hunters	60(80)	15(20)	44(54)	30(37)	8(9)

Approximately 210 hours of aircraft surveys have been flown in the polar bear predation study. These cover three major ice types (shorefast ice, flaw zone, and moving pack ice) in approximately equal time proportions. Forty (56%) of the kills have been in the flaw zone ice, 17 (24%) on moving pack ice, and 14 (20%) on shorefast ice. Bears appeared to be more successful in flaw zone ice due to the abundance of newly formed leads which allowed more access to seals via breathing holes. Forty-seven (66%) of 71 seals killed by bears were taken at breathing holes.

Bears were relatively unsuccessful in obtaining ringed seals from lairs. Only 22 seals were killed in 107 lairs excavated (21%) by bears. Sixty seal lairs (56%) were excavated on shorefast ice and 47 (44%) lairs were on pack ice. No excavated lairs were noted in the flaw zone. The densities of ringed seal lairs in the various ice types are unknown; however, the preferred habitat of breeding female ringed seals is the shorefast ice. Stirling and Archibald

Table 7. Species, sex and age composition of 71 pinnipeds killed by polar bears.

Species Composition			Sex Composition			Age Composition		
	number	percent	males(%)	females(%)	unknown(%)	adults(%)	juveniles(%)	pups or calves(%)
Ringed seal	65	92	34(52)	9(14)	22(34)	23(56)	16(39)	2(5)
Bearded seal	5	7	2(40)	2(40)	1(20)	-	3(60)	2(40)
Walrus	1	1	-	1(100)	-	-	-	1(100)
Total	71	100	36(51)	12(17)	23(32)	23(49)	19(40)	5(11)

(1977) found that bears in the eastern and western Canadian Arctic were successful in obtaining seals in only 8 percent of lairs excavated.

The walrus calf and one bearded seal pup were the only pinnipeds killed by bears after being stalked on the ice. No observation of bears killing seals swimming in leads or open water were obtained.

Bears fed predominantly on the hide and blubber and abandoned a considerable amount of meat. In 52 percent of the kills examined, more than 50 percent of the carcass was abandoned. Forty-two (91%) of 46 kills had all of the hide and blubber consumed except that on the head. The four cases (9%) where the hide and blubber were not consumed consisted of pups (2 bearded seals and 2 ringed seals), which do not have a thick layer of blubber. The hide and blubber are preferentially taken, apparently due to the high energy value of these tissues (Stirling and McEwan 1975). The abandoned carcasses are consumed by other bears or more often by arctic foxes. When two or more bears are on a kill the larger bear gets the hide and blubber and the smaller bear gets the rest of the carcass. The division of a carcass between a sow and cubs is unclear, but essentially the whole seal is consumed.

Two (10%) of 20 kills examined at Cape Lisburne during March and April of 1976 were cached by bears apparently for later use. Seals were buried under 1 m of snow and ice and the bears (1 boar, and 1 sow with 2 cubs-of-the-year) were within 0.5 km of the cached seals, resting or sleeping on pressure ridges.

Best (1977) found that a minimum of one ringed seal every 6.4 days was required by bears to meet their energy requirements of free existence. This estimate was derived from nutritional data on captive bears at Churchill, Manitoba. Marking, tracking, and resighting data on bears along the western Alaska coast in spring (Eley, unpubl. data) indicate a seal was killed on the average every 6.5 days. Using the estimates of 6500 bears in the western Alaska population and 2500 bears in the northern Alaska population (Lentfer, pers. comm.) a gross estimate of the number of seals killed by bears is possible. A maximum of 365,000-371,000 seals would be killed per year by 6,500 bears and 140,000-143,000 seals would be killed by 2,500 bears.

These predation figures asssume that the one seal killed every 6.4 days is constant throughout the year and does not take into consideration the fact that during certain seasons of the year larger prey, such as bearded seal and walrus, may be more available than ringed seal. Theoretically fewer of these larger prey would have to be killed to meet the bears' energy requirements if: 1) bears would cache these larger carcasses, and reutilize them at a later date; or 2) bears were able to store the excess energy, available from these large prey, as fat for later energy mobilization. In addition, the predation figures did not take into account pregnant females that would be denning for five to six months and not hunting. The reproductive cycle of Alaskan polar bears averages 4.13 years (Lentfer 1976) and 57.6 percent of the female population are potential breeders (Stirling et al. 1975). The sex ratio of bears appears to be 1:1 (Stirling et al. 1975). During a given year the western Alaska bear population would be comprised of 453 pregnant females and the northern Alaska population of 174 pregnant females. "Correcting" the predation figures to account for denning females results in an estimated 352,000-358,000 seals killed by the western Alaska population per year and 135,000-138,000 seals killed by the northern Alaska bear population.

Indices of ringed seal abundance

Successful feeding and reproduction are tantamount to the survival of all species. Therefore, the goal of seal management should be to protect these critical feeding and reproduction areas from unnecessary disturbance or disruption. These critical areas change temporally and spatially and, considering the dynamic state of the sea ice ecosytem, there can be large spatial changes in the location of critical areas in a short period of time. Habitat selection by ice inhabiting pinnipeds has been aptly discussed by Fay (1974) and Burns (1970), and the reader is referred to those papers for a fuller discussion. Breeding adult ringed seals are found primarily (but not entirely) associated with shorefast ice, while the bearded seal is associated with many ice types and overlaps with all ice-associated pinnipeds in the study area.

Critical areas are ascertained first by determining seal densities in various locations and then by correlations of densities with observed or measured ice, behavioral, ecological, or oceanographic conditions. In June 1970, 1975, 1976, and 1977 ringed seal surveys were conducted by airplane over the shorefast ice from Barter Island to Point Lay. In addition, the 1976 survey was expanded to cover the shorefast ice from Point Hope to Cape Krusenstern and Kotzebue Sound and the pack ice of the Beaufort and Chukchi Seas. The results of these surveys are presented in Table 9.

These densities should not be considered absolute densities as the figures are not corrected for "unseen" animals (Hansen 1968, Enright et al. 1969). The density figures should be used as indices of abundance. We are unsure, at this time, of the relationship of molting seals to breeding seals in an area of fast ice. Burns and Harbo (1972) used counts of dispersed seals as an index of breeding seals since many dispersed seals were seen hauled out in collapsed lairs or were mother-pup pairs. However, substantial numerical data are not available to support this breeding index hypothesis. We hopefully will provide these data during our future survey data analyses.

The areas of highest mean densities (Cape Krusenstern-Point Hope; Cape Lisburne-Point Lay; Wainwright-Barrow; Barrow-Lonely)

Table 9. Ringed seal densities (observed seals/mi^2) calculated from 1970, 1975, 1976, and 1977 surveys.

Location	1970	1975	1976	1977
Kotzebue Sound	-	-	0.7	-
Cape Krusenstern-Pt. Hope	-	-	2.3	-
Pt. Hope-Cape Lisburne	-	-	0.9	-
Cape Lisburne-Pt. Lay	-	-	4.9	-
Pt. Lay-Wainwright	5.4	2.9	1.9	3.3
Wainwright-Barrow	3.7	6.2	3.8	2.6
Barrow-Lonely	2.3	2.8	1.4	1.0
Lonely-Oliktok	1.0	1.4	1.1	0.5
Oliktok-Flaxman Island	1.4	1.0	1.4	0.7
Flaxman Island-Barter Island	2.4	1.8	0.4	1.2
Chukchi Sea-moving pack ice	-	-	0.2	-
Beaufort Sea-moving pack ice	-	-	0.1	-

are normally areas of very stable shorefast ice during late winter and spring. Within these larger areas there are variations in the density of ringed seals which appear to be dependent on the quality of shorefast ice. For example, between Cape Krusenstern and Point Hope the mean density was 2.3 ringed seals per square mile, yet within this larger area the densities varied from 0.2 seals per square mile near Kivalina (early breakup of shorefast ice) to 3.8 seals per square mile near Cape Thompson (stable shorefast ice).

The most stable shorefast ice is found either along complex coasts or along coasts where the 10-fathom line lies far offshore. The edge of the shorefast ice tends to coincide with the 10-fathom curve. The higher densities in the Chukchi Sea are probably reflective of the better ice condition together with higher overall biological productivity of the Chukchi as compared to the Beaufort Sea.

The densities of molting ringed seals in the moving pack ice are considerably less than in the shorefast ice (Table 9). However, circumstantial evidence obtained during our March-April 1978 field work (95 to 140km north of Prudhoe Bay, Alaska) indicates that the stable pack ice may be more important to breeding ringed seals than previously has been assumed. Perhaps ringed seals are responding to the stability of ice combined with available food rather than shorefast ice versus pack ice. The shorefast ice of the Chukchi Sea is much more stable than the Chukchi pack ice during the breeding and molting season, but the pack ice and shorefast ice appear essentially equal in stability during March to June in the Beaufort Sea.

A detailed "population" analysis will be presented in a future report. However, several trends are apparent at this time. Densities of ringed seals throughout the Beaufort Sea have declined approximately 50 percent between 1970 and 1977 and this decline is apparently due to heavy ice during 1975 and 1976 (Stirling et al. 1975, Burns and

Eley 1977). Ringed seal densities in the northern Chukchi Sea have decreased approximately 35 percent from 1970 to 1977. In more southerly areas such as Norton Sound, Bering, and southern Chukchi Seas there appears to have been an increase in ringed seal densities. In March of 1977, we surveyed 177.4 mi^2 of Norton Sound and observed 149 ringed seals. This is a density of 1.27 seals per square mile, and it is a high density for March in Norton Sound. Apparently what has happened is a net western and southwestern displacement of ringed seals from the Beaufort and northern Chukchi Seas into areas of more favorable ice conditions. If ice is the proximate causative factor for the decline, then we should see a gradual increase in ringed seal densities after the better ice years of 1977 and 1978. Based on subjective feelings, more ringed seals were in the Barrow area in March and April of 1978 as compared to March and April of 1977.

Although the densities (indices of abundance) have decreased since 1970, the density figures alone may not indicate the whole story. The density figures are not significant unless they are combined with areal measurements of ice to obtain "population estimates" for the various coastal sectors. For example, a smaller density of seals in a given coastal sector may still yield the same population estimate as a larger density if different areas of ice are involved. The ice data are being prepared at this time by Dr. W. J. Stringer and his group (RU #257) at the University of Alaska and will be presented in our population analyses report.

In our 1978 surveys and subsequent analyses we will be investigating the effects of human disturbance on seal densities and we will be looking specifically at seismic activities. We have seen in previous surveys that densities decrease in the vicinity of coastal villages (Fig. 1) and these decreased densities apparently are due to disturbance by snow machines and general village activities rather than by hunting. The same general trends are seen around villages whether or not much hunting is accomplished by the residents of the village. Oil exploration activities are becoming more and more prevalent on the shorefast ice of the Beaufort Sea and it is imperative that we understand what perturbations these activities may cause.

2. Growth and indices of condition

Growth

The embryonic and fetal development of the ringed seals is one of the parameters that influences fertility. Embryological development is usually considered as a continuous process of growth and differentiation from the formation of the zygote to parturition. Growth and differentiation appear continuous, albeit slow, during the 3-1/2 month delay before implantation, but the factors that affect the rate of growth and differentiation are unknown.

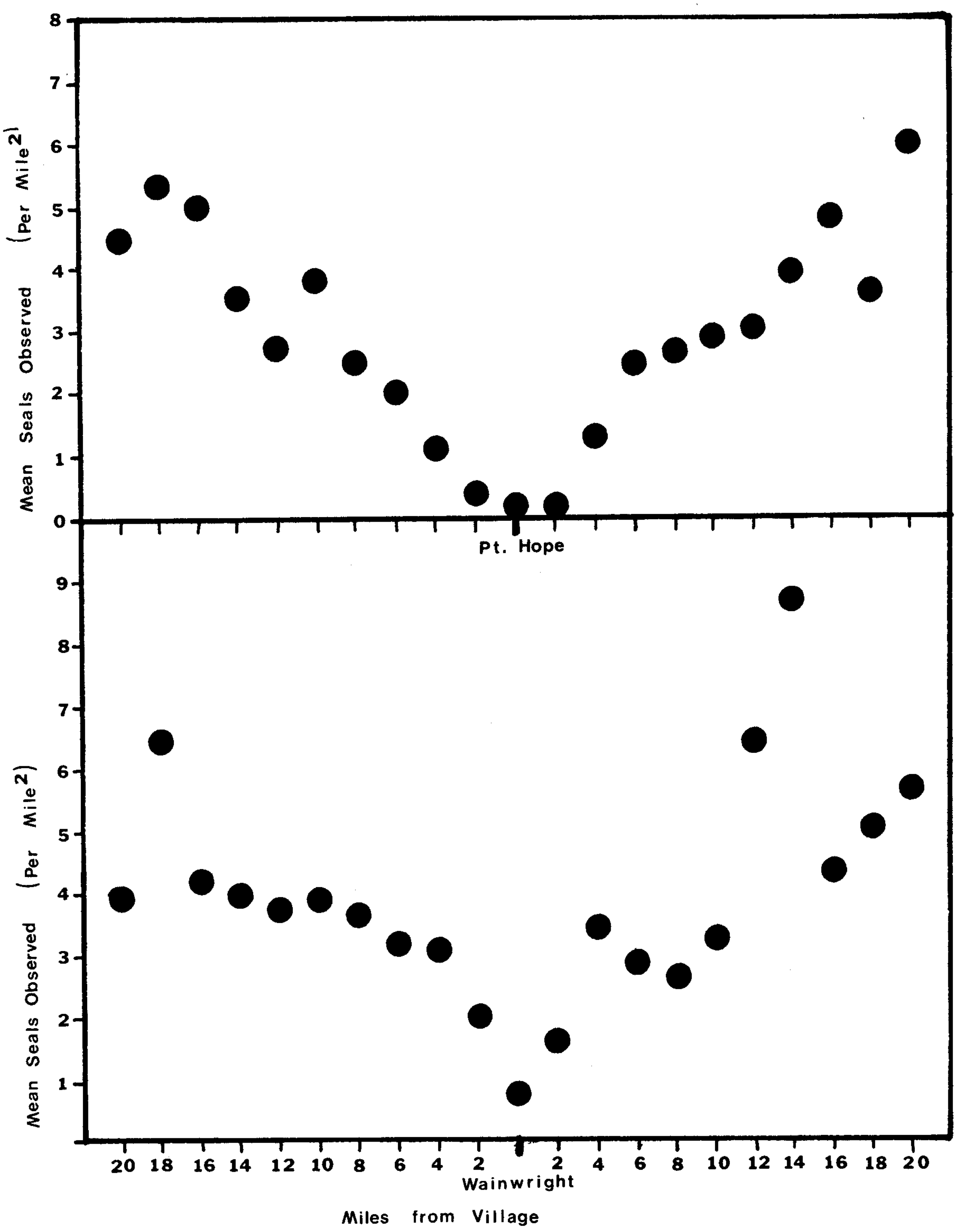

Figure 1. Observed densities of ringed seals in the vicinity of two Alaska villages.

Female ringed seals appear to be impregnated in late April or early May, soon after the birth of the pup. Impregnation is followed by a delay of up to 3-1/2 months before implantation, in late August. Mean implantation date appears to be around 25 August. Implantation appears to occur over a long period extending from early August to mid-September. Prenatal growth in length is essentially linear throughout the fetal period (Fig. 2). Prenatal weight gain is initially linear. It increases rapidly during mid-pregnancy and approaches asymstotic growth during late pregnancy (Fig. 2). The growth curves for ringed seals taken in Alaskan waters are similar to those for ringed seals in Canada (McLaren 1958, Smith 1973).

Seven newborn (less than 4 days old) ringed seals averaged 4.7 kg in weight (range 3.9kg-5.2kg). The mean weight of 10 full-term fetuses was 3.8 kg. The mean weights of male and female pups at birth are not significantly different ($P > 0.05$), although the sample size is small (3 males and 4 females).

Pup weights increase steadily from birth until weaning in late May or early June (Fig. 3). In late June and early July the weights of pups decrease somewhat as the pups adjust to life on their own. In mid- and late July pups' weights increase steadily, leveling off in August and September. The mean weights of male and female pups generally do not differ ($P > 0.05$); however, more variation is evident in the weights of males than of females.

Blubber thickness over the sternum increases from 0.5 cm or less at birth to an average of 2.6 cm in May and early June. During mid- and late June and July, the blubber thickness decreases to a mean of 1.1 cm and this decrease in thickness is probably associated with the loss of weight immediately after weaning. By August mean blubber thickness has increased to 1.9 cm and then levels out at a mean of 3.0 cm from September to February. There appears to be no difference in blubber thickness between male and female pups ($P > 0.05$).

The lengths of pups increased steadily from birth and appeared to begin leveling out in August and September (Fig. 3). The mean lengths of male and female pups did not differ ($P > 0.05$) and variation in length was approximately equal in the two sexes.

Increase in weight (Fig. 4) of ringed seals is most rapid during the first five or six years of life and begins to level off during the seventh to ninth years. In our samples, maximum weights were achieved during the eleventh to fourteenth years of life. From birth through the second year of life the weights of male and female ringed seals are not significantly different ($P > 0.05$). After two years of age male ringed seals are slightly heavier than females (Fig. 4) until the seventh year when females exceed males in mean weight. The majority of females seven years old and older are pregnant and the weight of a fetus and placenta (up to 6kg) results in higher mean weights for females.

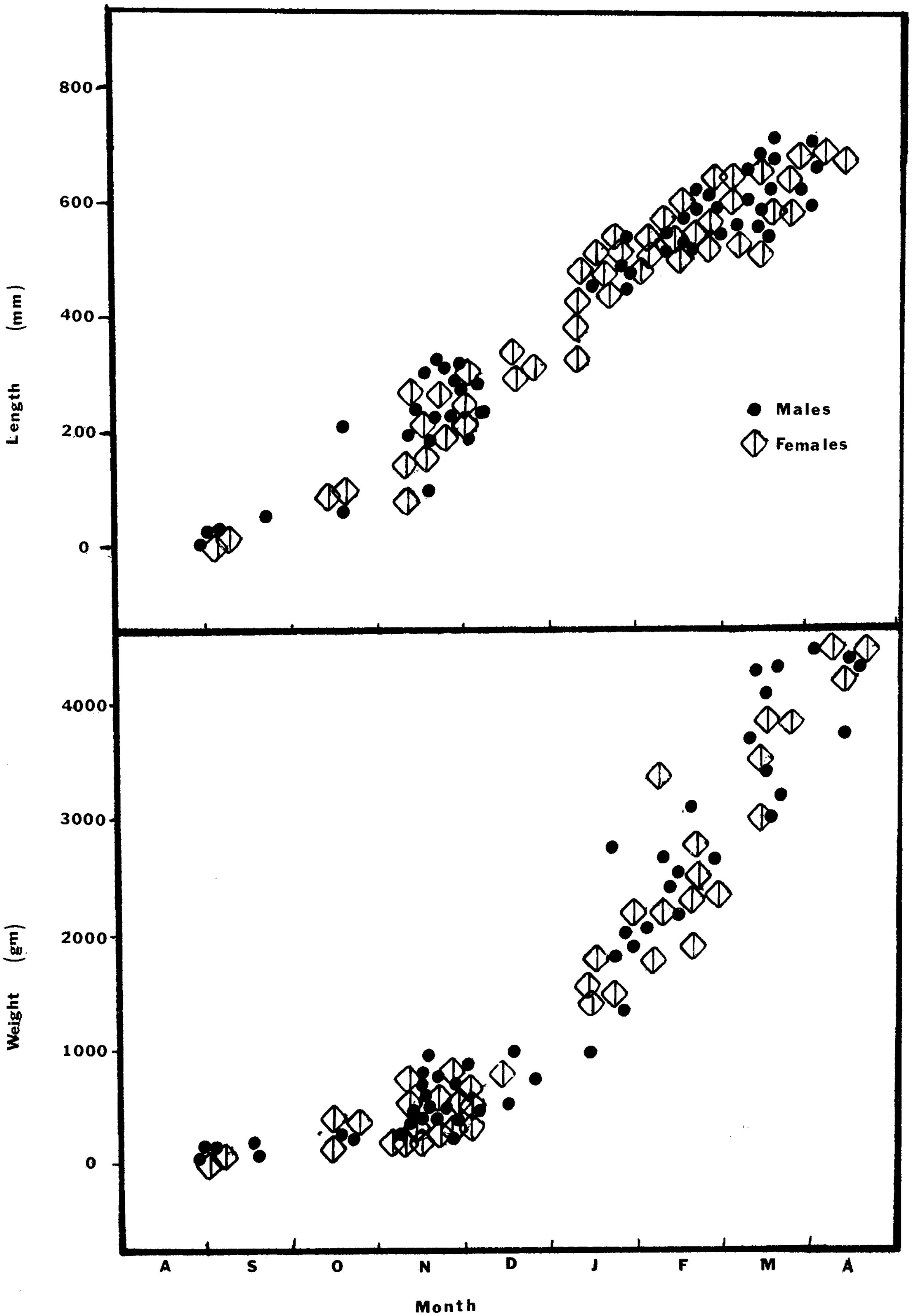

Figure 2. Growth of ringed seal fetuses taken in Alaska (standard length and weight) from implantation to birth.

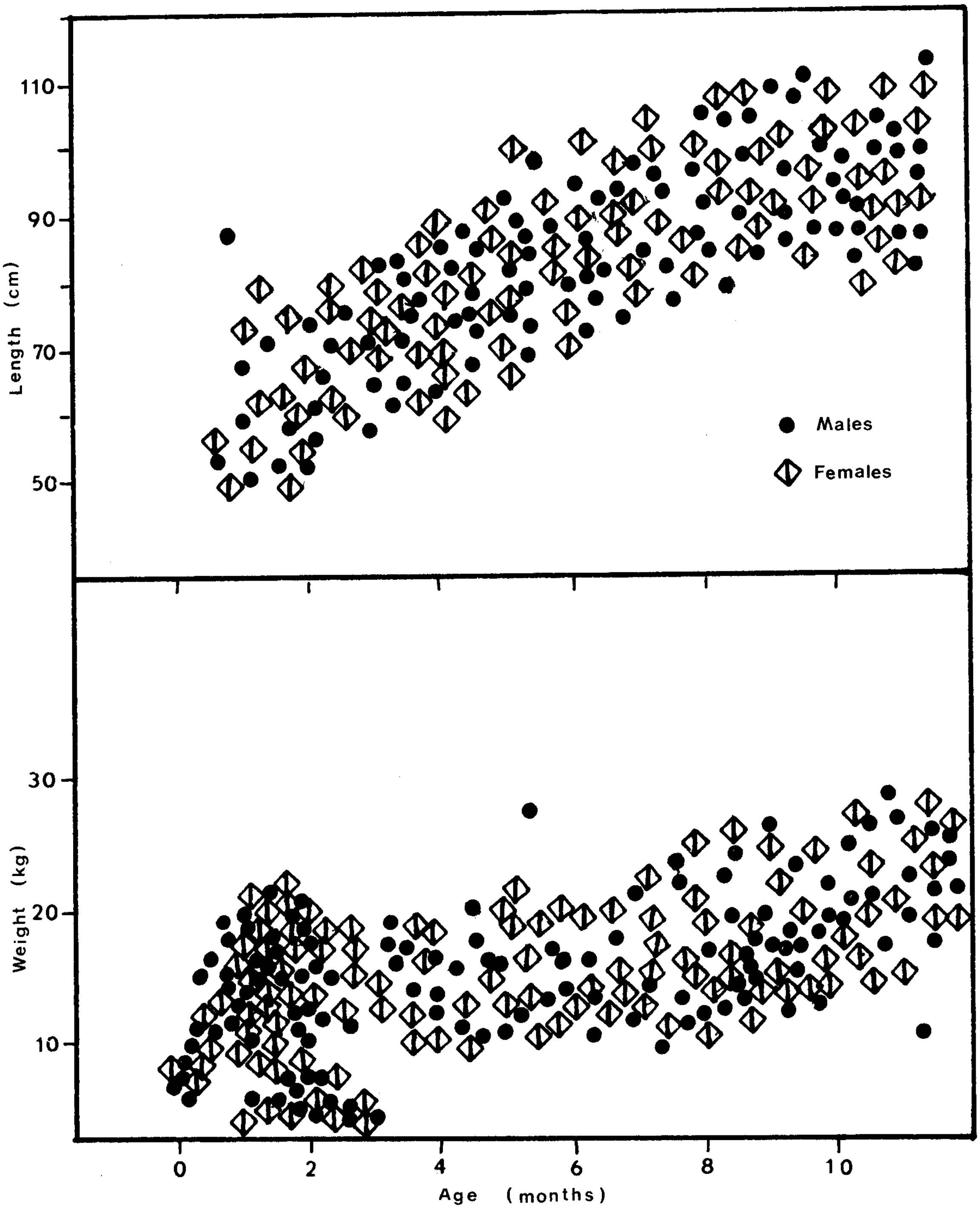

Figure 3. First year growth in standard length and weight of ringed seals.

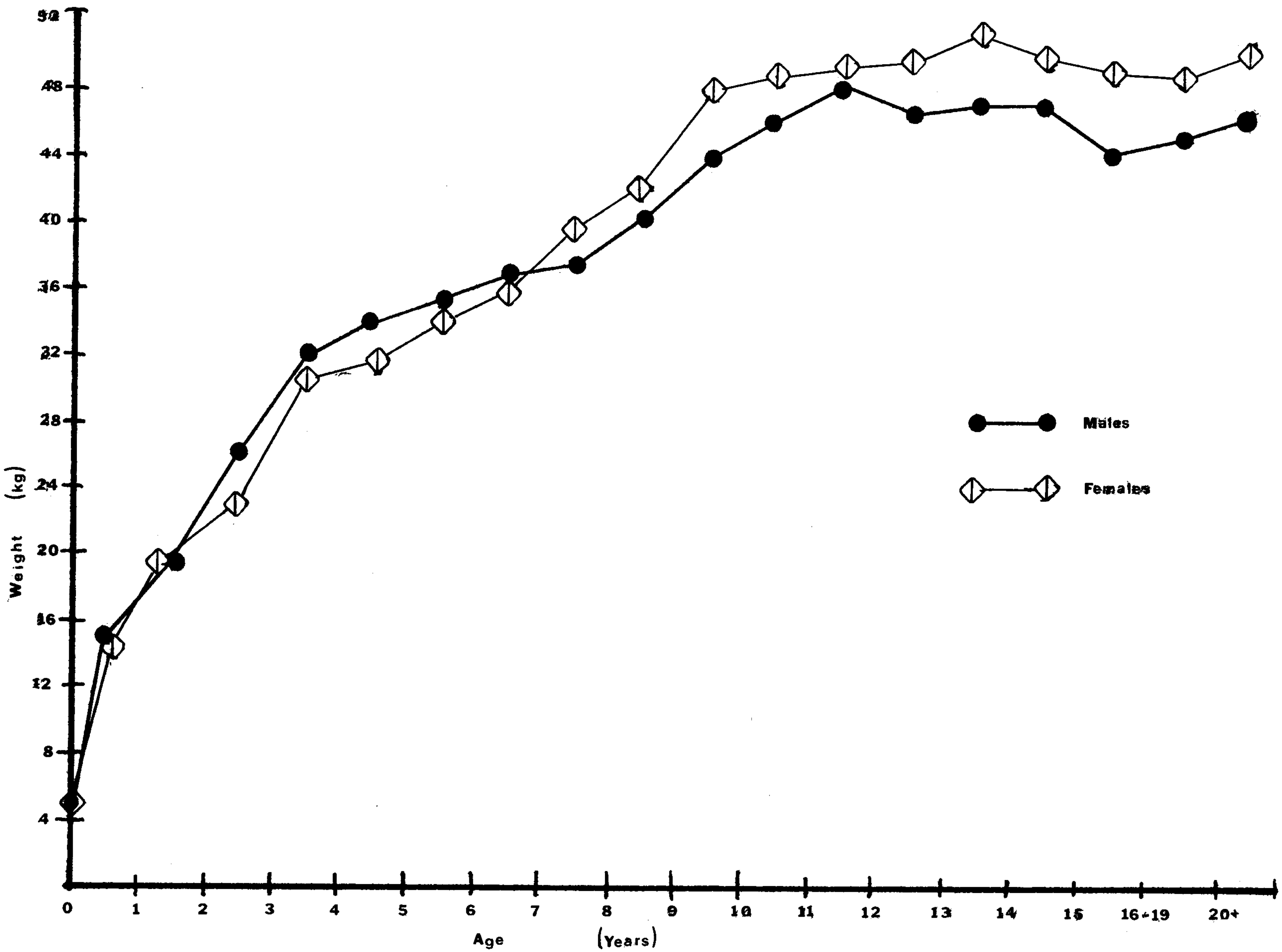

Figure 4. Weights of ringed seals taken in Alaska by age class.

Growth in skeletal size, as measured by standard length, is most rapid during the first six years of life (Fig. 5) and then skeletal growth tends to level out somewhat after the eighth year. Males are generally larger in standard length throughout life but this difference is not significant. The larger difference between males and females between the seventh and twelfth years apppears to be due to sampling bias. Maximum standard lengths are achieved during the eleventh to fifteenth years of life.

Ringed seals are the smallest of all pinnipeds in Alaska. The largest adult female recorded for Alaska was 187 cm in length and the largest male 146 cm. The heaviest ringed seals examined by us thus far were a 111.0 kg pregnant female, taken in March, and a 90.0 kg male, taken in January. However, the weight of an individual varies with age and season. Heaviest weights are achieved by adults in winter and early spring when the seal has a heavy layer of fat or blubber under the skin. This blubber is used for insulation and as an energy source during the breeding and pupping seasons. The weights of ringed seals decline with the decrease in feeding during the reproductive and molting season.

Indices of condition

Three measures of physical condition of Alaskan ringed seals have been analyzed thus far: total weight, blubber thickness, and a physical condition index (axillary girth/standard length x 100). These three indices are direct or indirect measurements of subcutaneous fat, with the assumption that high subcutaneous fat levels are synonymous with good physical condition. A comparison of other methods of determining physical condition, such as blood sera constituents, with fat level indices has not been made but would be quite useful.

The three measures of physical condition are compared in Figure 6. All three indices show the same general trends. There was no difference between sexes. The data for males and females are combined in the figures. Physical condition (amount of depot fat) is highest in January and February. During the birth and breeding periods (March-May) feeding appears to decline; therefore, more fat is metabolized and condition begins dropping to lower levels. Reduced feeding continues into June and early July as the seals molt. Ringed seals spend a considerable amount of time basking on the ice on sunny and warm days during the molt. Apparently the warmth and rest are required for rapid regrowth of hairs (Feltz and Fay 1966). In late July and August feeding intensifies and physical condition steadily increases.

Body size, growth rates, and indices of condition are indicators of a pinniped population's relationship to food resources. If abundant food is available less time and energy are expended in obtaining food. Whereas, if less food is available, more time and energy must be expended in foraging and meeting the body's minimal

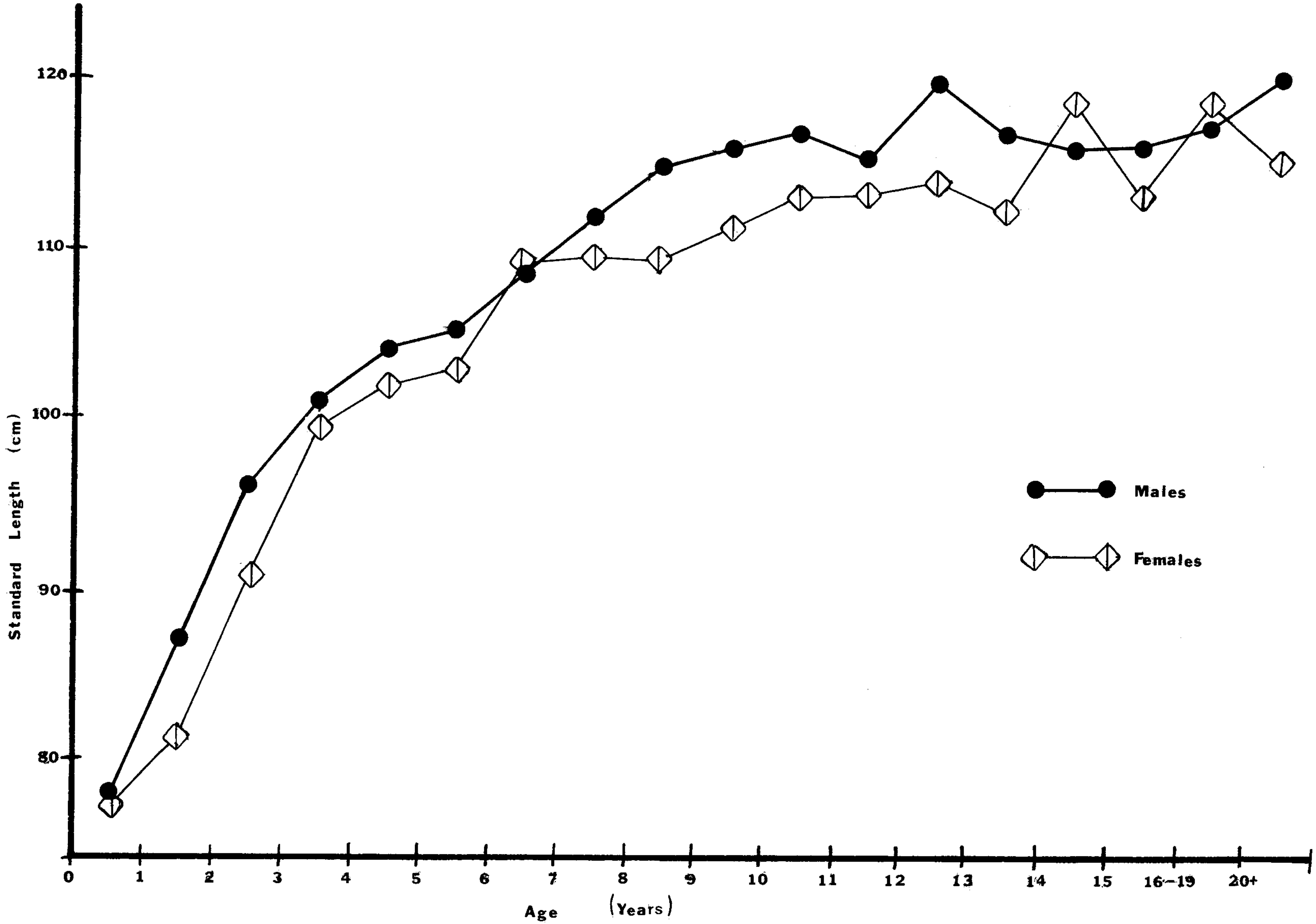

Figure 5. Standard lengths of ringed seals taken in Alaska by age class.

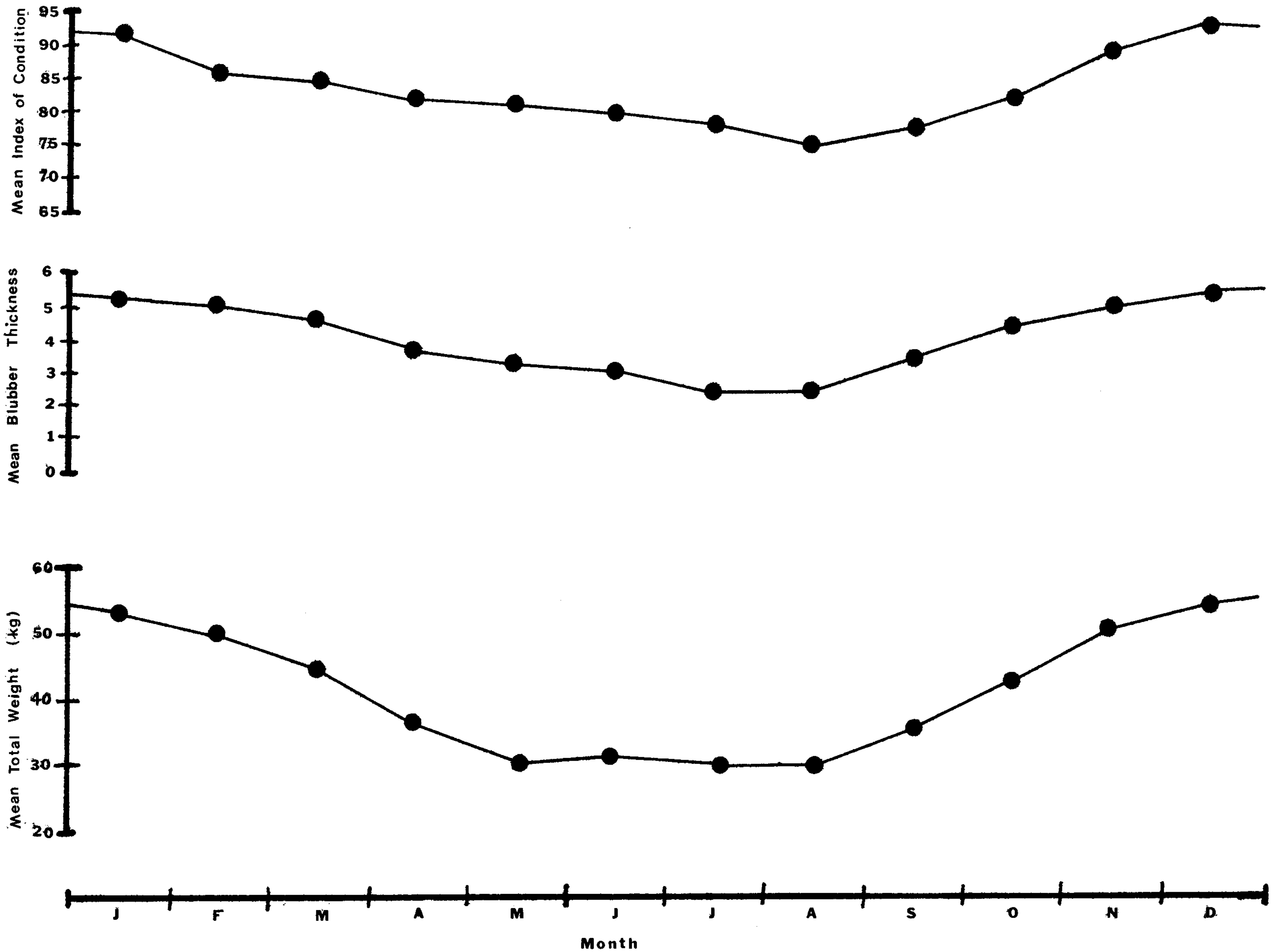

Figure 6. Indices of condition for both sexes and all ages of ringed seals older than pups, taken in Alaska.

energy requirements and less time and energy are available for other functions. Increases in body size, growth rates, and indices of condition by natural improvement, reduction in the number of seals, or artificial enhancement of food resources may result in a reduced age of sexual maturity and increased population productivity. Conversely, a reduction in food resources by natural or artificial perturbations (heavy ice, oil spills, or chronic exposure to toxic pollutants) of ringed seal habitat could result in an increased age of sexual maturity and decreased pregnancy and survival rates thereby resulting in decreased population productivity.

3. Reproduction

Pupping

Detailed observations and data on pupping and related activities have not been obtained. Most of our logistic support has been available either before or after the pupping season. However, some opportunistic data have been gathered. Seven newborn ringed seal pups were obtained between 31 March and 17 April which confirms the mid-March to late April pupping period reported by McLaren (1958). Ringed seals give birth to their pups in subnivean lairs on landfast, flaw zone and moving pack ice; however, landfast ice is the preferred habitat. The structure and function of the birth lair is discussed in detail by Smith and Stirling (1975). The basic function of the lair is protection from weather and predators. Ringed seals mate soon after the birth of the pup.

The young begin to shed their white fetal pelage about two weeks after birth and have grown their first-year pelage by mid- to late May (McLaren 1958). The female apparently stays with the pup until breakup of the ice in early to mid-June when weaning takes place (McLaren 1958). A pup taken on 27 May had milk in its stomach. No milk was noted in stomachs of pups taken in June or July. Pups with adults, in collapsed lairs, were observed during seal surveys as late as 20 June.

Males

The epididymides of 454 male ringed seals (representing all age classes and collected during all seasons) have been examined microscopically for the presence of sperm. The concentration of sperm in an epididymal smear was subjectively quantified as abundant, trace, or none. Males were considered sexually mature if abundant sperm were found in a smear and if the male seal was collected between 1 March and 15 June when ovulation is most likely to occur in females. It was found that males become sexually mature from five to seven years of age (Table 10). Active spermatogenesis was detected in essentially all males seven years old and older. No reproductive senility was noted.

Table 10. Age of sexual maturity in male ringed seals based on the presence of abundant epididymal sperm during the period 1 March - 15 June.

Age (years)	Number examined	Sperm Presence: Abundant (number)	Trace (number)	None (number)	Percent mature
Pup	32	-	-	32	0
1	24	-	-	24	0
2	14	-	-	14	0
3	10	-	-	10	0
4	11	-	-	11	0
5	12	4	1	7	33
6	10	4	2	4	40
7	7	6	1	-	86
8	19	19	-	-	100
9	13	13	-	-	100
10	15	15	-	-	100
11+	24	23	1	-	96

Weight and volume of testes has been used as an indicator of sexual maturity in pinnipeds (Laws 1956, McLaren 1958, Hewer 1964). Plots of testes volumes and weights show exactly the same trends. Only testes volume is illustrated in Figure 7. Testes are enlarged at birth due to the influence of maternal hormones. After birth and throughout the first year of life testicular volume decreases (Fig. 7). The increase in testes volume is slow from ages one to four, when it begins to increase rapidly. Testes volume remains relatively constant after eight years of age. Both testes volume and the presence of sperm in the epididymides indicate that sexual maturity is reached by male ringed seals by age seven or eight, although some are physiologically capable of breeding at an earlier age. However, the relationship between physiological sexual maturity and behavioral sexual (and physical) maturity is unknown. Studies of other pinniped species indicate that physiological maturity is achieved several years before behavioral maturity (Hewer 1964, Orr and Poulter 1967).

The earliest date that sperm was found in male epididymides was mid-December (Table 11) and active spermatogenesis appears to continue until early July. Substantial sperm remains in the epididymides of some males until mid-August. Most adult female ringed seals appear to ovulate in April and May; therefore, the males are physiologically capable of breeding well before and long after most females. A longer season of potential breeding capability also has been reported in other phocid seals (Bigg 1969, Ling 1969). No geographic variation in spermatogenic activity has been detected thus far; however, our sample size from the Beaufort Sea is small.

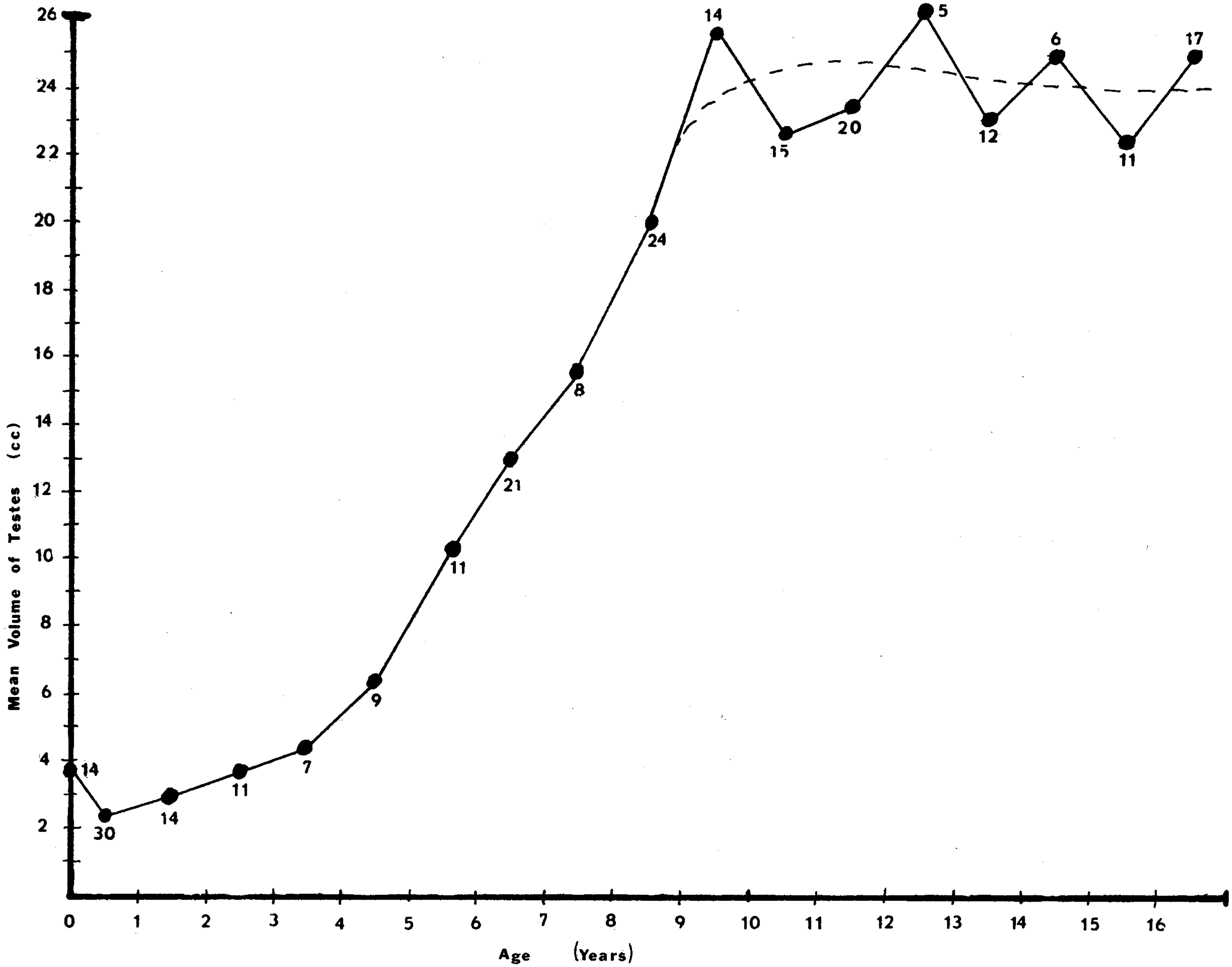

Figure 7. Testes volume of ringed seals taken in Alaska by age class. Sample size indicated near corresponding points.

Table 11. Seasonal variation in sperm presence in the epididymides of male ringed seals seven years old and older.

Month	Number examined	Sperm Presence Abundant (number)	Trace (number)	None (number)
January	17	7	2	8
February	12	5	3	4
March	29	28	1	-
April	20	20	-	-
May	27	27	-	-
June	44	26	8	10
July	32	4	3	25
August	18	1	6	11
September	7	-	-	7
October	2	-	-	2
November	21	-	3	18
December	14	1	1	12

Females

Sexual maturity in the female ringed seal has sometimes been considered as the age at which first ovulation occurs (McLaren 1958, Smith 1973). However, successful pregnancies frequently do not result from these first ovulations. Females may not be behaviorally or physically mature enough to accomplish successful fertilization or implantation. In those cases where fertilization appears to have taken place the blastocyst apparently had failed to implant. In population dynamic and natural history studies, the age at which a female produces her first offspring is a more useful concept, and this age has been termed productive maturity (McLaren 1958). Productive maturity will be the terminology used in this report.

Productive maturity, pregnancy rates, and productivity can only be ascertained with an accurate determination of pregnancy. During the period of delayed implantation, a normal appearing corpus luteum may be found in the ovaries even if a blastocyst is not present (Bigg 1973). In addition, all blastocysts do not necessarily implant, particularly in young females. Only reproductive tracts obtained after the normal period of implantation will be used in calculating reproductive parameters, unless otherwise stated.

Some confusion of meaning has arisen in terminology referring to reproductive status; therefore, the terminology used in this study is defined as follows:

1. Nulliparous: A female that has never given birth to an offspring at the normal birth time.

2. Primaparous: A female that has given birth to one offspring at the normal birth time.

3. Multiparous: A female that has given birth to more than one offspring at the normal birth time.

The examination of 142 females in the ages classes pup to two years of age failed to find any evidence of ovulations. Two (10%) 3-year-old females, three (14%) 4-year-olds, and eight (30%) 5-year-old females had ovulated for the first time but none of these ovulations resulted in a pregnancy. Productive maturity was reached as early as 6 years of age and as late as 10 years of age (Table 12). The majority of females attained reproductive maturity between the seventh and ninth years. All females 11 years of age and older were multiparous. The female that attained reproductive maturity at 10 years of age was collected in 1976 when ringed seal populations were on the decline and pregnancy rates were at a lower level. The female ringed seals attaining reproductive maturity at six years of age were during years (1964, 1967, and 1977) when pregnancy rates and population levels were apparently at higher levels. McLaren (1958) and Smith (1973) found first ovulations in ringed seals as early as four years of age and first pregnancies as early as six years of age in Canada. Pregnancy rates and population levels were high during the years these specimens were obtained. During the recent decline of ringed seals in the Canadian Arctic the same trend was seen: a decline in pregnancy rates and population levels and an increase in the age of reproductive maturity.

Table 12. Reproductive status of female ringed seals.

Age	Nulliparous (%)	Primaparous (%)	Multiparous (%)	Reproductive failures(%)
Pup	54(100)	-	-	-
1	51(100)	-	-	-
2	37(100)	-	-	-
3	20(100)	-	-	-
4	21(100)	-	-	-
5	24(89)	-	-	3(11)
6	23(77)	3(10)	-	4(13)
7	12(54)	9(41)	-	1(5)
8	5(33)	5(33)	3(20)	2(14)
9	1(6)	5(31)	9(57)	1(6)
10	-	1(11)	7(78)	1(11)
11	-	-	8(100)	-
12	-	-	6(100)	-
13	-	-	4(100)	-
14	-	-	4(100)	-
15	-	-	7(100)	-
16	-	-	2(100)	-
17	-	-	4(67)	2(33)
18	-	-	3(100)	-
19	-	-	4(100)	-
20+	-	-	6(67)	3(33)

Ovarian weight can be used as an indirect indicator of sexual and productive maturity. Ovaries are enlarged at birth due to the influence of the maternal hormones. Subsequent to birth and throughout the first year of life ovarian weight decreases (Fig. 8). Growth in ovarian weight is slow but constant from ages one to eight. Ovarian weight remains relatively constant after age eight when most females have attained productive maturity.

Three types of reproductive failures were noted in examinations of female reproductive tracts: 1) failure of the blastocyst to implant or failure in fertilization of ovum, 2) spontaneous abortion of a fetus, and 3) resorption of an embryo. Missed pregnancies resulting from productively mature females failing to ovulate, although a form of reproductive failure, will not be considered in this section (or in Table 12), but will be discussed as part of the section on reproductive rates.

Nine instances of failure of blastocysts to implant or failure of fertilization were noted. All nine cases were in females apparently ovulating for the first time (three 5-year-olds, four 6-year-olds, one 7-year-old, and one 8-year-old). The corpora lutea in the ovaries of these nine females were smaller than normal and were degenerating. No embryos or implantation sites were found in the uterine horns. All nine seals were collected after implantation should have taken place. No corpora albacantia were found in the ovaries of these nine females indicating previous pregnancies. Abortion of a fetus had occurred in one 8-year-old, one 9-year-old, and three females over 20 years of age. The causes of these abortions could not be determined. Three females (two 17-year-olds and one 10-year-old) were found to have fetuses in various stages of resorption. All three females were obtained in Nome. Two females were collected in the spring and one was obtained during the winter. As in the case of abortions, no gross pathological conditions were noted that may have resulted in resorption of the fetus.

In a sample of 33 adult female ringed seals obtained between 1962 and 1973, 30 were or just had been pregnant (Table 13), yielding a pregnancy rate of 91 percent. The reproductive tracts of 44 adult females collected during 1975-1976 have been examined and 31 (70%) were pregnant or recently had given birth. This 70 percent pregnancy rate is undoubtedly high as many females were taken after fertilization and before implantation; therefore, failures in fertilization and implantation are not evident. The pregnancy rate during 1976 and 1977 increased to 81 percent with 13 pregnant females of 16 examined that had been collected after implantation. Specimens examined thus far in 1977-1978 have yielded a 92 percent pregnancy rate, with 12 pregnant females of those 13 examined.

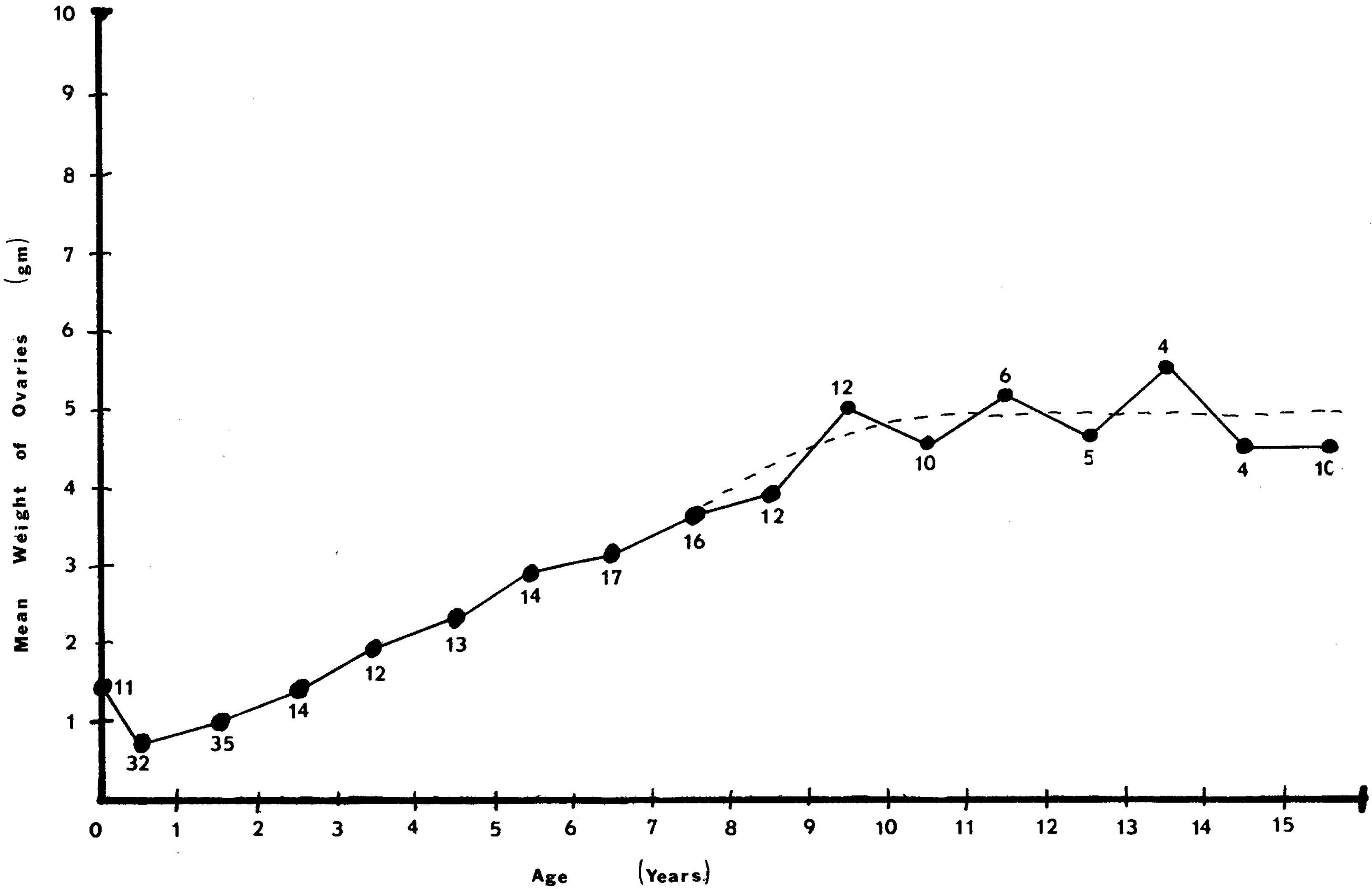

Figure 8. Weights of ringed seal ovaries by age class. Sample size indicated near corresponding points.

Table 13. Pregnancy rates of sexually mature female ringed seals collected by Alaska Department of Fish and Game personnel from 1962 to 1978.

	1962-1973	1975-1976	1976-1977	1977-1978
Number examined	33	44	16	13
Number pregnant	30	31	13	12
Percent pregnant	91	70	81	92

Johnson et al. (1966) found that 240 of 280 (86%) adult females (collected near Cape Thompson, Alaska during 1960 and 1961) were pregnant. The decline in the pregnancy rates of our samples between 1964-1973 and 1975-1977 corresponds to the decline in the pregnancy rates reported by Stirling et al. (1975) for ringed seals in the Beaufort Sea. However, the magnitude of the decline in pregnancy in Canadian ringed seals from the Beaufort Sea is significantly greater; in 1972 a pregnancy rate of 59 percent was found and in 1974 and 1975 a 0 percent and 11 percent pregnancy rate were found, respectively (Stirling et al. 1975).

The reasons for these changes in pregnancy rates of female ringed seals are unknown and they are presently under investigation. During the period of reduced pregnancy rates (January 1975 through April 1977) the majority of nonpregnant females apparently did not ovulate. In addition, absorption and resorption were more prevalent than in years with higher pregnancy rates. Parasitological and pathological examinations have not found evidence of parasite or disease agents which might be responsible for the decline; however, this possibility is still being pursued.

Blubber thickness at the sternum, total weight, and the index of condition (axillary girth/standard length X 100) are good indicators of physical condition of ringed seals. Blubber thicknesses and total weights were separately compared for sexually mature females collected from 1962 to 1977 during essentially the same season and there was no significant difference ($P > 0.05$) in blubber thickness or total weight. The index of condition is a more sensitive measure of condition, but indices of condition during November to April were not significantly different ($P > 0.05$) from 1962 through 1977. However, sample sizes for many months were less than six and several months of several years had no samples at all. Indices of condition during June through September 1975 and 1976 were higher than in previous years. If females were not involved in reproductive activities perhaps they do not decrease in condition as much as those who are reproductively active.

4. Literature review

Approximately 750 literature citations directly and indirectly concerning ringed seals have been recovered from our searches and those of OASIS and its updates. OASIS searches were not as effective in finding older references as were our own searches because OASIS searches did not extend back past 1972 for Biological Abstracts and 1964 for Oceanic Abstracts and Government Report Announcements. In addition, Zoological Record, the best literature citation source for marine mammals, is not searched by OASIS. OASIS search updates have been timely in providing references.

A summary of the literature as related to Alaskan ringed seals was presented in our Annual Report for 1976 and it is summarized as, III. Current State of Knowledge, in this report. The more important references are listed as, XI. References and Literature Cited. A more complete ringed seal bibliography will be presented in a future report.

5. Food habits and trophic relationships

See Annual Report For Research Unit #232, "Trophic relationships among ice inhabiting pinnipeds."

C. Bearded seals

Distribution and seasonal movements

Surveys from ships and aircraft operating in the ice front of the Bering Sea during March-April 1976 and 1977 have provided information about the distribution and relative density of bearded seals in this ice habitat. Also, changes in density between March and April suggest an important aspect of migration in these seals.

Extensive aerial surveys in the front, utilizing a P2V aircraft, were made between 8 and 23 April 1976. These surveys indicated that during that time bearded seals were distributed throughout the front, although the density was low. Figure 9 shows the general distribution of sightings recorded during these surveys.

Surveys utilizing a Bell 206 helicopter launched from the research vessel SURVEYOR operating in the ice front were also made in April 1976 and in March and April 1977.

From 23 to 25 April 1976 surveys utilizing the helicopter were made by K. Frost and L. Lowry. The general survey area was the ice front in southwestern Bristol Bay, at approximately 56°00'N, 163°22'W. A total of 231 nautical miles of transect lines was covered. Width of the strip transect was 0.5 nm. The observed density of bearded seals hauled out on the ice was low: 0.05 per nm^2.

Similar surveys in the ice front, utilizing the ship-based helicopter, were conducted in March and April 1977. Significantly higher densities of bearded seals were seen in March than in April. A comparison of the results of these surveys is presented in Table 14. The low densities recorded in 1976 and 1977 were similar.

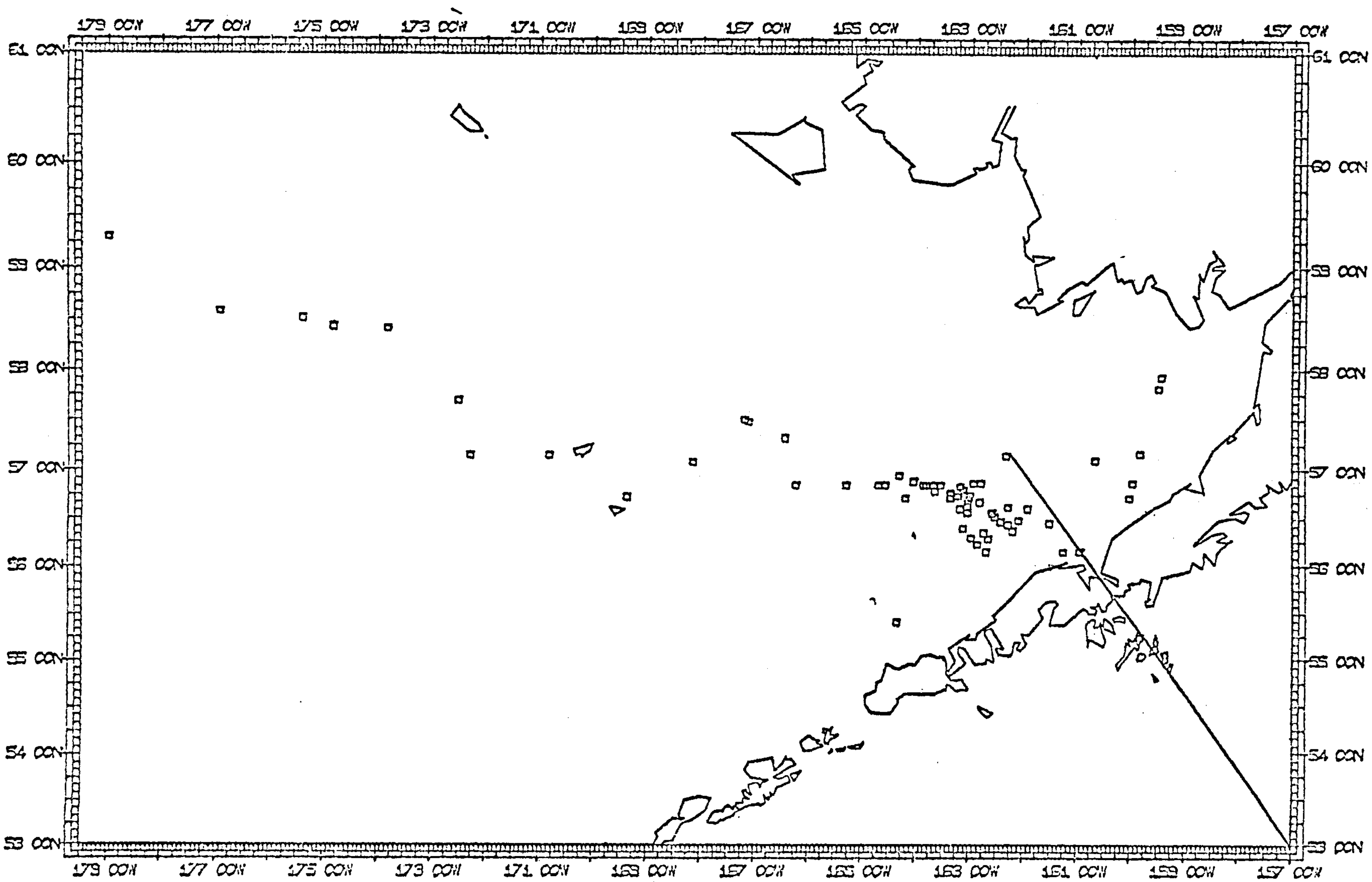

Fig. 9. Combined sightings of all bearded seals observed during surveys within the ice front. Computer map courtesy of H. Braham and B. Krogman, NMFS, Seattle.

Table 14. Results of aerial surveys for bearded seals in the ice front of the Bering Sea during March and April 1977.

Date	Position		General Location	Area Surveyed (nm^2)	Bearded Seals observed on the ice	Density/ nm^2
March						
27	55°49'	164°25'	SW Bristol Bay	82.7	0	0.0
28	59°08'	169°35'	SW Nunivak Island	103.3	68	0.66
30	58°20'	164°50'	SE Nunivak Island	81.2	16	0.20
April						
21	57°40'	164°55'	SE Nunivak Island	40.6	9	0.22
23	58°30'	169°50'	SW Nunivak Island	199.8	7	0.04
24	58°45'	169°30'	SW Nunivak Island	45.6	1	0.02
25	58°45'	169°30'	SW Nunivak Island	43.9	3	0.07
27	59°40'	174°20'	SW St. Matthew Island	55.9	0	0.00

During 15 days of shipboard operations in the ice front in late May and early June 1977, only one bearded seal was seen.

Surveys in more northerly areas indicate a reverse situation: fewer bearded seals seen in March than in April. In early March 1977 the density of bearded seals hauled out on the ice of Norton Sound, near Nome, was 0.09 per nm^2 during surveys totaling 43.2 nm^2. In comparison, on 20 April 1967, the observed density of these seals on the ice was 0.72 per nm^2 on aerial surveys covering 314 nm^2.

These records support the hypothesis that bearded seals occur throughout the ice-covered regions of Bering Sea, utilize the ice front in comparatively large numbers during winter, and begin an active spring migration which significantly precedes the disappearance of seasonal sea ice. Spotted seals (*Phoca vitulina largha*) and ribbon seals (*Phoca fasciata*) also move seasonally. However, these movements, in the spring-summer period, are correlated more closely to the disintegration of ice.

The shipboard sightings of bearded seals in conjunction with results of aerial surveys have again indicated that, while aerial surveys provide useful information about distribution and *relative* abundance, these surveys underestimate actual abundance because an unknown proportion of seals is not hauled out on the ice. Aerial surveys do, however, provide an accurate count of those seals which are hauled out. A comparison of counts of basking bearded seals, using sightings from the ship as opposed to sightings from the helicopter, indicates that the results are quite similar. On 28 March 1977 aerial surveys indicated a density of 0.66 seals per nm^2. On the following day in the same area the estimated density based on sightings from the ship was 0.64 per nm^2 in an area of 78 nm^2.

Age segregation

In a previous study Johnson et al. (1966) found that at Point Hope there was a "definite preponderance of adults over immature specimens" in the harvests. This was also the situation at Wainwright, in the northern Chukchi Sea, as indicated by the composition of harvests made during July and early August of 1964 and 1965 (Burns 1967).

Circumstantial evidence indicated that the tendency of bearded seals to remain near the ice so long as it occurred over water less than about 150 m was 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 subadult seals in Kotzebue Sound, during the ice-free period, has apparently given rise to the belief that a race of dwarf seals inhabits the area. All of the "dwarfs" we have examined from the area have proven to be sexually immature animals. The reported occurrence of dwarfs was also mentioned by Johnson et al. (1966).

Preliminary information obtained from 1975 through 1977 indicates that pups of the year comprise a substantially higher proportion of bearded seals taken in the Bering Sea than in the Chukchi and Beaufort Seas. Pooled data for these years show that 37.5 percent of 160 seals from the Bering Sea were pups of the year and 13.3 percent of 263 from the Chukchi and Beaufort Seas were pups. Composition of harvests at selected hunting sites is presented in Table 15. Reproductive parameters for sexually mature females from all areas were the same.

It appears that in the course of the northward spring migration adults tend to remain in association with the receding ice while juveniles, particularly pups, occupy more southern, ice-free areas in greater numbers.

Natural mortality of pups also contributes to the lower numbers of this cohort present in the Chukchi Sea during late summer and fall. The magnitude of this mortality is unknown.

<u>Reproduction - female bearded seals</u>

Our sample of female reproductive tracts obtained from 1975 through 1977 includes ovaries from 175 samples. Of these, 64 (37%) were juveniles and 111 (63%) were sexually mature (based on ovulation as indicated by presence of a corpus luteum in either of the ovaries).

Estimation of productivity for the population as a whole has not been accomplished as age determination of all specimens is not yet completed.

One of the important reproductive parameters that has been determined based on this sample is a more precise indication of when implantation of fetuses occurs.

Bearded seals breed from mid-April to mid-May, the period when female seals are in estrous. Males are in breeding condition for a longer period of time than the females. Although the females become impregnated, fetal implantation does not take place until some months after copulation.

Based on a sample of 64 females, which had given birth at least once, and obtained between 26 June and 4 August 1975-1977, fetal implantation begins in early July and occurs, in some females, at least as late as the first part of August. The site in the uterine horn where implantation will occur is obvious at least several days prior to the appearance of a recognizable embryo (one larger than 0.5mm).

Table 15. Proportion of bearded seal pups and animals six years or older in harvests taken at selected locations in Alaska during 1975-1977.

Location	1975			1976			1977		
	N	% Pups	% 6 Yrs. & older	N	% Pups	% 6 Yrs. & older	N	% Pups	% 6 Yrs. & older
Mekoryuk	28	60.7	7.1	0	-	-	0	-	-
Nome	10	10.0	60.0	5	20.0	40.0	14	14.3	50.0
Gambell	9	22.0	77.7	16	56.0	43.7	45	48.9	6.6
Diomede	7	0.0	57.1	14	21.4	71.4	12	25.0	66.0
Shishmaref	3	33.3	66.6	63	14.3	50.8	118	8.4	42.4
Wainwright	33	21.0	39.4	21	14.2	47.6	4	25.0	50.0
Beaufort Sea	0	-	-	5	40.0	20.0	16	18.8	56.2
SURVEYOR Cruise (southern Bering Sea)	0	-	-	1	0.0	0.0	10	30.0	50.0

Table 16 presents a summary of the progression of early implantation. Implantation sites were obvious as early as 26-30 June. However, newly implanted fetuses were not found until 6-10 July.

During the period of implantation almost the entire population of adult bearded seals is in the Chukchi-Beaufort Seas.

Table 16. Stage of implantation in 64 bearded seals obtained between 26 June and 4 August 1975-1977. Included are those females which had given birth at least once.

Dates	Sample Size	Without Obvious Implant Site N	Without Obvious Implant Site %	Implant Site Without Obvious Fetus N	Implant Site Without Obvious Fetus %	Implanted Fetus N	Implanted Fetus %
June 26-30	14	10	71	4	29	0	0
July 1-5	8	5	63	3	37	0	0
6-10	16	4	25	7	44	5	31
11-15	5	4	80	1	20	0	0
16-20	4	1	25	0	0	3	75
21-25	8	3	38	0	0	5	62
26-30	5	1	20	0	0	4	80
31-Aug.4	4	1	25	0	0	3	75
Totals	64	29		15		20	

VIII. Conclusions

Ringed and bearded seals and associated data have been gathered by the Department of Fish and Game personnel since 1962. However, this annual report covers examinations and analyses conducted between 31 March 1976 and 31 March 1978. Many of our samples and analyses are incomplete at this time and of an ongoing nature. Therefore the results and their preliminary interpretation are considered tentative and are not to be quoted without permission of the Principal Investigators.

Adult ringed seals are mainly associated with the shorefast ice of the Bering, Chukchi, and Beaufort Seas. By virtue of their nearshore habits and numbers, they are important to the coastal residents as a source of food and usable products. Bearded seals are found throughout the pack ice and flaw zone regions. Proposed OCS lease areas in the Bering, Chukchi, and Beaufort Seas are within the habitat of these seal species and pose a real threat to their populations. The objectives of our studies are to develop a baseline of ecological and behavioral data in order to prevent or lessen adverse impacts of outer continental shelf development.

General conclusions are as follows:

1. Ringed seals in Alaskan waters live to be at least 29 years old. Mean annual mortality rates from birth to seven years of age are 20 percent. The mortality rate is higher for pups then decreases slightly. Mortality rates for males and females are similar.

2. Indices of abundance show ringed seals to be more abundant on shorefast than moving ice (in June) and more abundant in the Chukchi Sea than in the Beaufort Sea. Surveys indicate an apparent shift of ringed seals from the Beaufort Sea into the Chukchi Sea during 1976 and 1977.

3. Ringed seals are apparently sensitive to disturbance. The density of ringed seals is low in the vicinity of coastal settlements.

4. Pregnancy lasts approximately 11 months with implantation delayed for about 3-1/2 months after conception. Females appear to be impregated in mid- to late April, soon after the birth of the pup.

5. Pups weigh 4.0 to 5.0 kg at birth and grow rapidly doubling their weight by weaning, two months after birth.

6. Heaviest weights are achieved in winter and early spring when the seal has a heavy, thick layer of blubber. The weights of ringed seals decline with the decrease in feeding during the reproductive and molting season.

7. Active spermatogenesis is found in essentially all seven-year-old and older males collected from March through June. Some five- and six-year-old males also undergo active spermatogenesis.

8. Males are physiologically capable of breeding earlier in the year and long after most females.

9. All female ringed seals seven years old and older appear to be capable of ovulation. Some three- to seven-year-old females are also capable of ovulation. Pregnancy rates have decreased from 91 percent during the period of 1964-1973 to 62 percent for those collected in 1975 and 1976. In 1977 and 1978 pregnancy rates appear to have returned to the 1964-1973 level.

10. In Alaskan waters, polar bears feed primarily on adult, male ringed seals and the bears kill one ringed seal about every 6.5 days during the spring. The hide and blubber are the part of the seal preferred by bears. An estimate of the number of ringed seals killed annually by the Alaskan populations of polar bears is about 500,000.

11. The fetal, pup, and older-than-pup sex ratio is 1:1 and the age composition essentially follows that of other ringed seal populations.

12. A literature review is underway and about 750 citations pertaining to ringed seals have been recovered. Few citations pertain specifically to ringed seals in Alaskan waters.

13. Shipboard and aerial surveys of bearded seals in the Bering Sea have demonstrated active spring migration in this species. Bearded seals that have wintered in the ice front begin moving north in late March, considerably before the disintegration of the ice.

14. Analysis of bearded seal harvest data has confirmed that a substantial proportion of bearded seal pups spends the summer in open waters in the Bering and Chukchi Seas while most adults remain in association with sea ice.

15. Bearded seals breed from mid-April to mid-May when female seals are in estrous. Males are in breeding condition for a longer period of time than females.

16. Bearded seal fetuses implant during July and early August. At this time almost the entire adult population is in the Chukchi and Beaufort Seas.

IX. Needs for further study

There are many needs within the Outer Continental Shelf Environmental Assessment Program which will no doubt be elucidated by many other investigators. Our primary need for further work is the examination of additional specimens, especially from the winter, from far offshore, and from the Beaufort Sea, so that we can fully address our task objectives. Collection of specimens should continue until a sample sufficiently large to determine seasonal, areal, and habitat variation in food habits and population distribution and structure is obtained. This same sample should provide enough reproductive material to calculate population productivity parameters.

The natural histories of important prey species of ringed and bearded seals should be investigated. The life histories and behaviors of prey species appear to have a direct effect on seal distribution, densities, and behavior. Emphasis should be given to potential effects of oil and gas exploration and development on these prey species.

Consideration should be given to developing a radio tracking system for pinnipeds. Once developed, the technique would rapidly provide badly needed information on movements, seasonal distribution, feeding areas, habitat utilization, and behavior. In addition, the use of remote sensing methods such as sonar have great potential for determining actual numbers of seals in an area and obtaining underwater behavioral data. The feasibility of using such equipment should be explored.

X. Summary of Fourth Quarter Operations

A. Field and laboratory activities

1. Schedule

Date	Location	Purpose
January-March 1978	Fairbanks	Routine laboratory and data analyses
January-March 1978	Fairbanks	Data management
January 1978	Anchorage	Game Division meeting
January 1978	Barrow	Beaufort Sea Synthesis Meeting
January-February 1978	Shishmaref	Collection of seal specimens
January-February 1978	Nome	Collection of seal specimens
February-March 1978	Gambell	Collection of seal specimens
February-March 1978	Kotzebue	Collection of seal specimens
March 1978	Prudhoe Bay	Collection of seal specimens
March 1978	Barrow	Collection of seal specimens
March 1978	Cape Thompson-Cape Lisburne	Collection of seal specimens
March 1978	Nome (including Norton Sound)	Collection of seal specimens
February-March 1978	Fairbanks	Preparation of annual report

2. Scientific Party

Name	Affiliation	Role
John J. Burns	ADF&G	Principal Investigator RU#230 and 232
Thomas J. Eley	ADF&G	Principal Investigator RU#230
Kathryn J. Frost	ADF&G	Principal Investigator RU#232
Lloyd F. Lowry	ADF&G	Principal Investigator RU#232
Glenn Seaman	ADF&G	Marine Mammals Technician
Robin Lynn	ADF&G	Marine Mammals Technician
Richard Tremaine	ADF&G	Marine Mammals Technician
Dan Strickland	ADF&G	Marine Mammals Technician
Diane Preston	ADF&G	Laboratory Technician
Paul Strickland	ADF&G	Marine Mammals Technician
Robert Pegau	ADF&G	Regional Supervisor Region V
Edward Muktoyuk	ADF&G	Marine Mammals Technician

3. Methods

From all specimens we endeavor to obtain weights, standard measurements, lower jaws, foreflippper claws, stomachs, reproductive tracts, and intestines. We also obtained blubber, tissue, organ, and blood samples as time and situation permitted.

The ages of seals are determined by evaluation of claw annuli (for animals six years and younger) and dentine or cementum annuli (for animals over six years of age). Growth rates are based on weight and standard measurements correlated with specimen age, sex and date and locality of collection. Species productivity and parasite burden are determined, respectively, through laboratory examinations of reproductive tracts and various organs and correlation of these data with age, sex, and date and locality of collection of each specimen.

Analytical methods are discussed in detail in our Annual Report.

4. Sample localities

Bering (including Norton Sound), Chukchi, and Beaufort Seas.

5. Data collected and other activities

Specimens collected during January, February, and March 1978 are as follows:

	Male	Female	Unknown	Total
Shishmaref				
Ringed seal	19	15	0	34
Nome				
Ringed seal	3	8		11
Bearded seal	8	3		11
Gambell				
Ringed seal	10	5	1	16
Bearded seal	3	1	1	5
Barrow				
Ringed seal	12	6		18

Jaws, claws, reproductive tracts, and stomachs were obtained from most animals and these specimens are being analyzed as rapidly as possible.

Much of this quarter was devoted to meetings and related activities. All permanent personnel (Burns, Eley, Lowry, Frost) were required to attend a Department of Fish and Game, Division of Game, meeting in Anchorage and these persons prepared presentations on their marine mammal research. The OCSEAP-sponsored Beaufort Sea Synthesis Meeting in January required an inordinate amount of time for preparation of the final disciplinary and interdisciplinary reports. Burns, Eley, Frost, and Lowry were chairpersons for either the disciplinary or interdisciplinary groups. The reports for these groups will be published as a separate document.

Project: 230

PI: Burns and Eley

MILESTONE CHART

MAJOR MILESTONES - SPECIMEN COLLECTIONS	1978-1979											
	O	N	D	J	F	M	A	M	J	J	A	S
Beaufort Sea												
Barrow		▲				▲	▲					
Prudhoe Bay		▲				▲	▲					
Icebreaker											△	
Chukchi Sea												
Wainwright										△	△	
Shishmaref	▲	▲	▲	▲	▲				△	△		
Point Hope							△	△				
Norton Sound												
Nome					▲	▲	▲	△	△	△		
Gambell					▲	▲		△	△			
St. George Basin - Bristol Bay												
Ice-reinforced vessel with helicopter								△	△			

△ Planned completion date

▲ Actual completion date

Project: 230

PI: Burns and Eley

MILESTONE CHART

MAJOR MILESTONES--OTHER PROJECT ACTIVITIES	1978-1979											
	O	N	D	J	F	M	A	M	J	J	A	S
Acquisition of specimens	▲						▲	△				△
Processing of specimens for age determination	▲						▲	△				△
Processing of reproductive tracts specimens	▲						▲	△				△
Compilation and analysis of specimen data	▲						▲	△				△
Submission of data	▲			▲			△			△		
Preparation of reports			▲			▲	▲		△			△
Preparation of FY 1979 proposal								△	△			

△ Planned completion date

▲ Actual completion date

XI. References and literature cited

Addison, R. F. and T. G. Smith. 1974. Organochlorine residue levels in Arctic ringed seals: variation with age and sex. Oikos 25:335-337.

Allen, J. A. 1880. History of North American pinnipeds. U.S. Geol. and Geogr. Surv. Terr., Washington DC. Misc. Publ. 12. 785pp.

Bee, J. W. and E. R. Hall. 1956. Mammals of northern Alaska. Univ. Kansas. Mus. Nat. Hist. Misc. Publ. No. 8. 309pp.

Benjaminsen, T. 1973. Age determination and the growth and age distribution from cementum growth layers of bearded seals at Svalbard. Fish. Dir. Skr. Ser. HavUnders 16:159-170.

Bigg, M. A. 1969. The harbour seal in British Columbia. Fish. Res. Bd. Can. Bull. 172:1-33.

Bisailon, A., J. Pierard and N. Lariviere. 1976. Le segment cervical des carnivores (Mammalia: Carnivora) adaptes a la vie aquatique. Can. J. Zool. 54:431-436.

Braestrup, F. W. 1941. Growth control in mammalian skin. Nature 193 (4815):520-523.

__________ and T. Rytomaa. 1965. Mitotic homeostasis. Nature 205 (4971):573-578.

Burns, J. J. 1967. The Pacific bearded seal. Alaska Dept. Fish and Game. Juneau. 66pp.

__________. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi Seas. J. Mammal. 51(3):445-454.

__________ and F. H. Fay. 1970. Comparative morphology of the skull of the ribbon seal, _Histriophoca fasciata_, with remarks on systematics of Phocidae. J. Zool. (London) 161:363-394.

__________ and S. J. Harbo, Jr. 1972. An aerial census of ringed seals, northern coast of Alaska. Arctic 25(4):279-290.

__________ and T. J. Eley. 1976. Natural history and ecology of the bearded seal (_Erignathus barbatus_) and the ringed seal (_Phoca_ (_Pusa_) _hispida_). Pages 263-302 _in_ Environmental Assessment of the Alaskan Continental Shelf, Principal Investigators' Reports for the Year Ending March 1976. Volume 1, Marine Mammals. NOAA, Environmental Research Laboratories, Boulder, CO. 420pp.

__________ and __________. 1977. Natural history and ecology of the bearded seal (Erignathus barbatus) and the ringed seal (Phoca hispida). Pages 226-284 in Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1977. Volume 1, Receptors-Marine Mammals. NOAA, Environmental Research Laboratories, Boulder, CO. 708pp.

Caughley, G. 1966. Mortality patterns in mammals. Ecology 48:834-839.

__________. 1977. Analysis of vertebrate populations. John Wiley and Sons, New York. 234pp.

Chapsky, K. K. 1940. The ringed seal of the western seas of the Soviet Arctic. Vsesoiriznyi Arktickeskii Institut., Trudy 145:1-72.

Cooper, A. R. 1921. Trematodes and cestodes of the Canadian Arctic Expedition 1913-1918. Rep. Can. Arctic Expedition 1913-1918. 9(G-H):3-27.

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

Degerbøl, M. and P. Freuchen. 1935. Mammals (2(4-5):278). In Report of the Fifth Thule Expedition 1921-1924. Copenhagen, Nordisk Forlag. Part I, Systematic notes by Degerbøl. Part II, Field notes and biological observations by Freuchen.

Delyamure, S. L. 1955. Helminthofauna of marine mammals: (Ecology and Phylogeny). Izd. Akad. Nauk SSSR, Moscow. 517pp.

__________ and V. N. Popov. 1974. Seasonal variation in the helminth fauna of the Okhotsk ringed seal. Parazitologiya 8(2):89-92.

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

Dunbar, M. J. 1941. On the food of seals in the Canadian eastern Arctic. Can. J. Res. 19:150-155.

__________. 1949. The Pinnipedia of the arctic and subarctic. Bull. Fish. Res. Bd. Can. 85:1-22.

__________. 1952. The Ungava Bay problem. Arctic 5(1):4-16.

Ekman, S. 1953. Zoogeography of the sea. Sidgwick and Jackson, Ltd., London. 417pp.

Eley, T. J. 1977. An analysis of polar bear predation on ice inhabiting pinniped populations of Alaska. Proc. Conf. Bio. Marine Mammals, San Diego, CA. 2:18.

__________. 1978. The ringed seal in Alaska. Wildlife Notebook Series, Alaska Dept. Fish and Game, Juneau. 2pp.

Enright, J. T., J. H. Wormuth and W. R. Hansen. 1969. Statistics of unseen animals. Science 165:824-825.

Fay, F. H. 1967. The number of ribs and thoracic vertebrae in pinnipeds. J. Mammal. 48(1):144.

__________. 1974. The role of ice in the ecology of marine mammals of the Bering Sea. Pages 383-399 in D. W. Hood and E. J. Kelley, eds. Oceanography of the Bering Sea. Inst. Mar. Sci., Univ. Alaska, Fairbanks.

__________, R. A. Dieterich and L. M. Shults. 1976. Postmortem procedures for examination of Alaska marine mammals. OCSEAP Alaskan Marine Environmental Assessment Program, Project RU # 194. 26pp.

Fedoseev, G. A. 1965a. Comparative characteristics of ringed seal populations in the Chukotskii Peninsula coastal waters. Izv. Tikhookean. Nauchno-Issled. Inst. Rybn. Khoz. Okeanogr. 59:194-212. (Fish. Mar. Ser. Transl. No. 3428, 1975).

__________. 1965b. A note on the ecology of seal reproduction in the northern Sea of Okhotsk. Izv. TINRO 57:212-216.

__________. 1965c. Age and sex composition of the kill of the ringed seal (Phoca hispida ochotensis Pall.) as an index of the age structure of the population. Morsk. Mlekop., Akad. Nauk SSSR. pp. 105-112. (Transl. from Russian by Fish. Res. Bd. Can. Transl. Ser. No. 799:23pp., 1966).

__________. 1965d. The diet of ringed seal (Pusa hispida Schr.). Izvest. Tikhookeanskogo Nauch.-Issled. Inst. Rubn. Khoz. Okeanogr. 59:216-223.

__________. 1966. Aerial observations of marine mammals in the Bering and Chukchi Seas. Izv. TINRO 58:173-177.

__________ and A. V. Yablokov. 1965. Morphological description of the ringed seal (Pusa hispida, Pinnipedia, Mammalia) in the Sea of Okhotsk. Zool. Zhur. 44(5):759-765.

__________ and V. N. Goltsev. 1974. Some morphological adaptations of the Okhotsk Sea seals and their ecological conditionality. Zool. Invest. of Siberia and the Far East. Acad. Sci. SSSR. Far Eastern Sci. Center, Vladivostok. pp.63-69.

Feltz, E. T. and F. H. Fay. 1966. Thermal requirements in vitro of epidermal cells from seals. Cryobiology 3(3):261-264.

Frame, G. W. 1972. Occurrence of polar bear in the Chukchi and Beaufort Seas, summer 1969. J. Mammal. 53(1):187-189.

Freeman, M. M. R. 1969/1970. Studies in maritime hunting. I. Ecologic and technologic restraints on walrus hunting, Southampton Island N.W.T. Folk 11-12:155-171.

Freuchen, P. and F. Salomonsen. 1958. The Arctic year. G. P. Putnam's Sons, New York. 438pp.

Freyman, S. Yu. 1971. The commercial nature of the northern portion of the Sea of Okhotsk. Memorial Univ. St. John's Newfoundland Libr. Bull. 5(5):37-39.

Geraci, J. R. and T. G. Smith. 1975. Functional hematology of ringed seals (Phoca hispida) in the Canadian Arctic. J. Fish. Res. Bd. Can. 32(12):2559-2564.

__________ and __________. 1976. Direct and indirect effects of oil on ringed seals (Phoca hispida) of the Beaufort Sea. J. Fish. Res. Bd. Can. 33:1976-1984.

Golenchenko, A. R. 1963. Ringed seals of the White, Barents, Karsk and Laptev Seas. In Problems of the Exploitation of the Game Resources of the White Sea and the Inland Waters of Kareliay. Akad. Nauk SSSR (Moscow-Leningrad) 1:156-160.

Goto, S. and Y. Ozaki. 1930. Brief notes on new trematodes. III. Jap. J. Zool. 3:73-82.

Hansen, W. R. 1968. Estimating the number of animals: a rapid method for unidentified individuals. Science 162:675-676.

Harington, C. R. and D. E. Sergeant. 1972. Pleistocene ringed seal skeleton from Champlain Sea deposits near Hull, Quebec - A reidentification. Can. J. Earth Sci. 9(8):1039-1051.

Harrison, R. J. 1960. Reproduction and reproductive organs in common seals (Phoca vitulina) in The Wash, East Anglia. Mammalia 24:372-385.

Hewer, H. R. 1964. The determination of age, sexual maturity, longevity and a life-table in the grey seal (Halichoerus grypus). Proc. Zool. Soc. London 142(4):593-624.

Holden, A. V. 1970. Monitoring organochlorine contamination of the marine environment by analysis of residues in seals. Proc. FAO Tech. Conf. Mar. Poll. Rome.

__________ and K. Marsden. 1967. Organochlorine pesticides in seals and porpoises. Nature 216:1274-1276.

Jensen, S., A. B. Johnels, M. Olsson and G. Otterlind. 1969. DDT and PCB in marine mammals from Swedish waters. Nature 224:247-250.

Joensen, A. H., N. O. Søndergaard and E. B. Hansen. 1976. Occurrence of seals and seal hunting in Denmark. Danish Review of Game Biology 10(1):1-16.

Johnson, A. and C. Lucier. 1975. Hematoxylin hot bath staining technique for aging by counts of tooth cementum annuli. Alaska Dept. Fish and Game. Unpubl. rep. 29pp.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson and M. X. Barbour. 1966. Marine Mammals. Pages 877-924 in N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. USAEC, Oak Ridge, TN.

Kenyon, K. W. 1960. A ringed seal from the Pribilof Islands, Alaska. J. Mammal. 41(4):520-521.

__________. 1962. Notes on phocid seals at Little Diomede Island, Alaska. J. Mammal. 26(4):380-387.

King, J. E. 1964. Seals of the world. Trustees of the British Museum (Natural History) London. 154pp.

Krotov, A. I. and S. L. Delyamure. 1952. Data on parasitic worms of mammals and birds of the USSR. Trudy Gelmintol. Lab ANSSR 6:278-392.

Laws, R. M. 1956. Growth and maturity in aquatic mammals. Nature 178: 193-194.

__________. 1962. Age determination of pinnipeds with special reference to growth layers in the teeth. Z. Saugetierkande 27:129-146.

Ling, J. K. 1969. A review of ecological factors affecting the annual cycle in island populations of seals. Pacific Science 23(4):399-413.

Lowry, L. F. and J. J. Burns. 1976. Trophic relationships among ice inhabiting phocid seals. Pages 303-333 in Environmental Assessment of the Alaskan Continental Shelf, Principal Investigator's Reports for the Year Ending March 1976. Volume 1, Marine Mammals. NOAA, Environmental Research Laboratories, Boulder, CO. 420pp.

__________, K. J. Frost and __________. 1977. Trophic relationships among ice inhabiting phocid seals. Pages 303-433 in Environmental Assessment of the Alaskan Continental Shelf, Annual Reports of Principal Investigators for the Year Ending March 1977. Volume 1, Receptors-Marine Mammals. NOAA, Environmental Research Laboratories, Boulder, CO. 708pp.

Lyster, L. L. 1940. Parasites of some Canadian sea mammals. Can. J. Res. 18(12):395-409.

Mansfield, A. W. 1967. Seals of the arctic and eastern Canada. Fish. Res. Bd. Can. Bull. 137:35pp. (2nd ed).

__________. 1968. Seals and walrus. Pages 378-381 in C. S. Beals, ed. Science, history and Hudson Bay. Vol. 1 Dept. Energy, Mines and Resources, Ottawa.

__________. 1970. Population dynamics and exploitation of some arctic seals. Pages 429-446 in M. W. Holdgate, ed. Antarctic Ecology, Vol. 1. Academic Press, London.

Marakov, S. V. 1968. Materialy po ekologii largi komandorskikh ostrovov. Trudy Polyarnogo Nauchno-Issledovatel' skogo i Proektnogo Instituta Morskogo Rybnogo Knozyaistva i Okeanografii in. N. M. Knipovicha (PINRO) 21:126-136. Fish. Res. Bd. Can. Transl. 1079.

Margolis, L. and M. D. Dailey. 1972. Revised annotated list of parasites from sea mammals caught off the west coast of North America. NOAA Tech. Rep. NMFS SSRF-647. 23pp.

Massler, M., I. Schour and C. T. Linden. 1958. Atlas of the mouth in health and disease. Am. Dental Assoc., Chicago, IL. 140pp.

McLaren, I. A. 1956. Summary of the biology of the ringed seal in waters of southwest Baffin Island. Pages 185-186 in M. J. Dunbar, ed. The "Calanus" expeditions in the Canadian Arctic. Arctic 9:178-190.

__________. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian Arctic. Fish. Res. Bd. Can. Bull. 118:97pp.

__________. 1961. Methods of determining the numbers and availability of ringed seals in the eastern Canadian Arctic. Arctic 14(3):162-175.

__________. 1962. Population dynamics and exploitation of seals in the eastern Canadian Arctic. Pages 168-183 in E. D. LeCren and M. W. Holdgate, eds. The exploitation of natural animal populations. Blackwell Scientific Publications, Oxford.

__________. 1966a. Analysis of an aerial census of ringed seals. J. Fish. Res. Bd. Can. 23(5):769-773.

__________. 1966b. Taxonomy of harbor seals of the western North Pacific and the evolution of certain other hair seals. J. Mammal. 47:466-473.

__________. 1967. Seals and group selection. Ecology 48(1):104-110.

Messelt, E. B. and B. A. Schytyye. 1973. On the salivary glands of the ringed seal. Comp. Biochem. Physiol. (A). Comp. Physiol. 46(1):1-4.

Milne, A. R. 1974. Use of artificial subice air pockets by wild ringed seals (Phoca hispida). Can. J. Zool. 52:1092-1093.

Mineev, V. N. 1975. Regulation of pinniped hunting in Soviet waters. Rapp. P.-v. Reun. Cons. int. Explor. Mer. 169:550-551.

Muller-Wille, L. L. 1969. Biometrical comparisons of four populations of Phoca hispida Schreb in the Baltic and White Seas and Lakes Ladoga and Saimaa. Commentationes Biologicae, Societas Scientiarum Fennica 31(3):1-12.

Myers, B. J. 1957. Nematode parasites of seals in the eastern Canadian Arctic. Can. J. Zool. 35:291.

__________. 1959. Lice on Phoca hispida Schreber. Can. J. Zool. 37:1123.

Orr, R. T. and T. C. Boulter. 1967. Some observations of reproduction, growth and social behavior in the Steller sea lion. Proc. Calif. Acad. Sci. 35:193-226.

Pedersen, A. 1964. Ringsalen. Grønland 2:307-314.

Pikharev, G. A. 1946. The food of the seal Phoca hispida. Izv. Tikh. N. I. Institua Rybnovo Khosiaistva i okeanografii Tom 22:259-261. (Fish. Res. Bd. Can. Transl. Ser. No. 150, 1957)

Ramprashad, F., K. Ronald, J. Geraci and T. G. Smith. 1976. A comparative study of surface preparations of the organ of Corti of the harp seal (Pagophilus groenlandicus Erxleben 1777) and the ringed seal (Pusa hispida). 1. Sensory cell population and density. Can. J. Zool. 54:1-9.

Rausch, R. L. 1970. Trichinosis in the Arctic. Pages 348-373 in S. E. Gould, ed. Trichinosis in man and animals. Charles C. Thomas, Springfield, IL.

Rausch, R., B. B. Babero, R. V. Rausch and E. L. Schiller. 1956. Studies on the helminth fauna of Alaska. 27. The occurrence of larvae of Trichinella spiralis in Alaskan mammals. J. Parasit. 42:259-271.

Roth, H. 1950. Nouvelles experiences sur la trichinose arec considerations speciales sur son existence dans les regions arctiques. Off. Intl. d. Epizootics, Rapport 18th Session. pp.1-24.

Russell, R. H. 1975. The food habits of polar bears of James Bay and southwest Hudson Bay in summer and autumn. Arctic 28(2):117-129.

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

Shusterman, R. L. and R. L. Gentry. 1971. Development of a fatted male phenomenon in California sea lions. Developmental Psychobiology 4(4):333-338.

Smirnov, H. 1927. Diagnostical remarks about some seals (Phocidae) of the Northern Hemisphere. Tromso Mus. Arsh. 48(5):1-23.

Smith, A. W., T. G. Akers, C. M. Prato and H. Bray. 1976. Prevalence and distribution of four serotypes of SMSV serum neutralizing antibodies in wild animal populations. J. Wildl. Dis. 12:326-344.

Smith, T. G. 1970. Computer programs used in the study of ringed seal population dynamics in the Canadian eastern Arctic. Fish. Res. Bd. Can. Tech. Rep. 224:45pp.

__________. 1971. Population dynamics of the ringed seal in the eastern Canadian Arctic. Ph.D. Thesis, McGill Univ. 168pp.

__________. 1973a. Censusing and estimating the size of ringed seal populations. Fish. Res. Bd. Can. Tech. Publ. No. 427:26pp.

__________. 1973b. Population dynamics of the ringed seal in the Canadian eastern Arctic. Fish. Res. Bd. Can. Bull. 181:1-55.

__________. 1973c. Management research on the Eskimo's ringed seal. Can. Geog. J. 86(4):118-125.

__________. 1975a. Rough-legged hawk, Buteo lagopus (Pontoppidan), as carrion feeders in the arctic. Can. Field-Nat. 89(2):190.

__________. 1975b. Ringed seals in James Bay and Hudson Bay: Population estimates and catch statistics. Arctic 28(3):170-182.

__________. 1976. Predation of ringed seal pups (Phoca hispida) by the arctic fox (Alopex lagopus). Can. J. Zool. 54:1610-1616.

__________. 1977. The wolffish, cf. Anarhichas denticulatus, new to the Amundsen Gulf area, N.W.T., and a probable prey of the ringed seal. Can. Field-Nat. 91(3):288.

__________, B. Beck and G. A. Sleno. 1973. Capture, handling, and branding of ringed seals. J. Wildl. Manage. 37(4):579-583.

__________ and J. R. Geraci. 1974. The effect of contact and ingestion of crude oil on ringed seals of the Beaufort Sea. Interim Rep. Beaufort Sea Proj. Study 45. 27pp.

__________ and I. Stirling. 1975. The breeding habitat of the ringed seal (Phoca hispida). The birth lair and associated structures. Can. J. Zool. 53(9):1297-1305.

Sokolov, A. S., G. M. Kosygin and A. P. Shustov. 1968. Structure of the lungs and trachea of Bering Sea pinnipeds. Izv. TINRO 62:252-263.

Stirling, I. 1969. Tooth wear as a mortality factor in the Weddell seal, Leptonychotes weddelli. J. Mammal. 50(3):559-565.

__________. 1973. Vocalization in the ringed seal (Phoca hispida). J. Fish. Res. Bd. Can. 30(10):1592-1594.

__________. 1974. Midsummer observations on the behavior of wild polar bears (Ursus maritimus). Can. J. Zool. 52(9):1191-1198.

__________. 1975. Adaptations of Weddell and ringed seals to exploit polarfast ice habitat in the presence or absence of land predators. In G. A. Llano, ed. Adaptations within Antarctic Ecosytems. Proc. 3rd Symp. on Antarctic Biol., Washington, DC. 26-30 August 1974.

__________ and E. H. McEwan. 1975. The caloric value of whole ringed seals (Phoca hispida) in relation to polar bear (Ursus maritimus) ecology and hunting behavior. Can. J. Zool. 53:1021-1027.

__________, R. Archibald and D. DeMaster. 1975. The distribution and abundance of seals in the eastern Beaufort Sea, Victoria, Canada. Beaufort Sea Tech. Rep. No. 1. 58pp.

Terhune, J. M. and K. Ronald. 1975. Underwater hearing sensitivity of two ringed seals (Pusa hispida). Can. J. Zool. 53(3):227-231.

Tikhomirov, E. A. 1959. The question of feeding of Steller sea lions on warm-blooded animals. Izv. TINRO 47:185-186.

__________. 1961. Distribution and migration of seals in waters of the Far East. Pages 199-210 in E. H. Pavlovskii and S. K. Kleinenberg, eds. Transactions of the Conference on Ecology and Hunting of Marine Mammals. Akad. Nauk SSSR, Ikhtiol. Comm., Moscow.

__________. 1964. Distribution and biology of pinnipeds in the Bering Sea. Izv. TINRO 52:272-280.

__________. 1966. On the reproduction of seals belonging to the family Phocidae in the North Pacific. Zool. Zhur. 45:275-281.

Timoshenko, Yu. K. 1975. Craniometric features of seals of the genus Pusa. Rapp. P.-v. Réun. Cons. int. Explor. Mer. 169:161-164.

True, F. W. 1883. The osteological characters of the genus Histriophoca. Am. Nat. 17:798.

__________. 1884. On the skeleton of Phoca (Histriophoca) fasciata, Zimmerman. Proc. U.S. Nat. Mus. 6:417-426.

__________. 1889. The mammals of the Pribilof Islands. Pages 345-354 in D. S. Jordan, ed. The Fur Seals and Fur Seal Islands of the North Pacific Ocean. U.S. Gov. Printing Off., Washington, DC. Part 3.

Wilke, F. 1954. Seals of northern Hokkaido. J. Mammal. 35(2):218-224.

Usher, P. J. 1969. Field tables for the calculation of ringed seal weights from length and girth measurements. N. Sci. Res. Group, Dept. Indian Affairs N. Dev. Tech. Notes 3:9pp.

__________ and M. Church. 1969. On the relationship of the weight, length and girth of the ringed seal (Pusa hispida) of the Canadian Arctic. Arctic 22:120-129.

Weber, N. A. 1950. A survey of the insects and related arthropods of arctic Alaska. Part I. Trans. Am. Entomol. Soc. 76:147-206.

Youngman, P. M. 1975. Mammals of the Yukon Territory. Nat. Mus. Can. Publ. Zool. 10:1-192.

Yurakhno, M. V. and A. S. Skrjabin. 1971. Parafilaroides krascheninnikovi sp. n. parasite of the lungs of the ringed seal Pusa hispida krascheninnikovi Naumov et Smirnov. Vestnik Zool. 1971(1):32-36.

Zheglov, V. A. and K. K. Chapskii. 1974. Test of an aerial survey of the ringed seal and the grey seal and of their holes in the gulfs of the Baltic Sea and on Lake Lakoga. Can. Fish. Res. Bd. Transl. Ser. No. 3185:524-558.