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

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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 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 land fast 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 obtained 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 land fast 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 by products. 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 include, but are not limited to, such things as natality, mortality, population size, population structure, trophic relationships, detailed understanding of factors determining density, distribution, seasonal movements, critical habitat requirements, relationship to ice habitats, behavior and other biological processes. Historical events indicate that marine mammals, as intelligent, irritable (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. Acquisition 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 marine environment and the probable effects of disturbance both to the species themselves and the environment on which they depend.

A. Ringed seal

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 northern 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 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 chiefly depends 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 2 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 very few animals 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 found 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 in lairs or in the water. From May and June 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). 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 polar 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/mile^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 essentially unknown.

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 geographic 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 or 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 involves 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 0.1g 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 ascertain 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 01.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 or 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 outline in Fay et al. 1976.

H. Samples (about 125cm^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 cause of death, physical condition, and amount consumed by 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 petro-chemicals.

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 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 collectors 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 airplane and helicopters. Aircraft used thus far for surveys have been a Cessna 180, Cessna 185, DeHavilland Twin-Otter, and Lockeed P2V (all fixed-wing aircraft) and a Bell 206B helicopter. Survey transects were 0.8 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 on a prepared survey form.

Locations 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 are 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. However, this information is accepted with caution. Interview of several hunters may be required to separate facts from legends, or information given just to please the investigators. 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 collections of specimens and surveys of ice habitats and seal densities and distribution. Specimens were obtained at hunting sites in Nome, Stebbins, Savoonga, Gambell, Shishmaref, Point Lay, Wainwright, Barrow, and Barter Island. Collections offshore, with the aid of ships, boats or helicopters, were made in Norton and Kotzebue Sounds and the Beaufort, Chukchi and Bering Seas. A complete listing of field activities for the reporting year are presented in Table 1.

During reporting year 1976-1977, specimens were obtained from 307 ringed seals and 133 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 293 ringed seals obtained, 154 were males and 139 were females; a 1:1 sex ratio ($P > 0.05$). Similarly 128 bearded seal (54 males and 74 females) were found to have a 1:1 sex ratio (P 0.05).

B. Marine mammal harvests

One objective of this study is to determine the size and composition of the harvest of ice associated marine mammals obtained by coastal residents of Alaska. The area in which this was done extends from Cape Newenham to Barter Island and includes all coastal settlements of the northern Bering, Chukchi and Beaufort Seas. This aspect of the work for seals, belukha whales and walrus was accomplished by J. Matthews, ADF&G, Nome.

A record of annual seal harvests was obtained for four of the most dependably productive seal hunting locations; the villages of Hooper Bay, Gambell, Savoonga and Shishmaref. Hooper Bay is in

Table 1. Schedule of field activities, March 1976-March 1977.

Location	Date	Activity
Cape Lisburne	March-April 1976	Specimen collection and surveys of seals and ice habitats
OSS SURVEYOR (Bering Sea ice edge)	March-April 1976	Specimen collection and surveys of seals and ice habitats
P2V aerial surveys (Bering Sea ice edge)	April 1976	Aerial surveys of seals and ice habitats
Point Hope	April-June 1976	Specimen collection
Oliktok	May 1976	Specimen collection
St. Lawrence Island (Gambell and Savoonga)	May-June 1976	Specimen collection
Kotzebue Sound to Barter Island	June 1976	Aerial survey of seals and ice habitats
Barrow	June 1976	Specimen collection
Shishmaref	July 1976	Specimen collection
Wainwright	July-August 1976	Specimen collection
USCGS GLACIER (Beaufort Sea ice edge)	August 1976	Specimen collection and seal surveys
OSS DISCOVERER	August 1976	Specimen collection and seal surveys
R/V NATCHIK	September 1976	Specimen collection
Nome	November 1976	Specimen collection
Stebbins	November 1976	Specimen collection
Nome	January 1977	Specimen collection
Barrow	February 1977	Specimen collection
Wainwright	February 1977	Specimen collection

Table 1. (Continued).

Location	Date	Activity
Point Lay	February 1977	Specimen collection
Norton Sound	March 1977	Specimen collection
Kotzebue Sound	March 1977	Specimen collection

Table 2. Seal specimens obtained from March 1976 to March 1977.

Location	Males	Females	Unknown	Total
Barrow, 1976				
Ringed seal	10	4	2	16
Bearded seal	2	-	-	2
Barrow, 1977				
Ringed seal	2	-	-	2
Barter Island, 1976				
Ringed seal	-	2	1	3
Bearded seal	-	3	-	3
Cape Lisburne, 1976				
Ringed seal	12	-	7	19
Bearded seal	-	1	-	1
OSS DISCOVERER, 1976				
Ringed seal	-	2	-	2
Bearded seal	-	1	-	1
Gambell, 1976				
Ringed seal	2	3	-	5
Bearded seal	5	11	3	19
USCGC GLACIER				
Ringed seal	1	-	-	1
R/V MILLER-FREEMAN				
Bearded seal	1	-	-	1
Nome, 1976				
Ringed seal	3	6	-	9
Bearded seal	2	3	1	6
Nome, 1977				
Ringed seal	10	19	-	29
Bearded seal	5	-	-	5
Point Hope, 1976				
Ringed seal	37	7	3	47
Savoonga, 1976				
Ringed seal	11	7	-	18
Shishmaref, 1976				
Ringed seal	59	84	1	144
Bearded seal	31	42	-	73
Stebbins, 1976				
Ringed seal	2	1	-	3
OSS SURVEYOR, 1976				
Bearded seal	-	1	-	1
Wainwright, 1976				
Ringed seal	5	4	-	9
Bearded seal	8	12	1	21
Total Seals				
Ringed seals	154	139	14	307
Bearded seals	54	74	5	133

southeast Bering Sea, Gambell and Savoonga are on St. Lawrence Island, in northern Bering Sea and Shishmaref is in extreme southeast Chukchi Sea. These villages account for approximately 20 percent of the annual seal harvest and data obtained from them are used as a basis for estimating total harvest. Additional information, obtained from work in other villages, is utilized to augment and refine estimates.

In view of the geographical location of our four major sampling sites, and distribution of the seal species, composition of the harvest tends to overestimate the proportion of spotted seals in the harvest and to underestimate the proportions of ringed and bearded seals.

All factors considered, the estimated harvest of seals during calendar year 1976 was 7,000 to 8,500 animals with a species composition as follows:

59% ringed seals (4130 - 5015 individuals)
28% bearded seals (1960 - 2380 individuals)
13% spotted seals (910 - 1105 individuals)
1% ribbon seals (50 individuals)

With respect to comparative yield, it should be noted that each bearded seal is equivalent to between three and five ringed seals.

Estimates of the annual walrus harvest are much more precise than for seals. ADF&G personnel are stationed at all of the major walrus hunting sites during the period of productive walrus hunting. Other villages where walruses are taken are routinely visited and the take of walrus determined. The walrus harvest, composition, chronology and geographic distribution of the kill during 1976 was as follows:

1. Total harvest - 2,989 animals

   1,820 males older than one year (61%)
   867 females older than one year (29%)
   302 calves of either sex (10%)

2. Geographical distribution of harvest

   Bering Sea - 2,570 animals (86% of total)
   1,485 males (58%)
   789 females (31%)
   296 calves (11%)

   Chukchi Sea - 419 animals (14% of total)
   335 males (80%)
   78 females (19%)
   6 calves (1%)

3. Seasonal distribution of harvest

January-March, 50 animals (2%)
April-June, 2,444 animals (82%)
July-September, 436 animals (14%)
October-December, 59 animals (2%)

A fall survey of walruses in the Soviet sector of the Chukchi Sea, during September and October 1975, was conducted by V. N. Gol'tsev, Magadan Branch of the Pacific Research Institute of Fisheries and Oceanography (TINRO). An English version of this very important paper, translated by J. Burns, is attached as Appendix 1.

Other significant harvests of ice associated marine mammals obtained by residents of the west and north coasts of Alaska during 1976 include:

39 bowhead whales (data reported by NMFS);
79 polar bears (as indicated by ADF&G bear sealing records);
285 belukha whales (based on information from villages where belukhas were taken).

A majority of the belukhas were taken by residents of Buckland, a village in southeastern Kotzebue Sound. The remaining kill was taken at scattered locations between Kuskokwim Bay and Wainwright.

C. Bearded and ringed seal food habits

See Annual Report of "Trophic relationships among ice inhabiting phocid seals" (RU#232).

D. Bearded seals

During this report period investigation of the natural history and ecology of bearded seals has been secondary to that of the ringed seal. Because of the smaller number of these seals which are taken by coastal residents and other difficulties associated with working on this large mammal, our main objective has been to acquire an adequate sample of sufficient size to warrant detailed analyses. The number of bearded seals examined during the past year is not yet sufficient for meaningful, detailed assessment of the major aspects of their biology.

Emphasis of our work on bearded seals during the past year was directed at (1) determination of distribution and density within the ice front and shore ice areas surveyed (mainly for other species of seals), (2) the collection and examination of seals obtained in the vicinity of coastal hunting sites by subsistence hunters, (3) collection of seals by ADF&G personnel in areas not sampled by land-based subsistence hunters, (4) the partial analysis of some specimen material (mainly stomachs examined and reported on under project RU#232), and (5) the formating, keypunching and submission of those data about bearded seals which did not involve the laboratory examination of material collected (excepting stomachs).

1. Aerial surveys

Extensive surveys of marine mammals, by aircraft, were conducted in two separate areas; the ice front of southeastern Bering Sea and the landfast ice of the northeastern Chukchi Sea and Beaufort Sea east to Barter Island. These surveys were primarily for the purposes of determining density and distribution of other marine mammal species. However, they did provide additional information about bearded seals.

A survey of the ice front was undertaken between 27 March and 23 April. The principal objective of this survey was to determine distribution and density of spotted seals, Phoca vitulina largha, which concentrate in the front during the winter-spring period. Short survey flights were undertaken with a helicopter from the OSS SURVEYOR and extensive coverage of the front in southeastern Bering Sea was achieved with use of a long range P2V aircraft (refer to reports of project RU#231). The region within which surveys were conducted with the P2V aircraft is shown in Fig. 1. It was bounded to the south by the ice "edge" and to the north by the heavy pack ice.

Bearded seals were uncommon in the front, especially near the southern boundary. Most sightings were made near the northern limit of survey tracks, indicating the possibility that larger numbers were north of our survey area, associated with heavier pack ice. This has been the situation observed in the past. Surveys by H. Braham (RU#67), also conducted during April 1976, confirmed the occurrence of higher densities of bearded seals north of the front.

Fig. 2 indicates sightings of bearded seals in the area shown in Fig. 1. Fig. 3 shows sightings of ringed seals made during the same survey flights.

It can be concluded that both species are not commonly found in the front.

An extensive survey of ringed seals was undertaken during June 1976 and included mostly areas of landfast ice from Kotzebue Sound to Barter Island. Bearded seals do not occur on landfast ice of these regions until it begins to melt and break up during June. A total of 4,157 seals were counted on the landfast ice of which only 51 (1.2%) were bearded seals. The remainder were ringed seals. Part of this June survey included survey tracks over the drifting ice of northwestern Chukchi Sea. Composition of seals observed was markedly different. In the drifting ice bearded seals accounted for 33 percent of all seals observed and the proportion of ringed seals dropped to 66 percent.

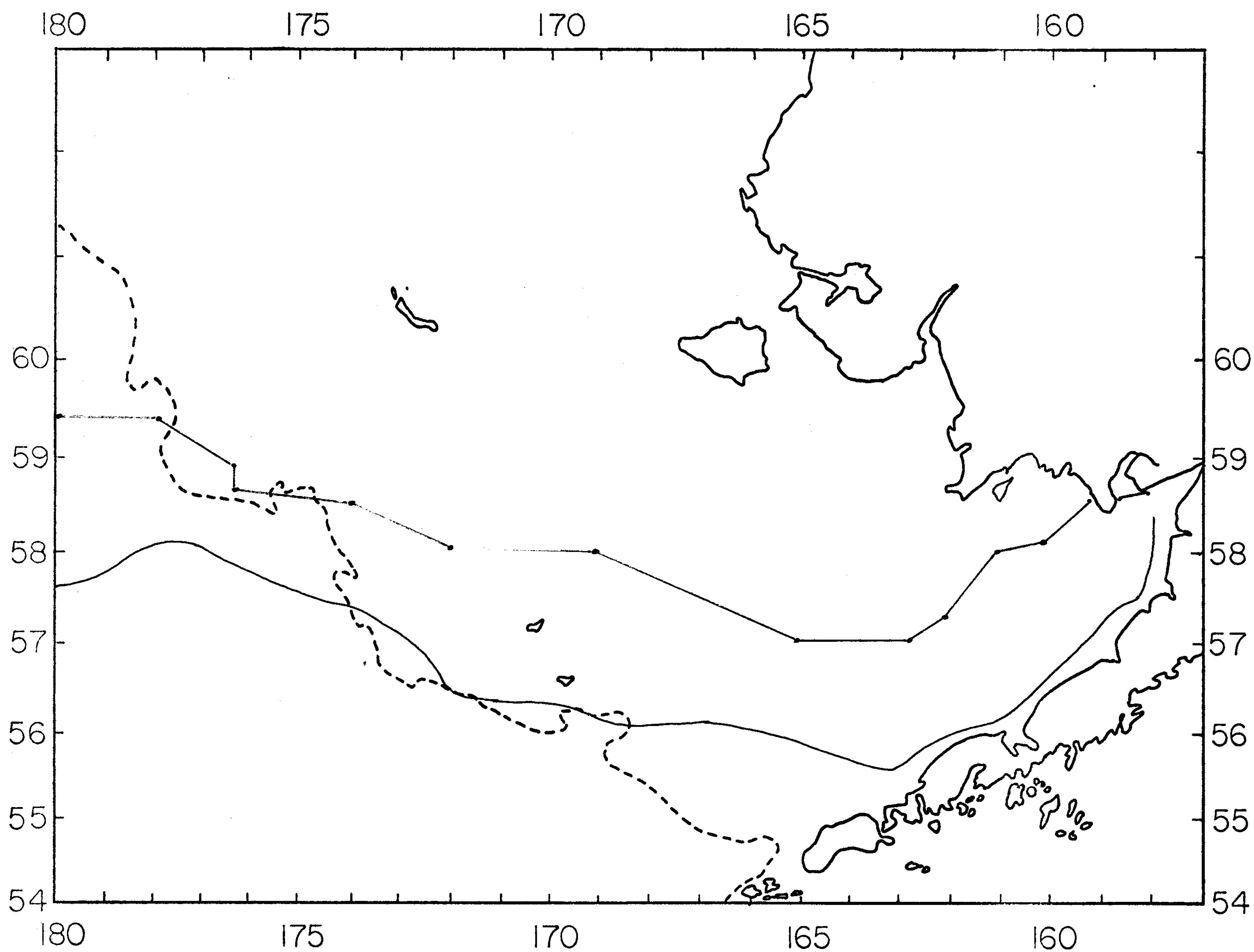

Fig. 1. Area within which shipboard and aerial surveys were conducted during March-April 1976. Southern limit of surveys was the ice edge. Northern limit approximated the inner margin of the front. The 200 meter depth contour is indicated by the light, dashed line.

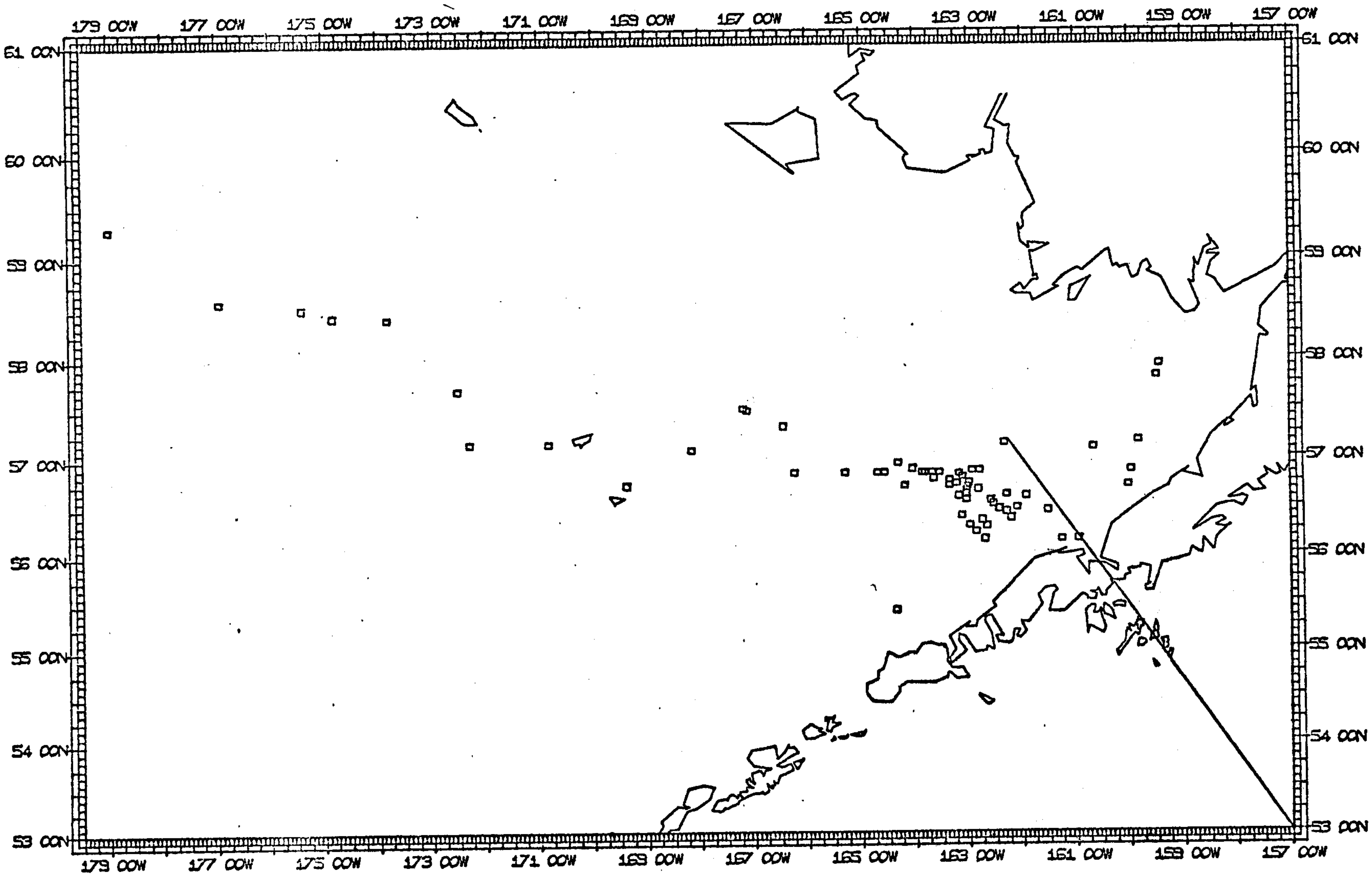

Fig. 2. Combined sightings of all bearded seals observed during surveys within the area shown in Fig. 1. Computer map courtesy of H. Braham and B. Krogman, NMFS, Seattle.

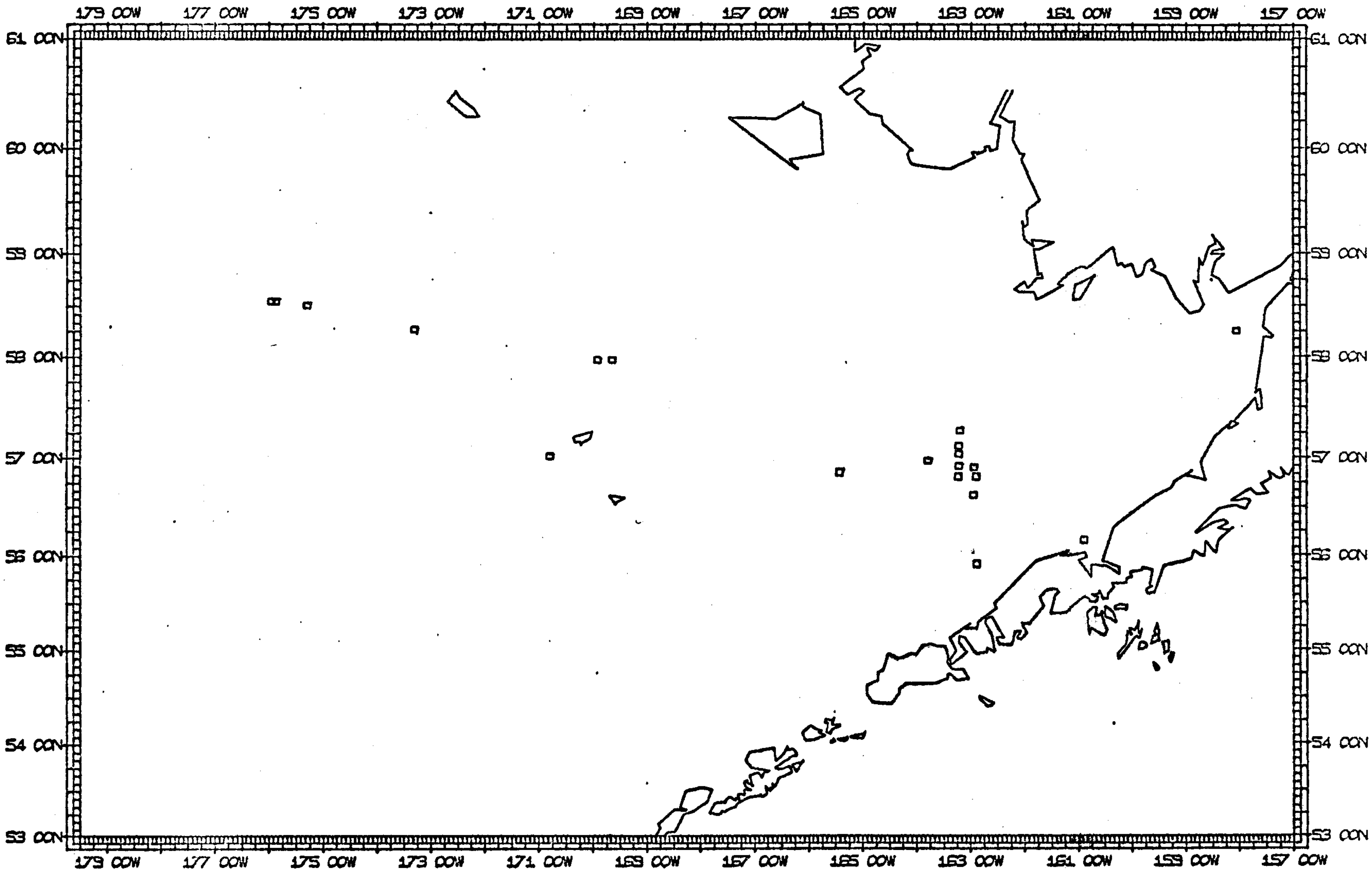

Fig. 3. Combined sightings of all ringed seals observed during surveys within the area shown in Fig. 2. Computer map courtesy of H. Braham and B. Krogman, NMFS, Seattle.

2. Specimen collections

A total of 114 bearded seals were examined during this report period. Eight were obtained between March and June, 99 between July and September, 2 between October and December and 5 between January and March. Examination of stomachs obtained prior to January and containing food has been completed and reported elsewhere (RU#232). Body measurements and other information recorded on field data forms have been coded and, except for seals collected since January, these data have been submitted to NODC. To date, no analyses have been made.

It was anticipated that the required laboratory analyses of reproductive tracts would be completed for inclusion in this report. However, due to other commitments, including the Beaufort Sea Synthesis Meeting and associated reports, this aspect of the work has not yet been accomplished.

Age determination of all bearded seals obtained during this report period has not been completed, but will be in the near future.

E. Ringed seals

1. Distribution and taxonomy

The ringed seal has a widespread northern, circumpolar distribution. Ringed seals have been recorded from the North Pole southward, in ice covered seas, to Finland, northern Iceland, southern Greenland, Labrador, Hudson Bay, southern Bering Sea, Sea of Okhotsk and northern Hokkaido. There are isolated ringed seal populations in the Gulfs of Bothnia and Finland, Lake Ladoga (USSR), Lake Saimaa (Finland) and in at least one lake on Baffin Island (Canada). Stragglers have been recorded in France, Scotland, southern Japan and at San Diego, California. In Alaska, ringed seals inhabit the Bering, Chukchi and Beaufort Seas, and have been found in the Pribilof and Aleutian Islands.

Seven subspecies have been proposed for the ringed seal (Table 3) (Scheffer 1958, Muller-Wille 1969). However, the ringed seal is a highly variable species and the subspecies are difficult to separate without examining a large number of specimens. Muller-Wille (1969) investigated the relationships of *P. h. botnica*, *P. h. ladogensis*, *P. h. saimensis* and *P. h. pomororum*. These four subspecies were found to overlap in many traits but Muller-Wille concluded that they were significantly different enough to be classified as subspecies. The differences are attributed to the isolation of these populations for 8,000 to 12,000 years. The relationship between *P. h. pomororum* and *P. h. hispida* is unclear.

The populations and taxonomic relationships between *P. h. hispida*, *P. h. krascheninikovi* and *P. h. ochotensis* are presently

Table 3. Distribution of currently accepted subspecies of the ringed seal.

Subspecies	Distribution
Phoca hispida hispida	Arctic Ocean, northern Eurasia, Greenland, northern North America and southward to Hudson and James Bays and Labrador
Phoca hispida krascheninikovi	Bering Straits southward throughout the Bering Sea and Bristol Bay to the southern Kuril Islands
Phoca hispida ochotensis	Sea of Okhotsk, northern Kuril Islands and south to Hokkaido
Phoca hispida botnica	Baltic Sea, Gulf of Bothnia and Gulf of Finland
Phoca hispida ladogensis	Lake Ladoga
Phoca hispida saimensis	Lake Saimaa and its series of interconnected lakes
Phoca hispida pomororum	White Sea and the coasts of the Kola Peninsula and Novaya Zemlya

under investigation by Soviet and American biologists. *P. h. ochotensis* appears to be a valid subspecies. The status of *P. h. krascheninikovi* is unclear. Based on our observations, ringed seals move widely and Bering Strait is not a barrier. There is a net movement of ringed seals southward through the Strait in the fall with the formation of sea ice and conversely a net northward movement in the spring with breakup.

The Soviets have examined large numbers of ringed seal specimens from the Bering and Chukchi Seas and are finding that there are two morphos (which may be subspecies) of ringed seals. A larger morph is found in the shorefast ice and a smaller morph in the drifting ice. However, not enough is known about the ecology and behavior of ringed seals to ascertain the relationships between the drifting and shorefast ice seals. Based on specimen material and collecting programs, there appears to be age-specific, seasonal movements of seals between shorefast and drifting ice. In our future work we hope to delineate these movement patterns more clearly.

The Caspian seal (*Phoca caspica*) and the Baikal seal (*Phoca sibirica*), both found in landlocked water bodies (Caspian Sea and Lake Baikal), evolved from the ringed seal but are presently considered separate species.

2. Pelage

The color of ringed seals is quite variable, but the basic pattern is a gray back with black spots and a light belly. These black spots are ringed with light marks from which comes the seal's name. Several specimens have been examined which have the ringed pattern on back and belly and one adult specimen was observed to have the light coloration on both back and belly.

Pups are born with a white lanugo. The lanugo is shed when the pup is two to six weeks old. The first year pelage is quite variable but it is generally light in coloration with faint spots and rings.

Ringed seals molt annually. During the period of molt they haul out on the sea ice on "warm," sunny days. Hauling out during the molt appears to be an important adaptation to the arctic environment. Skin temperatures of ringed seals during immersion are generally within 30°C of water temperatures (which may be 2°C); upon hauling out the skin temperature may increase to 20°C or more. Epidermal cells of phocid seals in *in vitro* cultures were found to survive for six months at 4°C but required temperatures of at least 17° to 19°C for growth. The most rapid growth was at 37°C (Feltz and Fay 1966). Sleep or inactivity also may be a requirement for mitosis (Bullough 1962, Bullough and Rytomaa 1965). Therefore, growth and reparative functions of ringed seal skin may only be possible when the animal is hauled out and/or at rest.

The molt appears to begin in mid-May in the Bering Sea-Norton Sound and progressively later as one goes farther north; in Alaska the peak is in mid-June. Two adult ringed seals (BP-11-76, BP-12-76) collected at Barrow, Alaska in early August were just completing their molt.

3. Dentition

The dental formula of phocid seals varies according to the subfamily:

	Incisors	Canines	Postcanines	
Phocinae	$\frac{1-2-3}{0-2-3}$	$\frac{1}{1}$	$\frac{1-2-3-4-5-(6)-0}{1-2-3-4-5-0-0}$	= 34-36
Monachinae	$\frac{0-2-3}{0-2-3}$	$\frac{1}{1}$	$\frac{1-2-3-4-5-(6)-0}{1-2-3-4-5-0-0}$	= 32-34
Cystophorinae	$\frac{0-2-3}{0-0-3}$	$\frac{1}{1}$	$\frac{1-2-3-4-(5)-(6)-0}{1-2-3-4-(5)-(6)-0}$	= 26-34

The ringed seal follows the Phocinae pattern and typically has 34 teeth (lacks upper postcanine 6). Dental anomalies are not uncommon and those that we have found include:

a. Upper postcanine number 6 present
b. Upper postcanine numbers 4, 5 and/or 6 absent (never found)
c. Lower incisor number 1 present
d. Lower incisor number 3 absent
e. Supernumary lower incisor number 3
f. Supernumary lower canine

The incisors, canines and first postcanines are single rooted, while postcanines (upper and lower) 25 are double rooted. One postcanine number 5 had 3 roots. The relative size of postcanines in descending order is 3-4-2-5-1. The postcanines are reticulated and are offset such that when the jaws are closed a net-like structure is formed, which is presumably used to assist in the retention of smaller invertebrates from the seawaters.

Five early and mid-term fetuses (NP-14-76, STP-1-76, BS-11-70, BS-14-70, BS-15-70) had the deciduous dental formula:

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

A mid-February fetus (N-2a-71) had a complete set of permanent teeth but they were not erupted. At birth, ringed seals have a complete set of fully erupted, permanent teeth.

Several cases of dental disease have been noted during examination of specimens. Two ringed seals were found to have caries in their second postcanines. The caries were situated in the pit of a tooth reticulation. One seal from Nome had grooves in the enamel of all teeth and the grooves resembled those of hypoplasia. Hypoplasia is a deficient formation of enamel due to injury or dysfunction of the ameloblasts (enamel-forming cells) during enamel formation.

Erosion of the teeth at the gingivolabial and buccal level has been noted in 30 ringed seals. The lesion is characterized by a smooth, highly polished notch in the tooth surface with no evidence of caries. Erosion appears to originate in the canine-postcanine 1 region and spreads anteriorly and posteriorly. The lesion appears to become progressively worse and ultimately the tooth erodes to a thin level and breaks. The etiologic factors responsible for this condition are unknown. In humans, erosion is caused by acid secretions from the labial or buccal glands and it is found in nervous individuals who are chronic worriers (Massler et al. 1958).

Another form of tooth wear, noted in several seals, appears to be a mechanical wearing away of the cusps. The cusps become flattened and the tooth takes on a peg shape. The abrasive action of invertebrate exoskeletons has been postulated as the etiologic factor.

4. Growth rates and productivity

Ringed seals are the smallest of all pinnipeds, with the largest adult female recorded for Alaska being 155 cm in length and the longest male 146 cm. The heaviest ringed seals examined thus far in this research 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.

Fetal and pup development

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.

Female ringed seals appear to be impregnated in mid- to late April, soon after the birth of the pup. Impregnation is followed by a delay of up to 3-1/2 months before implantation, approximately in August. Additional seal specimens are required from August and

September to demonstrate the precise period of implantation and to determine early fetal growth rates.

Thus far, 50 ringed seal fetuses (27 males and 23 females) have been examined and measured, yielding a fetal sex ratio of 1:1 ($P>0.01$). The fetal growth curve for length (Fig. 4) closely resembles that of ringed seals in Canada (McLaren 1958). The growth curve for weight (Fig. 5) is similar to those for most mammals. The relative growth of length and weight (L/M) (Fig. 6) is most rapid just after implantation, in August and September, with relative growth rates leveling off in late pregnancy. No differences between the growth rates of males and females were detected ($P>0.05$).

Pup growth rates

Weights of 55 ringed seal pups (21 males, 33 females and 1 sex unknown) have been obtained thus far, yielding a pup sex ratio of 1:1 ($P>0.05$). Ringed seal pups weigh about 4.0 kg at birth. A live pup two or three days old weighed 5.0 kg while the mean weight of eight full-term fetuses was 3.4 kg.

Pup weights increase steadily from birth until weaning in late May or early June (Fig. 7). 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, there is more variation in the weights of males than in the weights 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 ($P>0.05$ cm).

The lengths of pups increased steadily from birth and appeared to begin leveling out in August and September (Fig. 8). A significant decrease in length immediately after weaning was not noted. The mean lengths of males and females did not differ ($P>0.05$) and the variation in lengths was approximately equal in the two sexes.

Reproduction

The epididymides of 275 male ringed seals (representing all age classes and collected during all months) have been examined for the presence of sperm. Active spermatogenesis has been detected in essentially all males seven years old and older which were collected

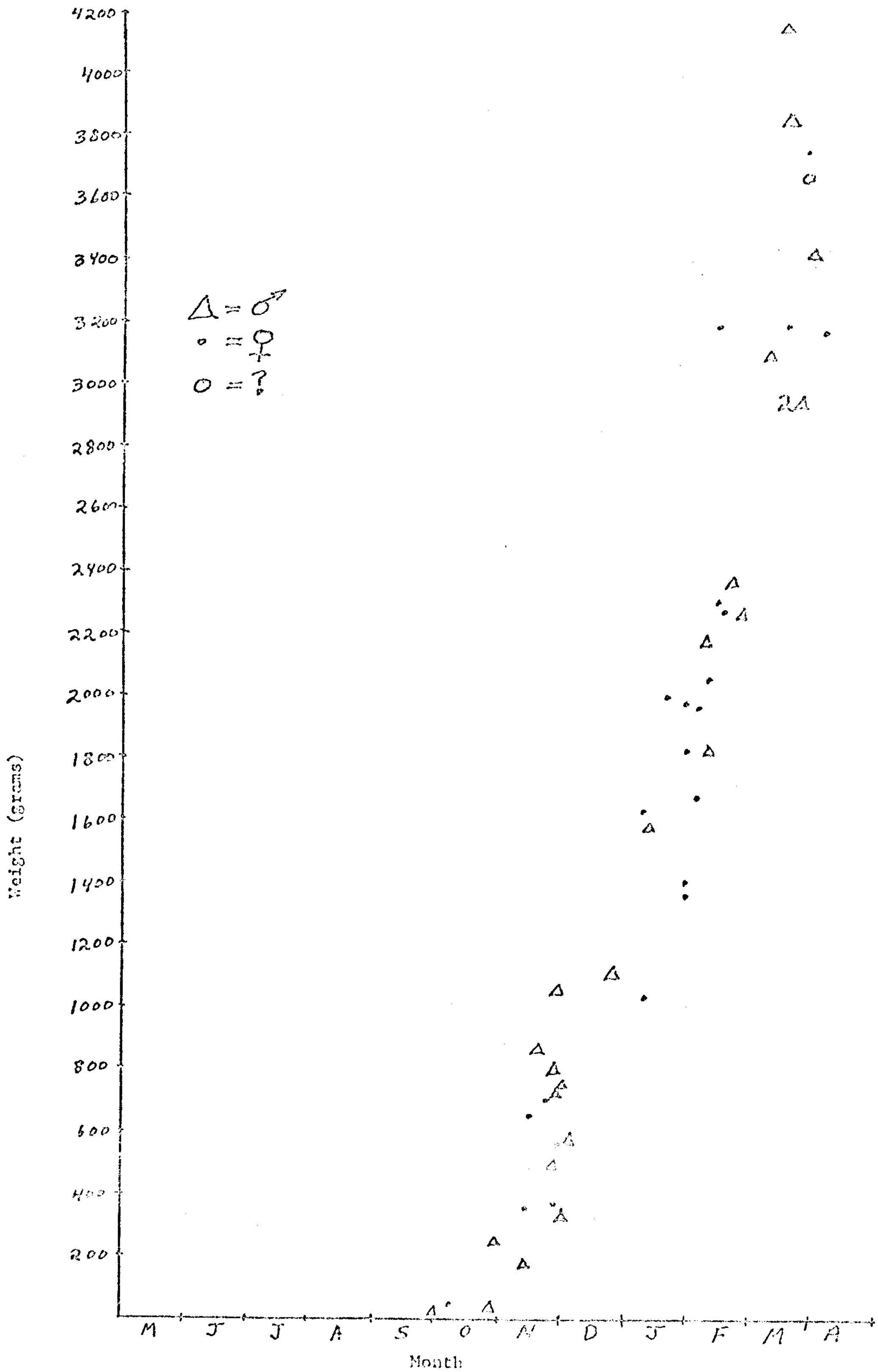

Figure 5. Fetal growth, weight in relation to month of collection.

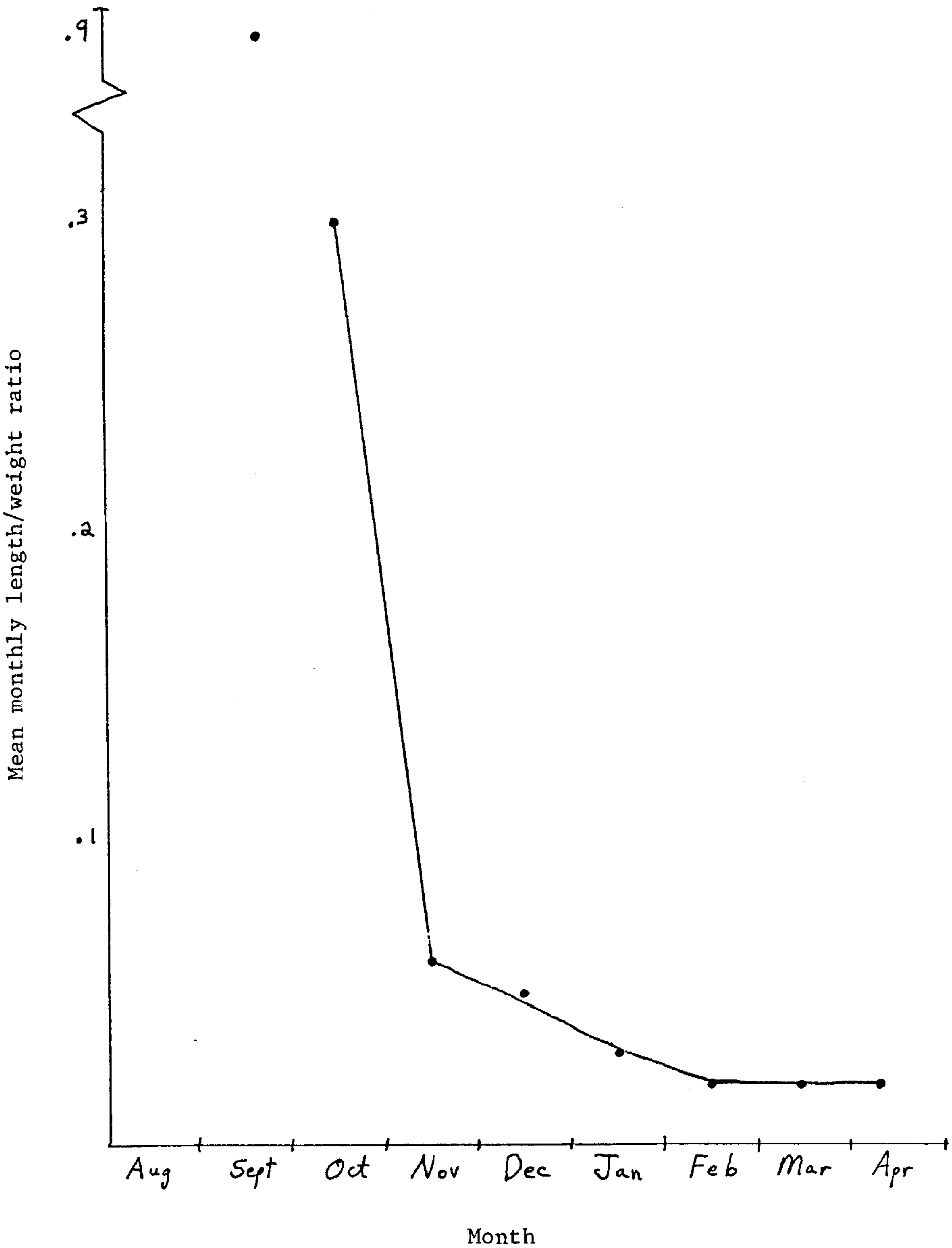

Figure 6. Fetal growth, length in relation to weight.

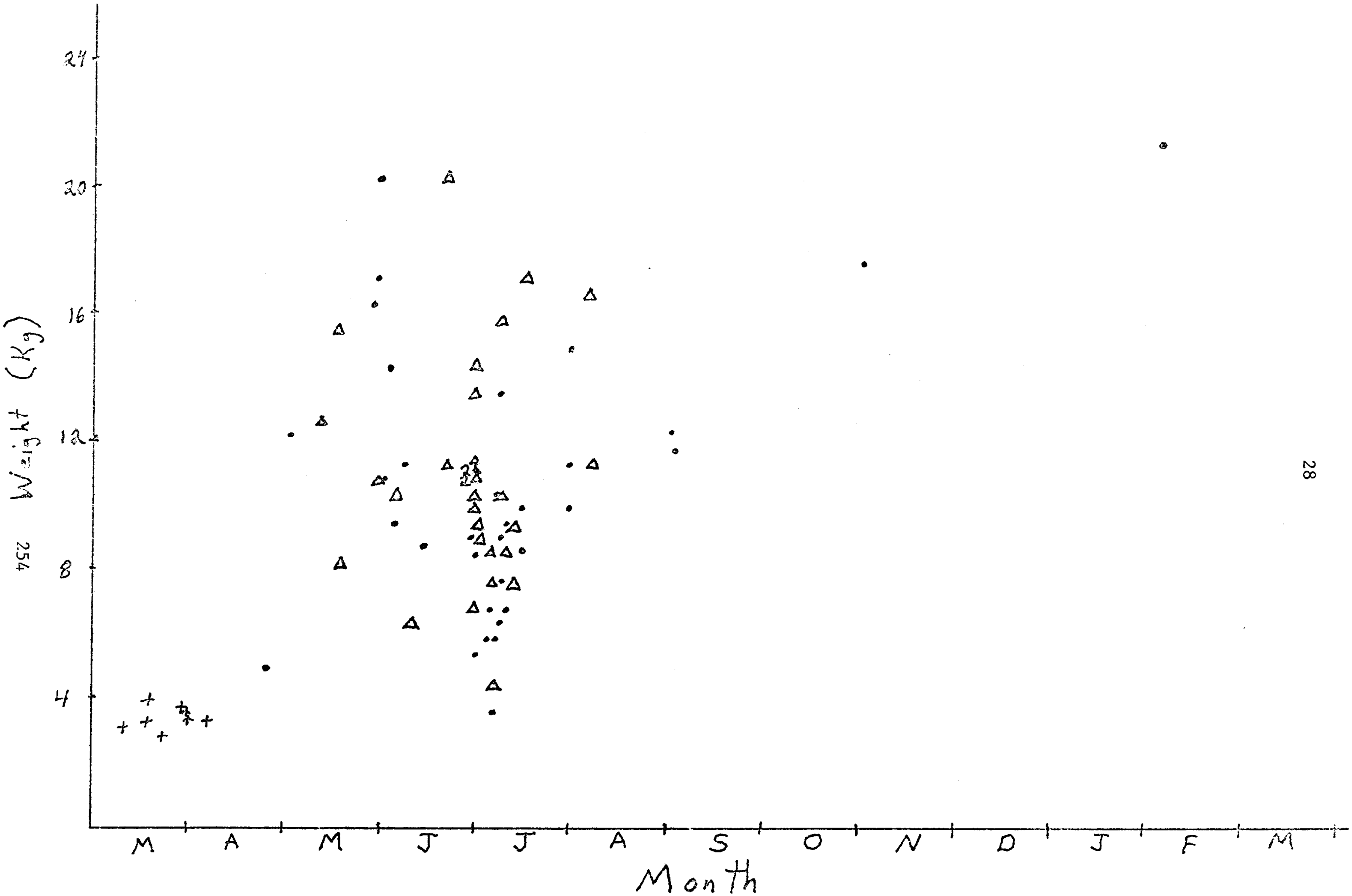

Figure 7. Pup growth, weight in relation to month of collection.

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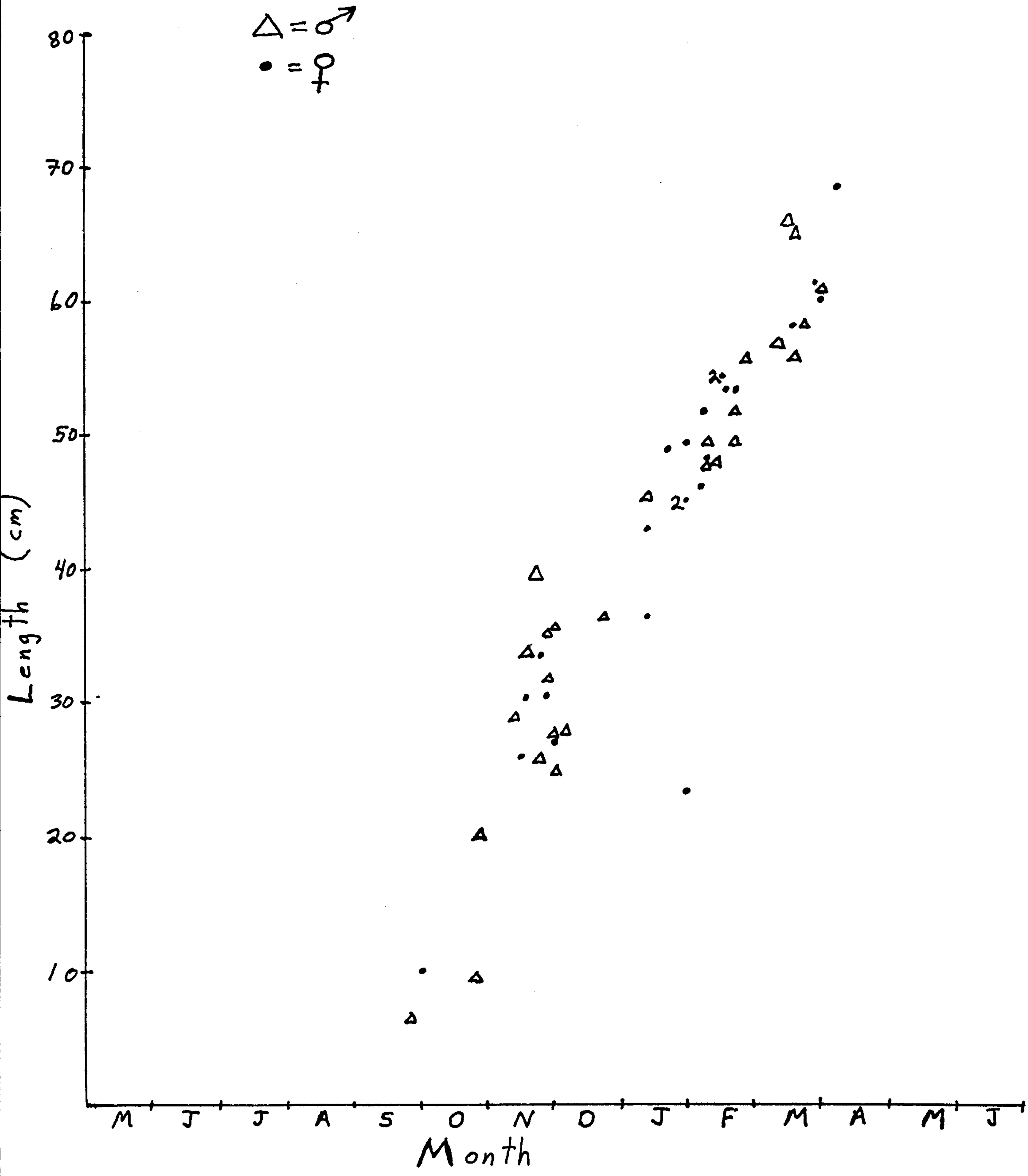

Figure 4. Fetal growth, length in relation to month of collection.

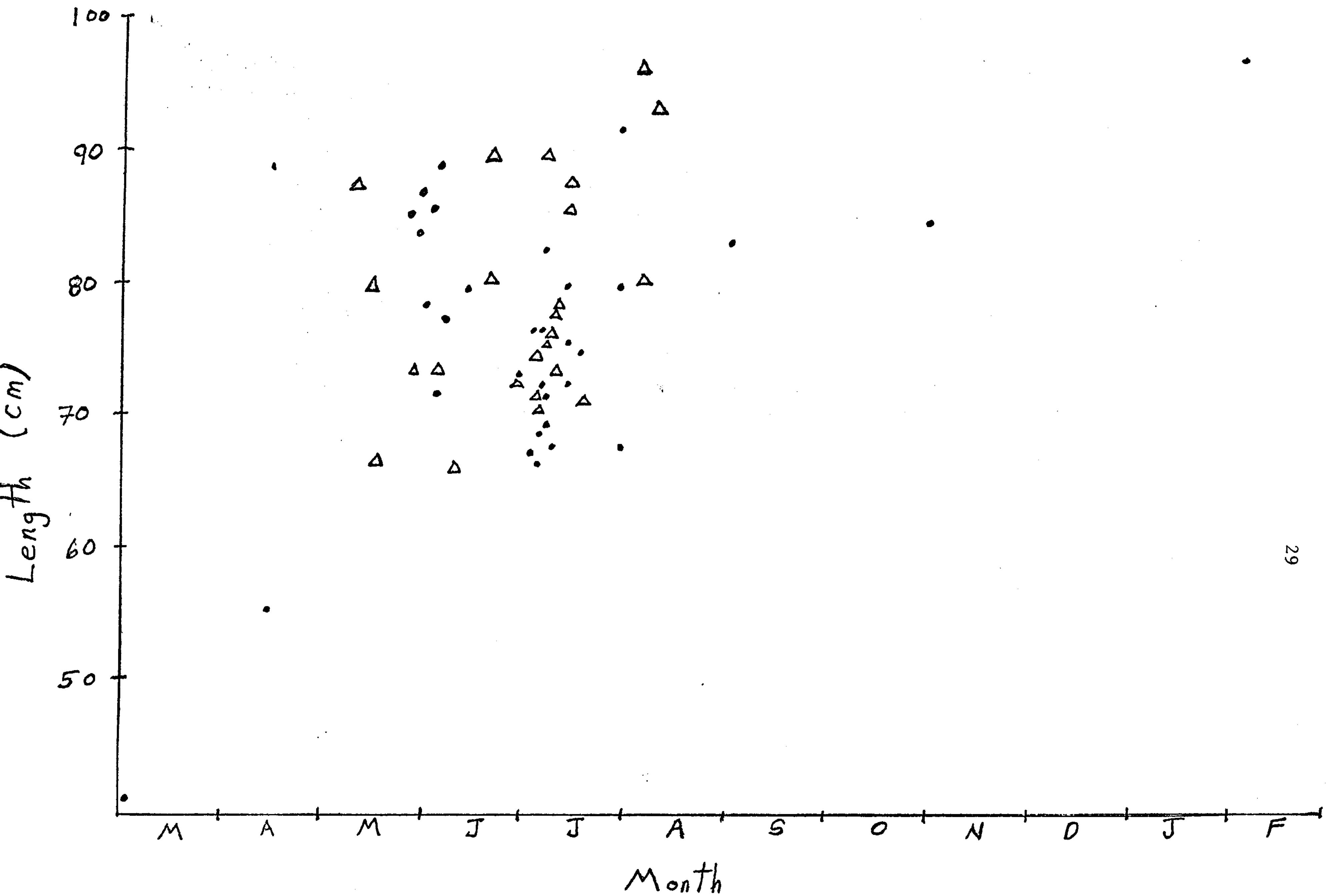

Figure 8. Pup growth, length in relation to month of collection.

during the months of March, April, May and June (Table 4). Two of five (40%) of seven-years-old plus males had abundant sperm during January, as did two of three (67%) males taken in February. Of 14 males examined during December, 1 nine-year-old had abundant sperm in his epididymides while 1 eleven-year-old had a trace of sperm. Eight of 15 (53%) six-year-old males collected between March and May had abundant sperm in their epididymides. One five-year-old male taken in May had a trace of sperm in its epididymides. No geographic variation in spermatogenic activity has been detected thus far, however our sample size from the Beaufort Sea is small.

The earliest date that sperm was found in male epididymides was mid-December and active spermatogenesis appears to continue until mid-June. 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. Similarly, a longer season of potential breeding capability has been found in male grey seal (Halichoerus gypus) (Ling 1969).

The ovaries of 143 female ringed seals have been examined thus far. Sexual maturity in the female is determined by the presence of a corpus luteum of ovulation and recent corpus albicans indicates an ovulation during the previous age-year. Older than previous age-year corpus albicans and corpus albicans of pregnancy also are discernible.

The examination of 53 females in the age classes pup to two years old failed to find any evidence of ovulations. Two (25%) three-year-old females, 1 (17%) four-year-old and 8 (57%) females had ovulated for the first time and apparently had not conceived. Twelve of 17 (71%) six-year-old females had ovulated during the age-year of collection but none had conceived. Seven of the 12 (58%) recently ovulated six-year-olds had ovulated the previous age-year, as evidenced by the presence of a corpus albicana. In addition, three of five (60%) of the non-recently ovulated six-year-old females supported corpus albican but no recent corpus luteum. One six-year-old female supported a corpora albicans and was pregnant. Of the 44 females seven-years-old and older, all 44 (100%) had apparently ovulated at least twice. A female 14 years old had cysts on both uterine horns. The cysts caused complete obstruction of the uterine horns and both ovaries had begun to atrophy. A 21-year-old female showed no follicular activity, whereas a 22-year-old female had ovulated but it could not be determined whether she had conceived. Three females (23, 25 and 29 years old) were pregnant and they appeared to have given birth during the previous year.

Recent pregnancies are determined either by the presence of a fetus in the uterus or by the presence of a corpus luteum or corpus albicans of pregnancy in an ovary. From 1964 to 1973, 33 adult female ringed seals were examined and 30 were or just had been

Table 4. Seasonal variation in sperm presence in the epididymides of male ringed seals seven years old and older.

Month	Number Examined	Sperm Presence: Abundant (Number)	Sperm Presence: Trace (Number)	Sperm Presence: None (Number)
January	5	2	-	3
February	3	2	-	1
March	17	17	-	-
April	15	15	-	-
May	24	23	-	1
June	36	21	5	10
July	21	1	1	19
August	5	-	2	3
September	1	-	-	1
October	2	-	-	2
November	1	-	-	11
December	14	1	1	12

pregnant, yielding a pregnancy rate of 91 percent. The reproductive tracts of 42 adult females, collected during 1975 to 1977, have been examined thus far and 26 (62%) were or just had been pregnant. Johnson et al. (1966) found 240 of 280 (86%) adult females (collected near Cape Thompson, Alaska during 1960 and 1961) 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). However, the magnitude of the decline in pregnancy rates in Canadian ringed seals is significantly greater (Stirling et al. 1975); in 1972 a pregnancy rate of 59 percent was found and in 1974 and 1975 a 0 percent and 11 percent pregnancy rate was found, respectively. The reason for the decline of pregnancy rates of female ringed seals in Alaska waters is unknown and it is presently under investigation. It may be that ringed seal populations, due to decreased hunting pressure and possible immigration of seals from Canadian waters, are reaching carrying capacities and that there is a concomitant decrease in productivity as the seals reach this level as seen in other animal populations. The Canadians attribute their decrease in productivity to poor ice conditions for ringed seals and emigration of some seals. However, their data are still speculative and they are also trying to determine the causative factors.

5. Polar bear predation on seals

From March 1976 to March 1977, 25 seals killed by polar bears were examined (Table 5). Ringed seals comprised 96 percent (24) of the seals killed and one bearded seal made up the remaining 4 percent. Four cases of bears feeding in garbage dumps near human habitation were noted and numerous observations were made of bears feeding on carrion, particularly on whale carcasses north of Barrow and on the beaches of St. Lawrence Island.

Of the 24 ringed seals examined, 14 (58%) were male and 10 (42%) were of undetermined sex. Thirteen (54%) of the ringed seals were adults (greater than six years old; had achieved sexual maturity); 2 (8%) of the seals were subadults (older than pups yet less than 6 years old); and 9 (39%) of the seals were of undetermined age, although tenuous evidence from the kill sites indicated that these seals were probably adults or older subadults. The single bearded seal comprised the only pup and the only identified female in the sample.

At Cape Lisburne, polar bears were tracked for 3,105 bear-kilometers, along which 20 seal carcasses were found. Bears killed, on the average, one seal every 155.2 kilometers at Cape Lisburne during March and April.

After killing a seal, a polar bear feeds predominantly on the hide and blubber and the meat is generally abandoned. In all seal specimens examined, all hide and blubber was consumed, except for that on the head. However, Stirling (1974) found that a large part of the blubber was often not consumed. The hide and blubber of

Table 5. Seal examined during 1976 that were killed by polar bears.

Location	Specimen Number	Species	Sex	Age (Years)	Ice Type	Kill Site	Date
Cape Lisburne	CLP-1-76	Ringed Seal	Male	10+	Flaw Zone	Breathing Hole	3/24/76
Cape Lisburne	CLP-2-76	Ringed Seal	Male	9+	Flaw Zone	Breathing Hole	3/24/76
Cape Lisburne	CLP-3-76	Ringed Seal	Male	3	Flaw Zone	Breathing Hole	3/25/76
Cape Lisburne	CLP-4-76	Ringed Seal	Male	11+	Flaw Zone	Breathing Hole	3/25/76
Cape Lisburne	CLP-5-76	Ringed Seal	Male	11	Flaw Zone	Breathing Hole	3/27/76
Cape Lisburne	CLP-6-76	Ringed Seal	Male	8	Shorefast Ice	Breathing Hole	3/31/76
Cape Lisburne	CLP-7-76	Ringed Seal	Male	10+	Flaw Zone	Breathing Hole	4/1/76
Cape Lisburne	CLP-8-76	Ringed Seal	Male	8+	Flaw Zone	Breathing Hole	4/1/76
Cape Lisburne	CLP-9-76	Ringed Seal	Unknown	Unknown	Moving Pack	Breathing Hole	4/7/76
Cape Lisburne	CLP-10-76	Ringed Seal	Unknown	Unknown	Flaw Zone	Breathing Hole	4/10/76
Cape Lisburne	CLP-11-76	Ringed Seal	Male	9	Flaw Zone	Breathing Hole	4/10/76
Cape Lisburne	CLP-12-76	Ringed Seal	Unknown	Unknown	Moving Pack	Lair	4/15/76
Cape Lisburne	CLP-13-76	Ringed Seal	Male	10	Shorefast Ice	Lair	4/16/76
Cape Lisburne	CLE-14-76	Bearded Seal	Female	Pup	Flaw Zone	Breathing Hole	4/16/76
Cape Lisburne	CLP-15-76	Ringed Seal	Unknown	Unknown	Shorefast Ice	Breathing Hole	4/16/76
Cape Lisburne	CLP-16-76	Ringed Seal	Unknown	Unknown	Moving Pack	Breathing Hole	4/16/76
Cape Lisburne	CLP-17-76	Ringed Seal	Unknown	Unknown	Flaw Zone	Breathing Hole	4/17/76
Cape Lisburne	CLP-18-76	Ringed Seal	Unknown	Unknown	Shorefast Ice	Lair	4/17/76
Cape Lisburne	CLP-19-76	Ringed Seal	Male	6	Flaw Zone	Breathing Hole	4/17/76
Cape Lisburne	CLP-20-76	Ringed Seal	Male	7	Flaw Zone	Breathing Hole	4/17/76
Barrow	BP-8-76	Ringed Seal	Male	8+	Flaw Zone	Breathing Hole	3/23/76
Barrow	BP-9-76	Ringed Seal	Male	Unknown	Moving Pack	Breathing Hole	3/25/76
Barrow	BP-10-76	Ringed Seal	Unknown	4	Moving Pack	Breathing Hole	4/22/76
Barrow	BP-14-76	Ringed Seal	Unknown	Unknown	Moving Pack	Breathing Hole	4/22/76
Barter Island	BIP-6-76	Ringed Seal	Unknown	12	Shorefast Ice	Breathing Hole	7/27/76

seals have the highest caloric value of any part of the seal (Stirling and McEwan 1975). The abandoned seal meat is consumed by other bears or more often by arctic foxes which follow polar bears for long distances (100 km+) over the ice.

When two adult bears are at a kill, the larger bear consumes the hide and blubber while the smaller bear is left with the meat. The division of a seal between a sow and her cubs has not been ascertained at this time, but in five observations of a sow and cubs feeding on kills the entire kill was consumed. Two of 20 (10%) kills examined at Cape Lisburne during March and April were found cached by bears apparently for later use. The unconsumed seals were buried under about one meter of snow near the kill site and the bears (a male, and a sow and her two, one-year-old cubs) were found within 1-1.5 km of the cached seals. Stirling and McEwan (1975) found that polar bears in the eastern Canadian Arctic generally did not cache seals for later consumption.

Approximately 35 flight hours of surveys were conducted in each of the three major ice types (shorefast ice, flaw zone and pack ice). Fourteen (56%) of the seals were killed on flaw zone ice, six (24%) on heavy, moving pack ice, and five (20%) on shorefast ice.

Most seals (88%) were killed by bears waiting at seal breathing holes. Bears were relatively unsuccessful in obtaining ringed seals from lairs as only 3 seals were killed in 32 lairs (9%) excavated by bears. Eighteen lairs were excavated on shorefast ice and 14 lairs on moving pack ice. No excavated lairs were noted in the flaw zone. The densities of lairs in the various ice types were unknown, however, the preferred habitat of the ringed seal is the shorefast ice. No observations or evidence were noted of bears stalking seals hauled out on the ice.

6. Sex and age composition

The fetal, pup and older-than-pup sex ratio of ringed seals obtained in this study does not depart significantly from unity (1:1). A 1:1 sex ratio also has been found by other ringed seal investigators (McLaren 1958; Johnson et al. 1966; and Smith 1973).

The age composition of ringed seal specimens obtained during 1975 and 1976, for which ages could be determined, are presented in Table 6. This age composition generally conforms to that of Smith (1973) except that Smith has a far greater proportion of pups in his sample. The sample obtained by Smith was collected from July through October when pups may be more available or at least more vulnerable. Table 7 compares the age composition of our samples from Shishmaref, Wainwright and Barrow, taken during the period July through October. When analyzed on a comparable time frame we find no significant difference between the age composition of our sample and that of Smith (1973).

Table 6. Sex and age composition of ringed seal specimens obtained during 1975 and 1976.

Age (years)	Males	Females	Sex Unknown	Total
pup	19	19	-	38
1	10	11	-	21
2	4	6	-	10
3	11	9	-	20
4	16	10	-	26
5	13	14	2	29
6	24	11	-	35
7	14	10	1	35
8	19	15	-	34
9	10	6	1	17
10	15	3	-	18
11	16	7	-	23
12	3	2	1	6
13	5	2	-	7
14	4	3	-	7
15	4	4	-	8
16	3	1	-	4
17	1	6	-	7
18	1	2	-	3
19	1	3	-	3
20	-	1	-	1
21	-	1	1	2
22	1	1	-	2
23	2	1	-	3
24	-	-	-	-
25	1	1	-	2
26	-	-	-	-
27	-	-	-	-
28	-	-	-	-
29	1	1	-	2
unknown	2	2	10	14

Table 7. Age composition of ringed seals collected during the period July-October.

Age (years)	This Study Number	This Study Percent	Smith 1973 Number	Smith 1973 Percent
pup	40	22	235	21
1	10	6	121	11
2	3	2	106	9
3	8	5	94	8
4	11	6	83	7
5	14	8	73	6
6	15	8	64	6
7	13	7	47	4
8	15	8	50	4
9+	52	29	271	24

7. Literature review

Approximately 635 literature citations 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 because OASIS searches did not extend back past 1972 for Biological Abstracts and 1964 for Oceanic Abstracts and Governmental Report Announcements. In addition, Zoological Record, the best leterature citation source for marine mammals, is not searched by OASIS. OASIS search updates have been timely in providing references to recent publications.

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.

8. Densities of ringed seals

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 ecosystem, 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 (1972), 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 and 1976, 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. The results of these surveys are presented in Table 8. The areas of highest mean densities (Cape Krusenstern-Point Hope; Cape Lisburne-Point Lay; Wainwright-Barrow; Barrow-Lonely) 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).

Table 8. Ringed seal densities (observed seals/mi^2) calculated from 1970, 1975 and 1976 surveys.

Location	1970	1975	1976
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
Wainwright - Barrow	3.7	6.2	3.8
Barrow - Lonely	2.3	2.8	1.4
Lonely - Oliktok	1.0	1.4	1.1
Oliktok - Flaxman Island	1.4	1.0	1.4
Flaxman Island - Barter Island	2.4	1.8	0.4
Chukchi Sea - moving pack ice	-	-	0.2
Beaufort Sea - moving pack ice	-	-	0.1

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 Seas.

In June, 23 transects totaling 689 square miles and 3 transects totaling 29 square miles were flown, respectively, over Kotzebue Sound and Hotham Inlet (Fig. 9). In Kotzebue Sound 504 ringed seals were observed, yielding an ecological density of 0.73 ringed seals per square mile of available habitat. In addition, one bearded seal and two spotted seals (Phoca vitulina largha) were observed in Kotzebue Sound. No seals were seen in Hotham Inlet.

The ecological density of ringed seals varied from 0.92 seals per square mile at the mouth of the Sound to 0.26 seals per square mile in the eastern portion of the Sound. The higher density of seals at the mouth was due to more stable ice conditions in this area. In the eastern portion of the Sound and in Hotham Inlet the ice had begun to break up due to warm weather and the influx of warm water from the Noatak, Kugruk, Kiwalik, Buckland, Selawik and Kobuk Rivers.

The ice cover in Kotzebue Sound was estimated to be 2,715 square miles and from the transects an ecological density of 0.73 seals per square mile was determined. Therefore, the estimated molting population of ringed seals is about 2,000 animals.

The density of molting ringed seals in the moving pack ice is known to be less than the shorefast. This year transects were flown over the pack ice of Chuckhi and Beaufort Seas to provide comparative data for our shorefast ice surveys. The data from these pack ice transects are still under analyses but the tentative findings are summarized at the bottom of Table 8.

It is obvious that densities of molting ringed seals are considerably less in the moving pack ice than in the shorefast ice. As was found in the shorefast ice, densities of ringed seals in the Chukchi Sea are 2 to 2.5 times higher than in the Beaufort Sea.

The total areas of fast ice, flaw zone ice and moving pack ice present during the 1975 and 1976 surveys are being calculated at this time from ERTS imagery. The total area of each ice type in each sector and the mean seal density for each type in a sector will give a minimum estimate of the ringed seal population in each sector. However, this estimate will only reflect the seals on the ice. Not enough is known of ringed seal behavior to correct for animals in the water or otherwise not seen.

The data from the 1970, 1975 and 1976 survey will be combined with data for surveys flown during 1977 and a detailed "population" analysis will be presented in our September 1977 Quarterly Report.

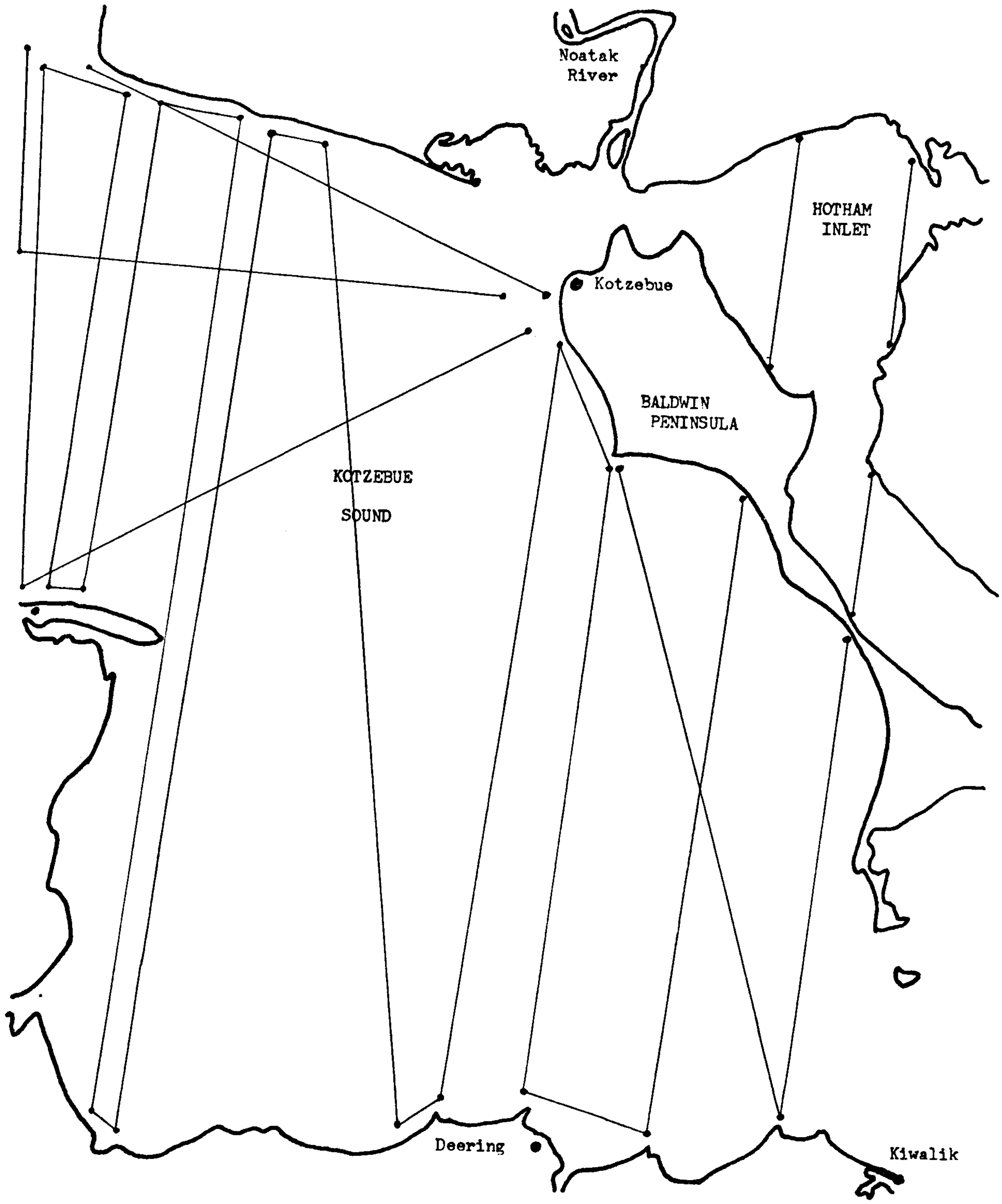

Figure 9. Seal survey tracks, Kotzebue Sound and Hotham Inlet, June, 1976.

F. Pathology and Parasitology

A considerable amount of material for pathological and parasitological examinations has been collected by this project. The bulk of this material has been provided to Dr. F. H. Fay and R. A. Dieterich and Mr. L. M. Shults (RU#194 - Morbidity and Mortality of Marine Mammals) for examinations and analyses. Within the limits of available time and funding, some material has been examined by ADF&G parasitologist Carol Nielsen. Her reports have been presented as Appendix IV to OCS Quarterly Report of RU#230, dated 30 September 1976.

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* (Leidy 1858) Anderson 1959. Examinations are still underway but findings thus far are presented in Table 9. The pathological and resultant physiological, behavioral and ecological effects of marine mammal heartworms is presently under investigation.

VIII. Conclusions - Ringed Seal

Ringed 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 1977. Most of our sampling 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. Proposed OCS lease areas in the Bering, Chukchi and Beaufort Seas are within the habitat of the ringed seal and pose a real threat to this species. 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. Three subspecies of ringed seals (*P. h. hispida*, *P. h. ochotensis*, and *P. h. kraschenínikovi*) may be found in Alaskan waters; however, the taxonomic relationship between these subspecies is unclear.

2. The color of ringed seals is quite variable, but the basic pattern is a gray back with black spots ringed with light marks and a light belly.

Table 9. Examinations for marine mammal heartworms (Dipetalonema (Acanthocheilonema) spirocauda).

Species	Location	Number Examined	Number Positive	Number Positive
Phoca vitulina richardii	Kodiak Island	18	4	22.2
Phoca vitulina richardii	Nanvek Bay	2	0	0
Phoca vitulina richardii	Southern Bering Sea	2	0	0
Phoca vitulina largha	Southern Bering Sea	13	0	0
Phoca vitulina largha	Shishmaref	8	2	25.0
Phoca hispida	Bering Sea	142	2	1.4
Phoca hispida	Chukchi Sea	65	1	1.5
Phoca hispida	Beaufort Sea	6	0	0
Phoca fasciata	Bering Sea	9	1	11.1
Erignathus barbatus	Bering Sea	4	0	0
Erignathus barbatus	Chukchi Sea	4	1	25.0
Odobenus rosmarus	Bering Sea	27	0	0
Odobenus rosmarus	Chukchi Sea	8	0	0
Odobenus rosmarus	Beaufort Sea	1	0	0
Eumetopias jubatus	Gulf of Alaska	21	0	0
Eumetopias jubatus	Southern Bering Sea	4	0	0
Phocoena phocoena	Gulf of Alaska	1	0	0

3. Ringed seals typically have 34 teeth and follow the Phocinae pattern. Several forms of dental disease have been noted.

4. 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.

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

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

7. Active spermatogensis 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 spermatogensis.

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

9. All females 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 from 1975 to 1977.

10. In Alaskan water, polar bears feed primarily on adult, male ringed seals and the bears kill one ringed seal about every 150 kilometers traveled during the spring. The hide and blubber are the preferred part of the seal by bears.

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 635 citations pertaining to ringed seals has been recovered. Few citations pertain specifically to ringed seals in Alaskan waters.

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 habitats 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.

X. Summary of Fourth Quarter Operations

A. Field and Laboratory Activities

1. Schedule

Date	Location	Purpose
Jan.-Mar. 1977	Fairbanks	Routine laboratory and data analyses and management
January 1977	Anchorage	Met with other OCS marine mammal investigators
January 1977	Nome	Collection of specimens
February 1977	Barrow	Beaufort Sea Synthesis Meeting and collection of specimens
February 1977	Wainwright	Arranged for collection of specimens
February 1977	Point Lay	Arranged for collection of specimens
Feb.-Mar. 1977	Fairbanks	Preparation of Annual and Fourth Quarter Report
March 1977	Nome-Norton Sound	Collection of specimens and seal habitat surveys
March 1977	Kotzebue-Kotzebue Sound	Collection of specimens and seal habitat surveys
March 1977	Barrow	Collection of specimens and seal habitat surveys
March 1977	OSS SURVEYOR cruise	Collection of specimens and seal habitat surveys

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
Lloyd F. Lowry	ADF&G	Principal Investigator RU#232

Kathy J. Frost	ADF&G	Principal Investigator RU#232
Harry V. Reynolds	ADF&G	Game Biologist
Edward Muktoyuk	ADF&G	Marine Mammals Technician
Glenn Seaman	ADF&G	Marine Mammals Technician

3. Methods

From all specimens we endeavor to obtain weights, standard measurements, lower jaws, foreflipper 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 examination 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.

Regional differences in seal density and distribution were assessed through aerial surveys following the methods of Burns and Harbo (1972).

Analytical methods are discussed in detail in our Annual Report.

4. Sample Localities

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

5. Data Collected

Specimens collected during January and February 1977 are as follows:

Specimen Number	Species	Date of Collection	Sex	Age	Stomach	Reproductive Tract	Parasito-logical Material
NP-1-77	P. hispida	27 Jan 1977	F	11+	X	X	X
NP-2-77	P. hispida	28 Jan 1977	F	10+	X	X	X
NP-3-77	P. hispida	28 Jan 1977	F	8+	X	X	X
NP-4-77	P. hispida	28 Jan 1977	M	8+	X	X	X
NP-5-77	P. hispida	27 Jan 1977	M	fetus	-	-	-
NP-6-77	P. hispida	28 Jan 1977	F	fetus	-	-	-
NP-7-77	P. hispida	28 Jan 1977	M	fetus	-	-	-
BP-1-77	P. hispida	1 Feb 1977	M	10+	X	X	X
BP-2-77	P. hispida	14 Feb 1977	M	11	X	X	X

As this report is being written during late February and early March, no specimens collected during March are reported. The next quarterly report will cover these animals.

6. Milestone Charts

All updated milestone charts are attached.

B. Problems Encountered/Recommended Changes

None

C. Estimate of Funds Expended

100. Salaries and Wages	$19,698.01
200. Travel	805.96
300. Contractual Services	3,912.15
400. Commodities	427.94
500. Equipment	00.00
	$24,844.06

Project: RU# 230

PI: Burns and Eley

REVISED MILESTONE CHART

MAJOR MILESTONES--OTHER PROJECT ACTIVITIES	1976-77											
	O	N	D	J	F	M	A	M	J	J	A	S
BEAUFORT SEA - Shipboard											*	*
CHUKCHI SEA												
Wainwright					*		*			*	*	
Point Lay					*		*					
Cape Lisburne							*					
Point Hope							*	*				
Kotzebue						*	*					
Shishmaref						*			*	*		
BERING SEA - NORTON SOUND												
St. Lawrence Island									*	*		
Nome						*	*	*	*			
Diomede									*	*		
Stebbin								*				
Norton Sound - Helicopter operations						*						

*Sampling Period

Project: RU# 230

PI: Burns and Eley

REVISED MILESTONE CHART

MAJOR MILESTONES--OTHER PROJECT ACTIVITIES	1976-77											
	O	N	D	J	F	M	A	M	J	J	A	S
St. George Basin - Shipboard in ice front and ice remnant						*	*	*				
Bristol Bay - Shipboard						*	*					
*Sampling Period												

Project: RU# 230

PI: Burns and Eley

REVISED MILESTONE CHART

MAJOR MILESTONES--OTHER PROJECT ACTIVITIES	1976-77											
	O	N	D	J	F	M	A	M	J	J	A	S
Acquisition of specimen	△											△
Processing of specimens for age determination	△											△
Processing of reproductive tract specimens	△											△
Processing of parasitological material	△											△
Compilation and analysis of specimen data			▲		▲	△			△			△
Submission of data	▲			▲			△			△		
Preparation of reports			▲		▲				△			△
Preparation of FY 1978 proposal							△					

△ planned completion date ▲ actual completion date

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APPENDIX I

Aerial Surveys of Pacific Walrus in the Soviet Sector during Fall, 1975*

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1976

I. Introduction

From September 17 through October 16, 1975 following a five-year break, work has again been done to determine the abundance of Pacific walrus (Odobenus rosmarus divergens, 1811), based on counts from aircraft.

The hauling grounds of walrus were photographed and walrus groups on the ice were subjected to methods of visual counts from aircraft, and subsequent extrapolation.

During the period of surveys there were nine coastal hauling grounds, seven of which were in the Bering Sea and two in the Chukchi Sea. Two new hauling grounds were found, one on the island of Nuneangan and the other one on the island of John the Baptist (Ioanna Bogoslova) both in the Bering Sea. The ice hauling grounds of the walrus were situated in the western part of the Chukchi Sea from Point Billings to Koluchin Island in near proximity of shore.

The count of walrus in the Soviet sector of the Arctic was 128 to 130 thousand head. Of that number the shore rookeries yielded 96.9 thousand head as photographed from the air. The remaining numbers were observed on the ice and while swimming. In comparison to the count of 1970 (101 thousand walrus) we have observed the growth of the population and extension of summer distribution in a southward direction.

The history of harvest of Pacific walrus is very similar to that of the northern fur seal, the bowhead and gray whales. Only the most severe measures of the interested governments had to be undertaken to save the species from complete extinction.

The take of Pacific walrus started in the middle of the 17th century. Each year 5 to 6 thousand walrus were taken. However, in the middle of the 19th century, as established by F. Fay (13), the size of the (walrus) stock had to still constitute around 200 thousand head and by the end of the 19th century 150 thousand head. The annual harvest was 15 to 20 thousand animals. However, the continued harvest attained in the beginning of the 20th century was 8-12 thousand head, not including losses additional to this. By the mid 1950's the walrus population had decreased to 38-40 thousand head (7, 13). By the end of the 1950's, both the United States and the Soviet Union forbade national harvesting in general, permitting harvesting only to serve the needs of the local population of Alaska and Chukotka.

*Translated by J. J. Burns, Alaska Department of Fish and Game, Fairbanks

The aerial count which was conducted in September 1958 by N. G. Nikulin was the first attempt by Soviet scientists to establish the absolute number of the walrus population. The second count was made in 1960 when aerial photo equipment was used to take pictures of the shore hauling grounds (9).

The total number in the population at that time was estimated at 50 thousand animals. On the basis of this figure recommendations for the conservation and regeneration of the stock were put forward (by the Soviet Government). Beginning in 1963, the ship harvesting of the walrus stopped and the size of the harvest was limited to serve the local needs of people inhabiting Chukotka. The annual take was set at 1000 animals. At this time also, American specialists began aerial surveys of the walrus (11) and they determined the population to be 70 thousand head or greater. At about that time E. Fay began studying the reestablishment of walrus in the southern portion of their range, as it showed an indication of an increase in their number (11). In 1965 J. Burns (12) estimated the population of the walrus to be 90 thousand animals. In 1968, on the basis of aerial surveys in walrus wintering areas, K. Kenyon (unpublished data) gave the figure 73 to 113 thousand.

Numerous facts obtained during the period 1966-1970, by Soviet investigators, have also indicated a southward shift of the southern border of distribution. In 1966 individual walruses were found in the Bay of Russia and Listvenichnia in Kamchatka. The appearance of smaller groups of walruses in Karaginski Bay was noted and the formation of a hauling ground on Verksoturova Island (10) was also observed. Individual walrus were observed near the Commander Islands (8) and on ice of the Okhotsk Sea (5). Several hauling grounds in the Bering Strait region (Island of Arakamchechen and near the abandoned village of Naukan) which up to this time were considered to be defunct and were not visited by walrus for many years, now started functioning regularly. The number of animals visiting these islands has grown each year.

Another count conducted in 1970 (3) supported the data provided by American scientists. The shore hauling grounds of the Chukotsk Peninsula and the ice formations of the Chukchi Sea (in the shared sector of the Arctic) yielded the count of 101 thousand animals.

New data have been obtained during the five year period following the last count. That data, in particular information of the new hauling ground in Peters Bay (personal observations by Captain A. V. Kiselev), supported the picture of walrus migrating farther south. In 1971 in Lavrov Bay (61°16' north) a female walrus with a calf were taken (5). In the fall of 1974 large groups of walruses were observed in Anastasii Bay (information provided by inspector of the Okhotsk Fisheries, N. Sokolov). All these facts suggest that the stock of Pacific walrus is increasing and is about to occupy its former range, which extends south along the coast of eastern Kamchatka to Cape Kronotski and, on the American coast, to the Alaska Peninsula (13).

To check the data obtained from the former survey and to monitor the abundance of the population, it was decided according to the agreements reached with American scientists to simultaneously conduct a count of walruses in the Soviet and American territories in the fall of 1975. Each side would conduct a count in its own territories and the boundary between them would be the "International Date Line."

II. Biological Considerations for Making Counts and the Methods Used In Carrying Out the Work

I(2). During the fall-winter period Pacific walruses inhabit ice in the northern part of the Bering Sea, occupying a broad aquatic territory from Nunivak Island in the south to the Chukchi Peninsula in the north. In the summer-fall period the basic mass (majority) of walrus move north to the Chukchi Sea when ice conditions permit. Only a small part of the herd stays in the Gulf of Anadyr forming one or two shore rookeries by Rudder Bay and on Meechkin Spit. According to observations made during the 1960's (2) this portion of the herd does not exceed 6 to 8 thousand head. During the June-August period, owing to the abundance of drifting or moving ice, the majority of the population disperses over the large water territory from Chaunskoi Inlet in the west, to Point Barrow in the east, and north to 72°.

At the time of greatest destruction of ice, which usually occurs in September, walrus concentrate in the region of Wrangell Island and also at one coastal hauling ground by Cape Inchoun. During years when the summers are warm and the edge of the pack ice is far north (to 73° or 74°) walrus abandon the ice and form coastal hauling grounds on Wrangell Island, Herald Island and a number of other places on the northern coast of the Chukchi Peninsula. The maximal hauling out of walrus on these rookeries takes place during the second half of September. These circumstances are particularly convenient for counting because by photographing the hauling grounds it is possible to obtain an absolute count of the larger portion of the population. In the case that summer ice remains close to shore, walruses do not abandon it. During the first 10 days of October, when the intense formation of ice begins in the region of Long Strait the walruses' ice rookeries are concentrated in a relatively small area near the ice edge, facilitating conduct of aerial surveys. At that same time migration of the walruses begins to the southeast, in the direction of Bering Strait. If no ice is present on their migration route, near shore, the walruses haul out on the shore, forming temporary hauling grounds. Knowing these peculiarities of this animal's distribution during the autumn period, we wanted to conduct two to three aerial surveys of the ice hauling grounds and to photograph the shore hauling grounds several times.

Taking into account what we have just said, the dates for conducting counts were in the period from September 15 to October 20.

2(2). Work was conducted from an airplane of the IL-14 type, from September 16 to October 16, 1975. The plane was equipped with two "blisters" with visors, which allowed the exact delineation of width of the survey track.

Subject to conditions of visibility and altitude of the flight, the observation angle was 45° or 63°; that is, the width of the strip in the first instance was equal to the altitude of the plane and in the second instance it was equal to two times the flight altitude. The plane speed, on the average, was 250 kilometers per hour.

The plane was equipped with two cameras: AFA TE-500 with a film format of 18 x 18; and AFA-42-20 with a film format of 30 x 30 cm. Focal length of the objective lens in the first camera was 500 mm. For the second camera it was 200 mm. Scale of the pictures depends on the relationship of focal distance of the objective lens to flight altitude. Pictures were usually taken from a height of 1000 m. In this case (from a height of 1000 m) the scale of pictures for the first camera was 1/2000, i.e. 1 cm on the photograph corresponded to 20 m of the place being photographed. For the second camera the ratio was 1/5000. On photos made with the first camera it is possible, using binocular magnifying lenses, to see the different parts of a walrus. The second camera was operated simultaneously with the first only when there were many walruses in the water near the rookeries and they could not be seen in the frames of the AFA-TE-500 camera.

3(2). Counts were accomplished in the following manner. First, the shoreline was inspected from Karaginski Bay (including Karaginski and Verkooturov islands) to Cape Schmidt with the aim of searching for occupied walrus hauling areas. Observation through the blisters and from the cockpit of the plane was constant throughout these search flights. The optimum altitude of these flights was 300-400 m. The shore was continually observed through binoculars.

After finding a rookery the plane assumed the required altitude and at the moment it flew directly over the rookery, pictures were taken. In order that nothing was missed, pictures with a linear overlap of 30-35 percent were made. The altitude from which pictures were taken was usually 1000 m. However, if there was a problem due to clouds, pictures were taken from a height of 700 m. In this case the speed of the airplane was reduced to a minimum in order not to obtain photos which were out of focus. With this same aim (obtaining pictures in focus) a minimum exposure time (1/140 sec.) was used. Regulation of light was done with the diaphragm. Counting of the animals appearing on the pictures was done by drawing contour lines around the hauling ground, and measuring its area with a planimeter. Several places in each frame, where the density of walrus varied, were pierced with needles marking the central points. Each of these areas was 1 cm^2. In these areas the number of walruses was counted with the aid of binocular magnifiers. After that, the average number of the animals per unit area was calculated and the results extrapolated to the entire area of the hauling ground. In areas with marked variation in density from the basic hauling ground all animals were counted individually under a binocular magnifying glass. The same procedure was used for counting walrus close to the rookery but in the water.

As a control for the area extrapolations of the hauling grounds we checked our data, obtained by this method, with the counts of individual walruses included in these same photographs. For instance, a picture of the Meechinsk rookery, taken on September 18, yields a difference between the area extrapolations and individual counts of only 198 animals or 2.46 percent (Table 1). As we can see this is not a large error.

Animals underwater at the moment pictures were taken could not be enumerated. However, as this is the period of greatest occupation of the hauling areas, the number of animals in the water was insignificant. Those that were diving were even fewer. Errors from this source can be ignored.

The process of aerial surveys of the ice rookeries was initially achieved with reconnaissance flights. During such flights a map would have ice conditions indicated on it. Those areas occupied by walruses were designated.

During the following day the areas in which walruses were discovered would be covered by uniform transects. The distance between adjacent transects varied between 10-20 kilometers. In the flight records, on board the aircraft, the time of sighting individual walruses or herds on the ice was noted. As we processed the resulting material these data were put on maps and regions with varying concentrations of walruses would be singled out. The extrapolation would only be done for those areas with similar densities of walruses. Simultaneously, from another airplane, a count of gray whales was also being conducted under the direction of a collaborator from the Magadan Branch of TINRO, V. V. Zimooshko. We used the data obtained by him concerning the distribution of the walruses in the open sea.

III. Distribution and Number of Walrus in September and October 1975

1(3). The reconnaissance flights that were carried out on September 17 and 19 and on October 25 allowed us to survey the coast from the Ossora Peninsula in eastern Kamchatka, to Koluchin Island in the Chukchi Sea and also the ice extending from the eastern ice edge to Point Billings in the west and Wrangell Island in the north. In September (1975) there were seven coastal hauling grounds in the Bering Sea. They were as follows:

1. on John the Baptist Island (o. Ioanna Bogoslova);
2. on the western extremity of Meechkin Spit (locally called Meechkinskoye);
3. on Red'kin Spit next to Rudder Bay (Rudderskoye);
4. on the coast of Nuneangan Island in Bering Strait (Nuneanganskoye);
5. the eastern end of Arakamchechen Island (Arakamchechenskoye);
6. the southern end of Ratmanova Island ((Big Diomede) Ratmanovskoye);
7. the former site of the village Naukan (Naukanskoye)

One hauling ground in the Chukchi Sea, the southeast part of Point Inchoun (Inchounskoye) was occupied by walruses. The Rudderskoye hauling ground stopped functioning in October. Walruses no longer appeared there but in the Chukchi Sea a large hauling ground at Cape Serdse-Kamen' was formed.

2(3). The greatest number of ice rookeries during September were concentrated mostly on the narrow strip of ice extending from Koluchin Island to the Bar of Two Pilots (Kosi Dvuk Pilotov) and extending 15 to 20 km eastward from Point Billings. The smaller hauling areas on the ice and in general the swimming walruses were noted all along the way from Point Billings to the eastern edge (of ice) (Fig. 1).

The ice conditions being formed in the region of Long Strait in September of that year (1975) were quite complex. Suffice it to say that the ice edge at the beginning of the last decade of September was 140-160 km farther to the east than it was at the same time in 1970 (3), and the ice density (coverage) was much higher. The basic ice hauling areas for walruses in 1970 were to the west and southwest of Wrangell Island, that is 300-350 km to the northwest of where they were in 1975. The new ice formations with densities reaching 5 to 9 tenths extended northward 15 to 20 km from the shoreline. The walruses occurred in this ice zone. Farther north the ice cover was complete (10 balls) consisting of grey and grey white ice among which were found occasional deposits of multiyear ice. There were no walruses observed on this ice.

The following day, September 20, the entire region from Point Billings to Koluchin Island was covered with transects. It turned out that in the region of Point Billings there are small polynia. Significant numbers of walrus were found in the water and on the adjacent ice. Amidst the thin ice along the coastline the walruses were in small groups of 3 to 5 animals as well as singly, and they were moving southeast. Quite frequently the groups included females and calves.

When the walrus would reach a field of grey ice or nilas, they would swim under the ice and, in order to breathe, they would break through it with their heads. Along the edge, where the water was clear enough to observe walrus, they were primarily moving to the southeast, although some animals moved in the opposite direction. In the area extending from Point Billings to 178^{o} west longitude the density of walruses was .76 animals per square kilometer and here there were 6.5 thousand animals counted. The lowest density turned out to be near the eastern ice edge between 69^{o} and 70^{o} north. That is .03 walruses per square kilometer. The greatest density was in the near shore strip of ice extending from the estuary of the Amguema River to Point Onman - 16.4 animals per square kilometer. Altogether 23 thousand animals were counted in this region. It is difficult to judge how complete this count was because the majority of the walruses encountered were in the water. While the count was taken it was inevitable that not all walruses were seen because the plane files low. Some walruses, because of fear of the noise of the motors, would dive as the plane came within 500-800 meters of them. After 4 or 5 seconds it was impossible to identify them in the water. Moreover it is entirely possible that some walruses were west of Point Billings but it was not possible to survey this region. There was no ice along the Chukchi coast between Koluchinskoi Inlet and Cape Inchoun and walruses were not observed on the side of Bering Strait.

3(3). The photocensus conducted on September 18 and 21 showed that on those dates the number of walruses on the shore hauling grounds reached 82 thousand head (Table 1). In 1970, at the same time, there were about 20 thousand walruses on them. Apparently because of the unusual ice conditions which occurred in the region of Long Strait in September of 1975, the majority of the population that (usually) inhabits Wrangell Island waters in the summer moved to the Bering Sea somewhat earlier than usual.

4(3). We expected that the freezing weather which started in mid-September would speed up the formation of ice in the Chukchi Sea and, because of this, the walruses would leave the ice earlier than usual and occupy the shore hauling grounds. However, the deep cyclone which paused over the Chukchi Peninsula at the end of September reversed the situation; the ice was broken up and its eastern edge moved 100-200 km westward, reaching the meridian of the Point Schmidt (Fig. 2).

On October 5 and 6 the ice hauling groups of walrus were situated 10-15 km north of Point Schmidt, although the general picture of distribution was practically unchanged from that of September (Fig. 1). Twenty-six thousand and six hundred walruses were counted on the ice. The greater part of these walruses, 19.7 thousand, were concentrated in two relatively small areas with a total area of 475 square km. Walrus density in the remaining part of the territory was low, between .3 to .76 per square km.

5(3). During the first 10 days of October, as in previous years (3,9), there was a migration of walruses to the southeast. Approximately half way between the Island of Koluchin, where the ice ended, and the Meechkinskii hauling ground, the walruses formed one large hauling ground, in October, near Cape Serdse-Kamen'.

6(3). Of the nine hauling grounds that functioned in the fall of 1975, two of them on John the Baptist Island (Ioanna Bogoslov) and Nuneangan Island, were recorded for the first time. There are no earlier references in literature about them. On the Island of John the Baptist the walruses were apparently part of a small herd which has remained in this region for several years during the summer. As has already been mentioned, in 1971 hunters saw the walrus hauling ground in Peter Bay (containing up to 1000 animals). The Island of John the Baptist is situated in the inlet to that bay. A bit to the north, in Anastasii Bay, on June 25, 1971, a group of 500 walruses was observed (8). In Olutorski Bay on September 9, 1975, 50 walruses were seen from an airplane which was engaged in a survey of whales. A colleague from the Magadan Branch of TINRO, V. V. Zimooshko, who at the time was conducting this work, also indicated encountering walruses 12 to 15 km off the coast of Anastasii Bay on October 1 (12 animals), and 3 walruses by Point Vitgenshtein. He counted 5 animals in Olutorskii Bay. On October 2, in the Anadyrskii estuary, he counted 7 walruses and 60 miles to the east of Cape Navarin he counted 2 walruses. Because there are no hauling grounds in the region of coast between Cape Olutorskii and Cape Navarin we assumed that the groups of walruses encountered were performing a feeding migration and all of them belonged to the herd which spends the summer in the Koryakskii region of the coast.

The hauling ground on Nuneangan Island was occupied for the first time in 1975 and perhaps, in some measure, took over the function of the Akkaniiskii hauling ground. This hauling ground was situated at Point Kriguigan and functioned during three seasons - 1972, 1973 and 1974. Up to 12 thousand walruses would haul out there. However, this fall, for some reason, this hauling ground was empty.

7(3). The majority of hauling grounds were photographed many times which, to some degree, permits us to evaluate their dynamics. It has frequently been noted that the maximum occupation of the hauling grounds usually occurs after a storm and during the evening. On stormy days the walruses occupy only those areas that are protected from the wind and waves, while the majority of animals go into the open sea or float near the hauling ground.

During calm weather the walruses begin abandoning their hauling grounds after 9 or 10 o'clock in the morning and the groups leave to feed. The distance of feeding migrations apparently varies greatly and may be due to the fact that the animals do not have sufficient time to return to the hauling ground during that same day. The walruses off the Islands of Arakamchehen and Nuneangan go to feed in Mechigmenskii Bay and also to the east and southeast off the hauling ground. We observed groups of walruses in October, 70-80 km eastward of Arakamchechen Island and one was encountered 120 km away (Fig. 2).

The fluctuations in counts of walruses occupying the hauling grounds is, to a great extent, connected with the fall migration. For instance, we can see that the Naukanskoye hauling ground is constantly occupied because of the animals coming there from the Chukchi Sea and the hauling grounds in the Chukchi Sea would correspondingly have smaller numbers of walrus.

By comparison with the 1970 count, a significantly larger number of the walruses were seen in 1975 on the Arakamchechenskii hauling ground. On the Naunkanskii and Inchounskii hauling grounds the number did not reach half of that which occurred in 1970 at the same time of year. This again is connected with the displacement of the migration dates.

8(3). V. P. Krilov determined the average area occupied by one walrus on the shore hauling grounds to be 3.3 square meters. In 1970 (3) the average area occupied by a single walrus on the hauling grounds varied from 2.7 to 3.8 square meters. This year (1975) on the same hauling grounds it appeared to be reduced by 50 percent (Table 1) with a variation of from 1.3 to 2.82 square meters.

Thus, this indicator was not constant and use of it as a reliable measure could yield large errors.

9(3). In calculating the total count of walruses we used the data obtained for the Chukchi Sea on October 5 and 6 and for the Bering Sea on September 18 and 21. It was during these days that we could photograph the maximum occupation of the hauling grounds (Table 2). Moreover 3 to 5 thousand walruses had to be added, which were encountered on September 21 as they were approaching the Arakamchechen hauling ground. The minimum figure obtained was 128 to 130 thousand animals. These are minimum numbers because between September 21 and October 5, the migration of the walruses from the Chukchi Sea to the Bering Sea continued. However, to determine the number of the walruses that actually moved from one sea to the other is impossible because the September count of the Chukchi Sea ice cannot be considered complete and in October, because of bad weather, we were prevented from photographing the maximum occupation of hauling grounds in Bering Strait.

Thus, based on a comparison with the data from previous surveys we observed a good increase in the Pacific walrus population.

But, once again, as we have stated, the data which we have obtained characterizes the number of the walruses that are in the Soviet sector of the Arctic only.

Table 1. Numbers of walrus on coastal hauling grounds in September-October 1975.

Date and local time of counts	Weather	Number of walruses	Area occupied by one walrus (m^2)	Remarks
1	2	3	4	5
		John the Baptist Island		
4-X-75, 1313	Overcast, calm	220	4	Individual count*
		Meechkinskoye (Point Kungas)		
17-IX-75, 1007	Clear, calm	8,242	1.8	Number based on extrapolation
17-IX-75, 1007	Clear, calm	8,044	1.8	Individual count
21-IX-75, 1547	Clear, slight wind	500-600	-	Visual estimate
17-X-75, 1546	Clear, moderate wind	Walruses swimming near the rookery and on the ice in Kresta Bay		
		Rudderckoye rookery		
21-IX-75, 1533	Clear, occasional light wind	445	-	Individual count
		Nuneanganskoye rookery		
18-IX-75, 1153	Overcast, stormy	1,152	-	Individual count
19-IX-75, 0955	Overcast, windy	627	-	Individual count
21-IX-75, 1412	Clear, occasional light wind	19,977	1.54	Number based on extrapolation
9-X-75, 1033	Overcast, north wind	1,628	-	Individual count
		Arakamchechenskoye rookery		
18-IX-75, 1215	Overcast, stormy	3,996	1.89	Extrapolation and individual count
19-IX-75, 1007	Overcast, windy	1,208	-	Individual count
21-IX-75, 1400	Clear, occasional light wind	41,882	1.56	Extrapolation and individual count
9-X-75, 1050	Overcast, north wind	Several thousand walruses sleeping in the water near the rookery.		
		Ratmanovskoye rookery		
21-IX-75, 1142	Clear, occasional light wind	4,228	2.43	Individual count
21-IX-75, 1146 (second pass over rookery)	Clear, occasional light wind	3,516	-	Individual count
		Naukanskoye rookery		
21-IX-75, 1132	Clear, occasional light wind	2,144	1.76	Extrapolation and individual count
5-X-75, 1233	Clear, calm	2,326	-	Walruses approaching from north
7-X-75, 1146	Clear, occasional light wind	2,417	1.32	Many walruses in the water

9-X-75, 1150	Overcast, south wind	3,357	1.88	Walruses approaching from north
		Inchounskoye rookery		
21-IX-75, 1115	Clear, slight wind	5,029	1.70	Extrapolation and individual count
5-X-75, 1246	Clear, calm	7,742	1.67	Extrapolation and individual count
7-X-75, 1132	Clear, north wind	3,700	1.30	Extrapolation and individual count
9-X-75, 1202	Light clouds, calm	5,700	-	Individual count
		Cape Serdse-Kamen' rookery		
5-X-75, 1320	Clear, calm	11,972	1.95	Extrapolation and individual count
9-X-75, 1245	Clear, calm	9,188	2.83	Extrapolation and individual count

*Translators note - Individual count refers to animals counted from photographs. JB

Table 2. Number of walruses on coastal hauling grounds and on the ice, based on aerial surveys in 1975.

Number	Date of count	Name of Rookery	Local time of survey	Number of walruses
1.	4 October	Ioanna Bogoslov	1313	220
2.	18 September	Meechkin Spit	1007	8,242
3.	21 September	Rudderskoye	1533	445
4.	21 September	Nuneanganskoye	1412, 1422	19,977
5.	21 September	Arakamchechenskoye	1400	41,882
6.	21 September	Ratmanovskoye	1142	4,228
7.	21 September	Naunkanskoye	1132	2,144
8.	5 October	Inchounskoye	1245	7,742
9.	5 October	Serdse-Kamen'	1315	11,972
	Total on coastal rookeries:			96,852
10.	5-6 October	On ice floes in the region between Point Billings and Koluchin	-	26,600
11.	21 September	Swimming in Mechigmenskii Bay	1350	5,500
12.	5 October	Swimming in waters between Cape Des¢hnev and Cape Serdse-Kamen'	1235, 1315	1,500
	Grand Total:			128-130 thousand

Legend to Figures 1 through 4

Fig. 1. Distribution of walruses on the ice and at shore rookeries, 17 to 21 September 1975. A = distribution on the ice; B = places of walrus concentration; C = groups of walruses in the water and the direction of their movement.

Fig. 2. Distribution of walruses on the ice and at shore rookeries, 4-9 October 1975. Symbols as in Fig. 1.

Fig. 3. The scheme of survey tracks flown on 20 September 1975. Dashed line indicates the ice edge.

Fig. 4. The scheme of survey tracks flown on 6 October 1975. Dashed line indicates the ice edge.

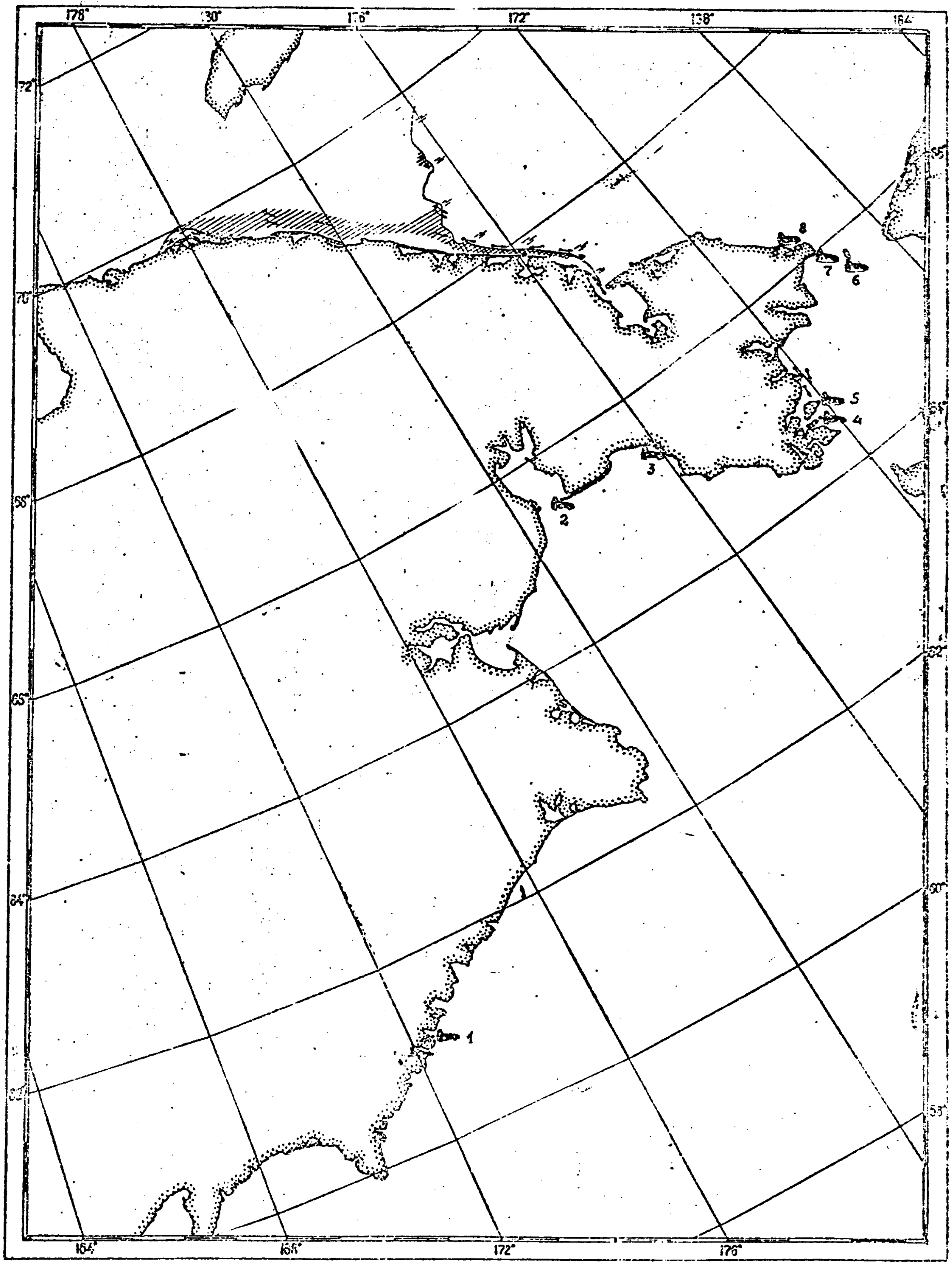

Рис. I. Распределение моржей на льдах и береговых лежбищах
Fig. I. I7 – 2I сентября I975 г.

A. распределение на льдах; B. места концентраций; C. группы моржей на плаву и направление их движения;

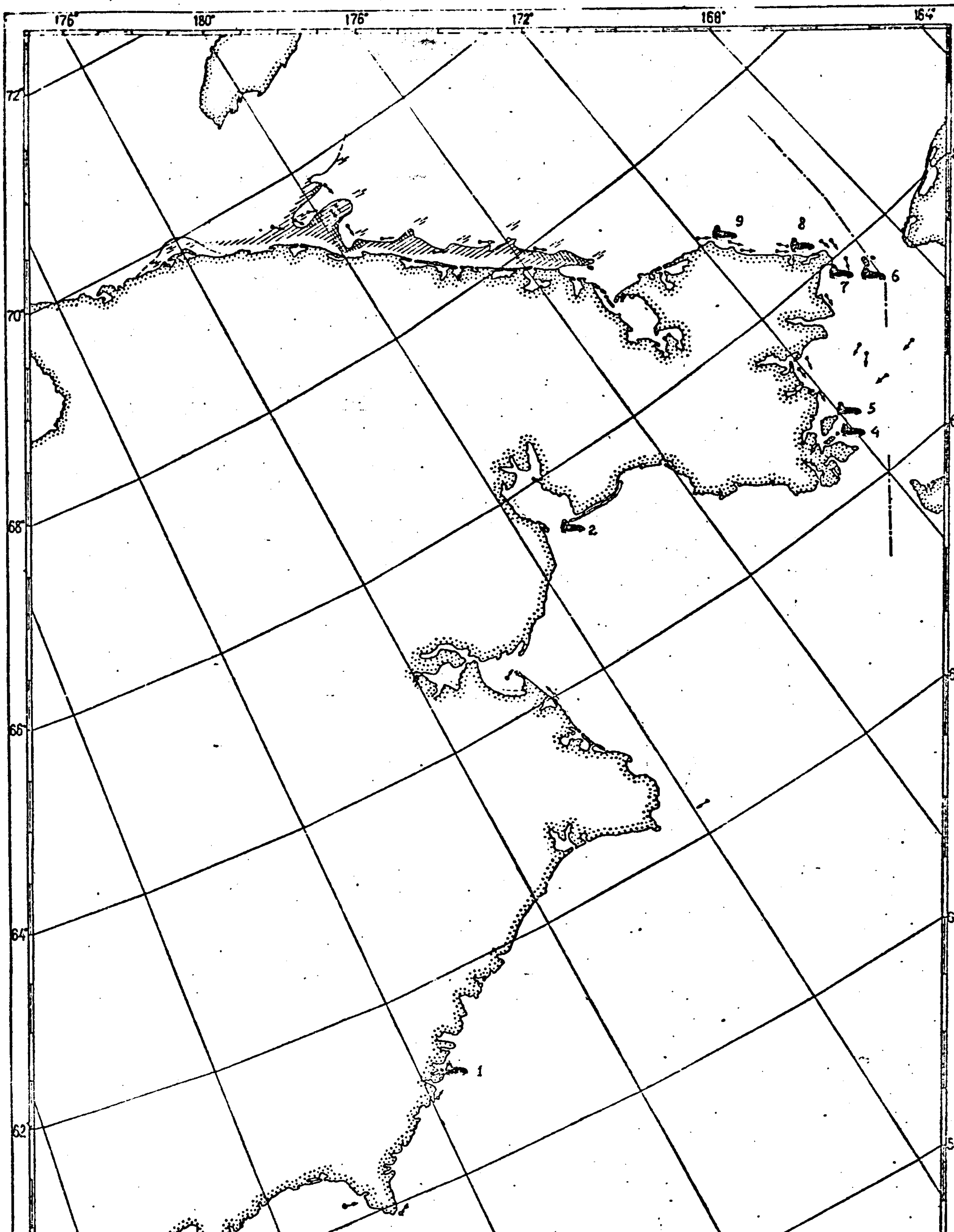

Fig. 2.
Рис. 2. Распределение моржей на льдах и береговых лежбищах 4–9 октября 1975 г.
(Условные обозначения на рис.I.) 299

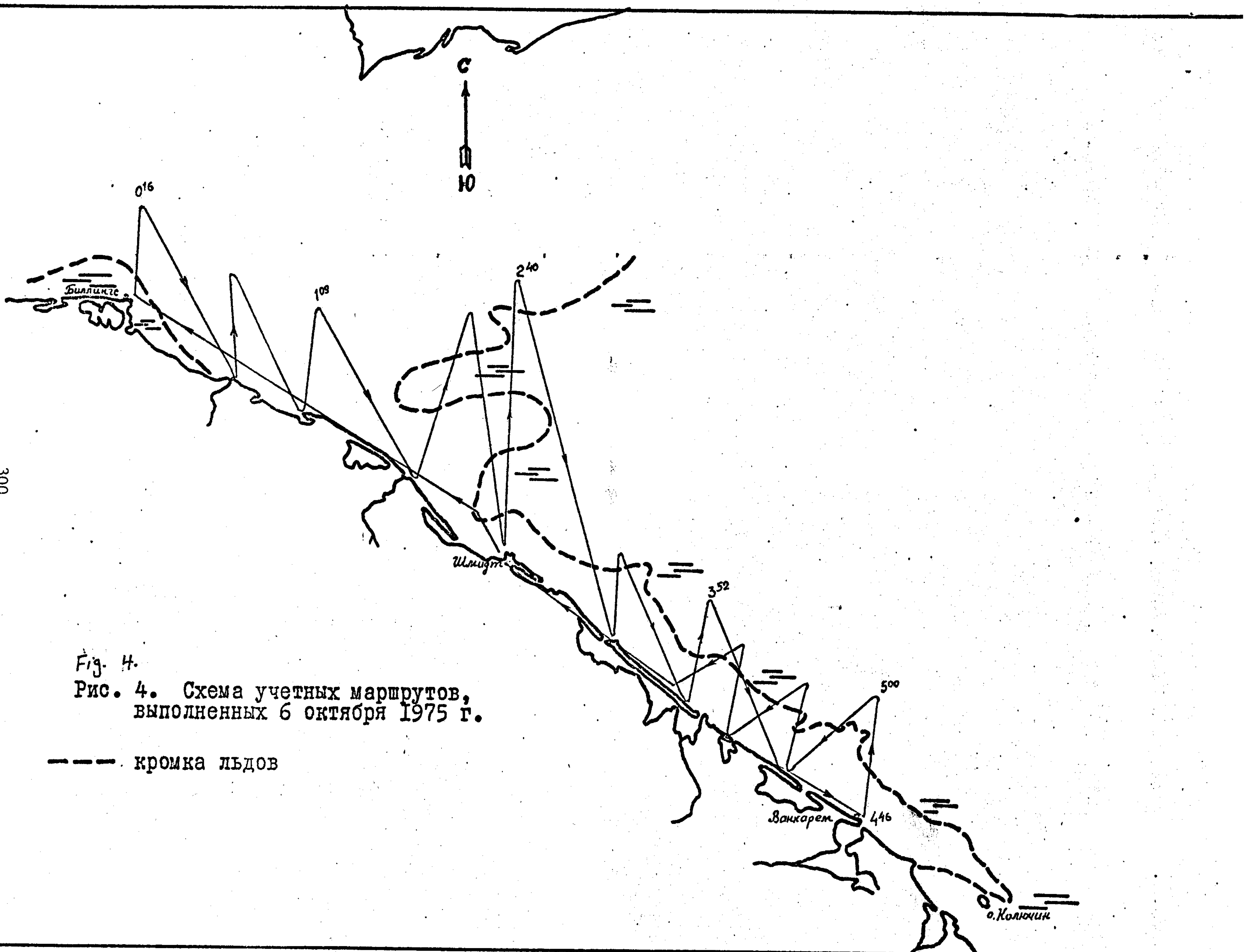

Fig. 4.
Рис. 4. Схема учетных маршрутов, выполненных 6 октября 1975 г.

— — — кромка льдов

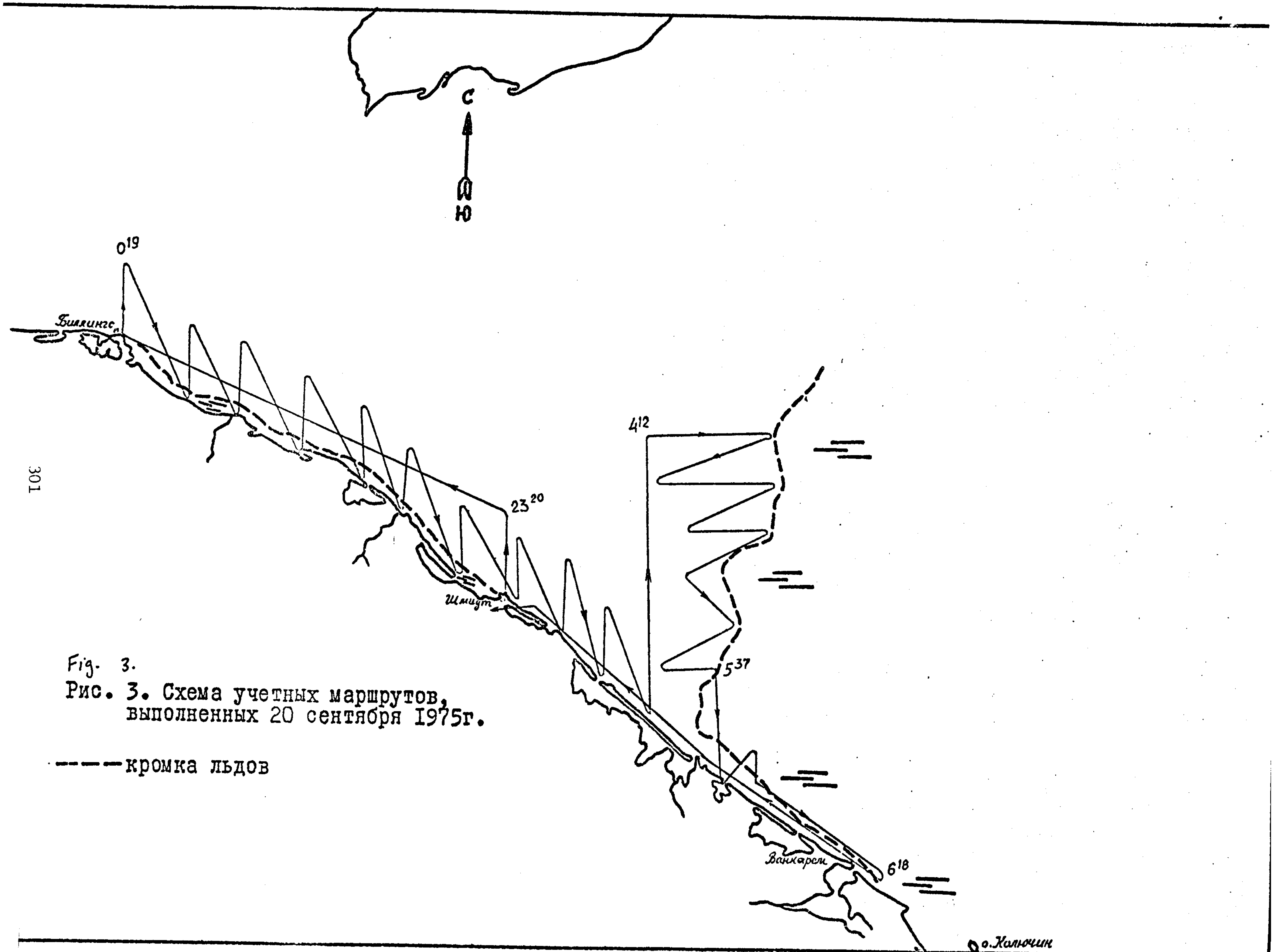

Fig. 3.
Рис. 3. Схема учетных маршрутов, выполненных 20 сентября 1975г.

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