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Studies of Ringed Seals in the Alaskan Beaufort Sea during Winter: Impacts of Seismic Exploration

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1. Summary

The potential impact of seismic exploration on ringed seals in the nearshore Beaufort Sea was investigated in 2 ways; determination of the fates of subnivian structures in relation to seismic exploratory activity, and differences in the density of seals as determined by aerial survey procedures. Radio-tracking of seals was also undertaken to determine its basic applicability to the study of ringed seal ecology and to determine seasonal changes in haulout activity.

'Field efforts extended from 2 March to 4 June 1982. A trained male Labrador retriever located 157 subnivian seal structures along approximately 144 nm of seismic and control search lines and approximately 15 nm of random search lines. Three female seals were captured at breathing holes, fitted with radio tags, released, and monitored from late April to 4 June. Aerial surveys were undertaken between 25 May and 4 June. In total, 1,083 nm of strip transects were flown, of which 74.3 miles were over pack ice and the remainder over fast ice. Transects over fast ice included 221.4 miles along a line also flown in 1981, 406.2 miles directly over seismic lines, and 380,8 miles of control line transects.

Of the 148 seal structures which were examined, 46% were breathing holes, 42% were single chambered resting lairs, 11% were complex lairs, and 1% were access holes to the snow surface. Of the 16 complex lairs, 11 were pupping lairs, the latter composing only 7% of all structures we examined. The method in which structures were examined had a direct influence on their fate. Those in which an open access hole was verified by simple probing with a rod became altered (froze or were otherwise altered) in 22% of the cases. Those dug into by the investigator became altered in 46% of the cases. These differences were considered in an analysis of structure fate in relation to distance from seismic and control search lines.

Two sample groups of structures were analyzed; structures within 150 m of search lines and those beyond that distance. Along control lines there was no difference in fates as a function of distance. Along seismic lines there was a significant difference. Only 54% of structures within 150 m of seismic lines remained open and unaltered. Beyond that distance 78% remained open and unaltered. We do not know the magnitude of natural freezing or alteration in undisturbed structures.

The impact of arctic foxes in our study area during spring 1982 was comparable to that reported in studies undertaken in the western Canadian Arctic. Foxes had marked 32.9% of all structures we found. They had entered 18% of all lairs and 60% of all pupping lairs. Seal pups were killed in 3 of 10 pupping lairs for an estimated predation rate of 30%.

Monitoring of 3 radio-tagged seals indicated that in our study area each seal used a single lair. Major differences were evident in the haulout patterns of each seal and between the adult and juvenile seals. The adult hauled out less frequently but for periods which averaged more than twice as long as those of the juveniles. Haulout at sites other than

the known lairs occurred after 24 May and coincided with an increase in the number of basking seals.

Aerial surveys showed that the density of ringed seals on fast ice of the Beaufort Sea was comparable to that recorded in several previous years. In 4 different sectors extending from near Point Barrow to Barter Island average density in 1982 ranged from 1.2 to 1.7/nm^2. There was no difference in the density of ringed seals along seismic and control transects as indicated by the combined results of all surveys conducted in 1982 and by analysis of the results of daily flights over control and seismic transects.

We conclude that some localized displacement of ringed seals occurs in immediate proximity to seismic lines but, overall, displacement resulting from this activity is insignificant in the nearshore Beaufort Sea.

11. Introduction and Background

Ringed seals are a widespread, circumpolar species which, in waters adjacent to Alaska, occurs in the Beaufort, Chukchi, and Bering seas. They are long-lived seals which in some instances are known to live more than 40years (McLaren 1958). They are the most abundant of the phocid seals found in the seasonally ice-covered seas adjacent to northern Alaska and are still taken in greater numbers than other seal species by subsistence-oriented coastal residents living north of Kuskokwim Bay.

Of the northern phocids, ringed seals are the best adapted to life in the extensive, thick pack ice and landfast ice of the Far North (McLaren 1958, Smith and Stirling 1975). In Alaskan waters, ringed seals are the only species which normally lives in and under the extensive, unbroken fast ice (Burns 1970). Using strong claws on their foreflippers, they make breathing holes in newly formed ice and maintain these holes as the ice thickens (Smith and Stirling 1975, Smith and Hammill 1981). During the course of a freezing season, ice thickens, becomes deformed, and accumulates an increasingly thicker snow cover. Some breathing holes are enlarged to provide access to the ice surface on which seals excavate snow lairs in which to rest or give birth and care for their single pup (Smith and Stirling 1975).

Compared to other phocids, ringed seals are small. In Alaskan waters, growth continues through the first 8 to 10 years of life. Sexual maturity in females is obtained at 5 to 7 years of age, when the seals have reached between 93 and 98% of their mature body size. Full size seems to be geographically variable, and there is difference in size of adult males and females, with males slightly longer (McLaren 1958, Johnson et al. 1966). Length of adults is 120 to 140 cm. Average weight is about 50 kg, although some individuals may exceed 100 kg.

Males (and perhaps females) begin to establish breeding territories as early as February. Females give birth to a pup in a complex, subnivean lair between late March and mid-April. Birth lairs have been described by McLaren (1958), Smith and Stirling (1975), and Lukin and Potelov (1978). These pups, born with a dense white hair covering called lanugo, are nursed for between 4 and 6 weeks. Mating occurs during late April and May. Most females mate every year, although the frequency of successful pregnancy has shown considerable annual variation (Stirling et al. 1977; Smith and Stirling 1978; Burns et al., in prep.). Pregnancy, including a period of delayed implantation which lasts until late August or early September in the Beaufort Sea, is about 10.5 months (Burns and Frost, in prep.). Based on sightings of small, white-coated pups in the Bering Sea, some births occur on exposed ice floes, where subnivean lairs are not constructed. Such young pups are usually considerably smaller than those recovered from more typical habitat at the same time of year (ADF&G, unpubl .). It is hypothesized that most such instances involve young, inexperienced females which are unable to successfully compete with older animals for more optimum habitat in which to bear pups (McLaren 1958).

The highest densities of breeding ringed seals occur in fast ice, and this type of habitat is very important to the population (McLaren 1958, Burns 1970, Smith and Hammil 1 1981) .

In the northern Chukchi and Beaufort seas, fast ice also provides a reasonably safe, convenient, and efficient platform on which certain phases of petroleum exploration can be conducted. In the Beaufort Sea, seismic exploration during late winter-spring has been undertaken with the use of heavy equipment deployed on the ice for long periods of time in February to late March and recently into May. During cold, "heavy ice" years, it is feasible to conduct seismic exploration through early May.

Energy sources utilized to generate seismic waves necessary for recording subsurface geological profiles have varied over the past 13 years. During the late 1960's and early 1970's, buried explosive charges were used. In the mid- and late 1970's, air guns provided the energy source. For the past 3 or 4 years, a vibroseis technique has been used. This technique employs one or more specialized vehicles, each of which is equipped with a machine which "vibrates" the ice surface, thus producing recordable shock waves within the earth's upper crust. Usually four machines simultaneously "sweep" from 10 to 70 Hz over a period of between 5 and 20 seconds. The peak power is approximately 13,750 ft lbs/s. Future efforts may employ the Poulter Technique in which the shock wave-producing energy source is an explosive device mounted on top of a pole placed upright on land or ice. Although energy sources have varied, procedures for deploying them and the required associated equipment have so far remained similar.

When fast ice becomes thick and stable enough to support heavy equipment and allow extensive mobility, a variety of machinery is deployed. Main ice roads, connecting roads, seismic shot lines, ice runways (for aircraft), and temporary camp sites are prepared. Each self-contained crew and its equipment moves over the fast ice, eventually covering as much of the area of interest as possible. The activities of such a crew in a given area may last for more than a week. Operations of seismic crews are constrained by ice roughness. They mainly operate in regions of relatively flat ice or where the surface relief is neither too high nor deformation too extensive in areal coverage.

Highest densities of ringed seals in the fast ice also occur in those regions where surface deformation (rough ice) is less than 40% in aerial extent (this report).

The first indications that on-ice exploratory activity may affect the distribution of ringed seals occurred near Nome in Norton Sound during the middle 1960's. In 2 consecutive years, an intensive shallow-core drilling program to locate marine deposits of placer gold was undertaken from fast ice between Sledge Island and Cape Nome. Subsistence hunting for ringed seals during winter by Native inhabitants of Nome was, during that time, still of major importance to the local economy. Many Nome hunters consistently reported declines in the availability of ringed seals in the area subject to exploration, both during and continuing after the activities ceased, until the ice began to deteriorate and migrating seals moved in. No studies of this potential disturbance were undertaken at that time.

The first extensive surveys of ringed seals in fast-ice areas of the northern Chukchi and Beaufort seas were made between 8 and 15 June 1970 to obtain baseline information about geographical variation in the relative abundance of seals in six sectors of the coast extending from Point Lay to Barter Island. These surveys were not designed to test differences in seal density, if any, between areas subjected to seismic exploratory activity and adjacent areas in which such exploration did not occur. At that time, seismic exploration, using fast ice as a working platform, was geographically restricted. However, a general test was made after the fact by comparing two adjacent blocks, one of which included ice roads and seismic shot lines. The "control" area (no seismic exploratory activity) was 83 nm^2, and the "experimental" area was 76 nm^2. Structure of the aerial surveys and size of the areas compared were considered inadequate, and results of the comparisons were inconclusive (Burns and Harbo 1972).

Extensive surveys were again undertaken in June 1975 to 1977, mainly to investigate the magnitude of annual variation in ringed seal abundance along the north coast. Canadian investigators had documented a significant decline in abundance during 1974 and 1975 in the eastern Beaufort Sea and Amundsen Gulf (Smith and Stirling 1978, Stirling et al. 1982), and it was not known if such a decline had also occurred in fast-ice regions north of Alaska. No specific tests of the possible effects of seismic exploration were included in the survey design as the objective was an extensive, broad-scale assessment of abundance rather than intensive comparisons among relatively small areas.

Nonetheless, a comparison of ringed seal densities between areas of seismic exploration and areas where no human on-ice activities occurred was requested. Results of the extensive surveys were the best available data to use in such a comparison, even though the surveys were not specifically designed to test differences between areas. Results of these comparisons are shown in Table 1 (ADF&G, internal memo). These comparisons consistently showed a lower density of seals in areas where seismic exploratory activity had occurred. Magnitude of the differences" ranged from 22 to 88%, with a combined average difference for 3 years of 51%.

Thus, the only available data indicated that seismic exploratory activity did result in the displacement of seals.

Seismic exploration is a necessary part of eventual oil production. It has to be undertaken. Although several methods for conducting such exploration, such as use of vessels during the open-water season, are available, "on-ice" exploration is a preferred method in northern,

Table 1. Comparison of ringed seal densities within areas of seismic operations and in adjacent control areas.

	Lonely - Oliktok		Oliktok - Flaxman Is.		Total	
	Seismic	Control	Seismic	Control	Seismic	Control
1975						
No. aerial survey miles	51	119	115	162	166	287
No. observed seals	18	117	61	189	79	306
Density/nm²	0.35	0.98	0.44	1.13	0.48	1.07
Density in seismic areas as % of density in controls	36		39		45	
1976						
No. aerial survey miles	96	43	30	60	126	103
No. observed seals	81	89	31	77	112	166
Density/nm²	0.84	2.07	1.15	1.30	0.89	1.61
Density in seismic areas as % of density in controls	41		88		55	
1977						
No. aerial survey miles	17	27	37	15	54	42
No. observed seals	7	17	18	34	25	51
Density/nm²	0.41	0.60	0.50	2.30	0.46	1.21
Density in seismic areas as % of density in controls	68		22		38	
1978						
No. aerial survey miles	164	189	182	237	346	432
No. observed seals	106	223	110	300	216	523
Density/nm²	0.64	1.18	0.60	1.27	0.62	1.21
Density in seismic areas as % of density in controls	54		47		51	

nearshore areas. It has been the intent of the responsible resource management agencies to allow for the orderly exploration and exploitation of petroleum resources, with the least practicable adverse impact on important renewable resources.

In a strict sense, the Marine Mammal Protection Act of 1972 did not permit "on-ice" seismic exploration (Title 1, Sec. 101.(a)) because "taking" was involved and because there were no provisions for permits to allow taking other than for scientific research and public display, or incidental take in connection with commercial fisheries (an appropriate provision is now included in the Act as amended in 1981). Notwithstanding the Act, seismic exploration was allowed. Although displacement of ringed seals was thought to be a probable consequence of such exploration, it was generally considered that such displacement, if it occurred prior to the pupping period of ringed seals, would be of little real consequence to the local population of seals. Conversely, displacement of adult seals caring for newborn pups would probably result in abandonment and subsequent death of pups. Thus, a cut-off date of 20 March was imposed on seismic operations conducted on ice. Such a restriction, though certainly advantageous to ringed seals, severely curtailed the seismic companies by restricting the duration of their potential operations and eliminating the optimum period of operation from the standpoint of weather, ice, and daylight conditions.

The restrictions have been viewed by the petroleum industry as costly and unnecessary, and the scientific data supporting such restrictions have continuously been in question.

In 1981, at the urging of many interested parties, the BLM/OCSEAP effort funded a program to initiate more rigorous studies to verify and quantify the perceived impacts of on-ice seismic exploration.

Aerial surveys of ringed seals in fast ice of the Beaufort Sea during June result in very useful information about seal distribution and relative abundance. When completed before any significant breakup of ice takes place, such surveys are a reflection of the late winter-early spring distribution of seals. However, distribution and abundance of seals observed during such surveys are only an indication of overall survival through the long winter-spring periods. These surveys provide no insight into the nature, extent, and causes of changes which may have occurred during those periods.

If on-ice seismic exploration does result in displacement of seals, as indicated by surveys undertaken in June, it is very important to determine the "processes" through which such displacement is effected and the distance to which the disturbance source has an impact. To investigate these aspects of the problem, it is necessary to monitor changes in seal distribution over the winter-spring seasons and to correlate any observed changes with the proximity and magnitude of disturbance sources.

Conceivably, this might be accomplished through bioacoustical monitoring. Preliminary efforts to explore that possibility were undertaken in 1981 (Cummings and Holliday 1981).

A promising method of following, over time, the presence of seals in control and experimental areas is to monitor their use of breathing holes and lairs. A variety of tests and manipulations can be made once the capability of locating these subnivean structures is developed. Such structures are beneath the snow and not detectable by eye. However, hunting dogs have been trained to locate such holes and lairs. Lukin and Potelov (1978) used a trained dog for this purpose in the White Sea during February-April 1972 and 1973, and Smith trained and utilized a female black Labrador retriever in various parts of the Canadian Arctic for several years starting in winter 1971 (Smith and Stirling 1975). In both instances, efficiency of the dogs in locating all subnivean structures with restricted search areas was judged to be very close to 100%. These are both examples in which good dogs, specifically bred for hunting, have been trained to accomplish what was formerly done by "Eskimo"-type dogs in the course of traditional subsistence hunting in some parts of the Arctic.

During April 1981, one of us (Brendan Kelly) worked with Dr. Thomas G. Smith (Canadian Fisheries and Marine Service, Arctic Biological Station, Ste, Anne de Bellevue, Quebec), with the goal of training two of our dogs to dependably locate subnivean ringed seal structures. Field training took place in Prince Albert Sound, near the Canadian settlement of Holman on Victoria Island, from 4 to 16 April. The trained dog of Dr. Smith was invaluable in the training of our dogs. She unfailingly located lairs while the younger dogs participated in the search. They were positively reinforced by the handlers' encouragement at each structure located. The dogs were also periodically exposed to dead ringed seals, a situation causing great excitement. In this manner the dogs were able to make a positive connection between the seals and structures from which the odor of seals emanated.

We worked initially with a male Labrador retriever and a male springer spaniel. The latter proved less interested in searching for structures and was eventually dropped from the field program.

As a follow-up to the training and reinforcing efforts in Prince Albert Sound, it was necessary to work our primary dog under circumstances where its efficiency could be tested. Kelly took the Labrador to Port Clarence (south side of the Seward Peninsula) from 26 April to 4 May 1981. In that setting, it was possible to continue the training and reinforcing under controlled field trial conditions. These trials were successfully concluded, and our Labrador retriever was judged suitable for field work to be conducted in 1982 (Burns et al. 1981).

III. Objectives

The main thrust of this study was to evaluate the extent of disturbance (= displacement) of ringed seals resulting from seismic exploration conducted on the fast ice of the nearshore Beaufort Sea. This question obviously has several sub-parts. As previously indicated, work during 1981 focused on developing the required expertise to locate and follow the fate of ringed seal structures, as well as to conduct some aerial surveys of seals along and adjacent to seismic lines. The major part of this study was accomplished in 1982, and objectives of the work were:

1. To determine relative abundance and distribution of ringed seals inhabiting the fast ice in the nearshore central Beaufort Sea region, as determined by presence of seal holes and lairs.

2. To determine effects, if any, of "on-ice" seismic exploratory activity on distribution and density of ringed seals, as indicated by continued use of subnivean structures at various distances from seismic lines.

3. To investigate the relationship of seal density and type of seal-made subnivean structure with ice characteristics within the study area.

4. To determine the effects of seismic exploratory activity on distribution and density of ringed seals, as indicated by aerial surveys conducted in May-June.

5. To integrate results of objectives 1-4 as a basis for formulation of recommendations.

IV. Study Area

The geographical area within which studies were conducted in 1981 included that portion of the coast extending from Tangent Point (approximately 32 nm southeast of Point Barrow) to Barter Island and from shore to the seaward edge of landfast ice. This is a linear distance of about 235 nm along the coast and a variable distance from shore. The area of concern is indicated by the distribution of survey lines shown in Figure 1.

Within the region of interest, establishment of shorefast ice begins with initiation of the freezing process, usually in late September or early October. In those years of relatively warm autumn weather accompanied by periodic southerly winds, formation of shore ice is delayed as the developing ice sheet is blown away from shore. In autumns dominated by cold temperatures and prevailing northerly winds, formation of shore ice is accelerated in two ways. The ice sheet forms rapidly, and thick floes from the multi-year ice are driven into shallow water, become grounded, and are incorporated into the developing sheet of landfast ice. Grounded

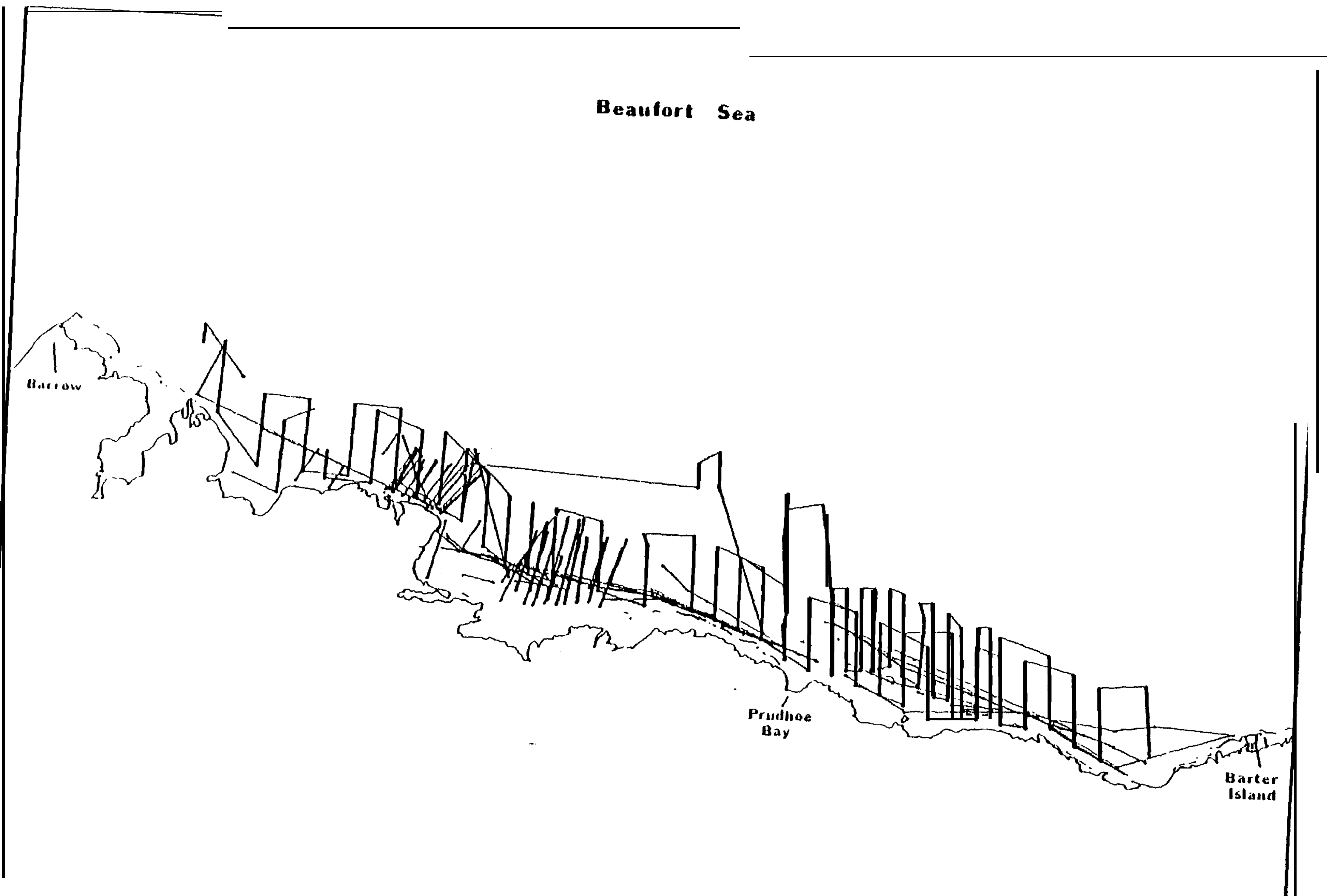

Figure 1. Map of the Beaufort Sea coast showing the study area as indicated by survey flight tracks flown in 1981.

floes anchor and protect the developing landfast ice sheet. According to Stringer (1974), shorefast ice within the study area generally includes numerous pressure ridges, the most seaward of which characteristically becomes grounded in about 18 m of water.

Reimnitz and Barnes (1974) have provided an informative description of the study area, which is paraphrased below.

Width of the Beaufort Sea shelf in the study area is quite variable, ranging from 55 km off Barter Island to 110 km in the west. The flat coastal plain of adjacent land terminates in a line of bluffs to 6 m high, which are broken by low, prograding deltaic mudflats at the mouths of major rivers. Barrier islands at varying distances from shore occur along much of the coast. Most are low and narrow and composed of sand and gravel. Others which support tundra vegetation are erosional remnants of the submerged coastal plain.

The shelf is flat and variable for a considerable distance from shore. Surface sediments range from fine mud to sand with occasional occurrences of gravel and boulders. The inner shelf is covered by seasonal fast ice which, by the end of the freezing period, reaches a thickness of 2 m. This ice is present for about 9 months of the year. Contact between fast ice and the offshore pack is marked by a well-defined shear line (Reimnitz and Barnes 1974).

In our experience, there is usually a series of large pressure ridges roughly parallel to, and inshore of, the active shear line. Each of these ridge lines probably represents a zone of impingement by the pack on the fast ice during episodes of active movement earlier in the winter. Usually deformation of the fast-ice sheet is least close to shore and becomes greater toward the seaward margin.

Presence of a snow cover is of great importance to seals. Surface deformation usually results in greater accumulation of wind-drifted snow, particularly on the downwind side of irregular ice features such as grounded floes and ridges. Obviously, depth of snow and size of drifts' continue to increase over the winter and spring. The minimum snow depth in which seals excavate lairs is 20 cm, and the maximum is greater than 150 cm. Areas of flat ice with little or no snow contain breathing holes but no subnivean structures (Smith and Stirling 1978).

V. Methods

In 1982, field efforts were undertaken on a continuous basis from 2 March to 5 June. The main base of operations was Deadhorse. Ice camps were established in the vicinity of Reindeer Island and were moved as required by the focus of field studies and, in May, by the deterioration of ice. The five major aspects of the 1982 field work can be broadly categorized as: 1) preparation for the field effort (2 January to

26 February); 2) locating and following (over time) the fate of subnivean structures in relation to seismic exploration activities and within areas where seismic activity did not occur (5 March to 26 May); 3) radio tagging and monitoring of radio-tagged seals (17 April to 4 June); 4) aerial surveys of seals along, between, and away from seismic lines (25 May to 4 June); and 5) data analysis and reporting (1 July to 15 November).

The prolonged field effort during 1982 involved, in addition to the principal investigators, assistance from many people. NOAA personnel who provided logistical support were helicopter pilots Eric Davis, Gary Vandenberg, and Bud Christman; mechanics Bob Neild, Roy DeHart, Stephen Davis, and Russell Talley; and logistics coordinator George Lapiene.

Scientific personnel included Larry Aumiller (who assisted throughout the field effort), Robert Nelson, Sue Hills, Kathryn Frost, and Jesse Venable, all with the Alaska Department of Fish and Game. Dr. Lev A. Popov and Mr. Yuri A. Bukhtirov, visiting Soviet scientists, assisted in the project from 18 April to 5 May.

The complex nature of the field effort, which required specialized equipment and supplies necessary for operation on the arctic sea ice during winter and, further, specialized scientific equipment for use in the field, posed some significant problems. Final approval of this contract occurred in early 1982. Therefore, the period available for acquisition of supplies and equipment was limited to January and February 1982. This posed several administrative and practical problems because the lead time was too short to allow adherance to normal government procedures for equipment purchases, testing, and transport to the Beaufort Sea. However, the field effort began as scheduled.

Location and Fate of Seal Structures

Location of subnivean seal structures was accomplished mainly by a trained, male Labrador retriever. Three structures were found by a male springer spaniel, although this dog was infrequently used. Initially, searches were made along lines laid out for purposes of seismic exploration. The dog proceeded along the seismic lines, trotting or running in front of a slow-moving snow machine. Similarly, a series of "control" lines chosen by us was searched.

When a scent was detected by the dog, he turned into the wind and ran to the location from which the scent emanated. He was further trained to indicate where the seal lair or opening through the ice was located by digging in the snow directly over it. The area indicated by the dog was probed with a wooden-handled aluminum rod, 7/16" in diameter and marked in centimeter increments to a length of 150 cm. Initially, some structures were opened to confirm their presence and type. However, this practice *was* discontinued once it was determined that the dog unfailingly indicated the actual presence of subnivean structures.

In most instances, when a new structure was indicated by the digging activity of the dog, it was probed until an open hole to the water was located. Open access or breathing holes indicated that a seal was periodically using the hole and preventing it from freezing closed. The small probe holes were closed with snow, and no additional disturbance of the area was caused by the investigators.

When an open access hole could not be located by probing, the structure usually had been abandoned and the access hole frozen over. However, there were instances when an active hole was present but could not be probed from the snow surface because it was under a shelf of upthrust ice or otherwise situated such that it could not be located. In some instances, structures indicated by the dog could not be confirmed because they were in pressure ridges or ice piles.

Structures were classified into five types:

1. breathing holes, holes maintained by seals but not used for hauling out of the water

2. resting lairs, single-chambered cavities excavated in the snow above an access hole

3. complex lairs, single multi-chambered excavated cavities

4. pupping lairs, single complex lairs in which was found positive evidence of a pup's presence. Evidence of a pup included the actual presence of a live or fox-killed pup, birth blood, lanugo, and pup tunnels, which are small tunnels off a main chamber, excavated by a seal but too small to accommodate animals larger than pups.

5. access holes without lairs, haulout holes not within a lair but used to haul out onto the snow surface.

Normally, when opened, dimensions of a structure were measured. Measurements included length and width of breathing or access holes and length, width, and height of snow lairs associated with exit holes. For those lairs which had more than a single chamber (referred to as complex lairs), measurements were of the largest one. Snow depth to the ice surface was measured at all locations.

Notations for each structure included the extent of ice deformation within a radius of 200 m (0% to 100%) and indications that the structure had been marked (urine or feces), entered (tunnel), or a seal pup killed by arctic foxes (Alopex lagopus). A marker stake was placed in the snow immediately over the access hole of each active structure and over inactive structures. Distance and magnetic heading from the search trail were noted. In many instances, intermediate stakes were placed between the structure and the trail to facilitate relocation of the structure.

So far as possible, each active structure was revisited at approximately 2-week intervals, up to a maximum of seven times. At each revisit the access hole was probed to determine if it was still open. At the time of the last revisit, each structure that had not previously been examined was opened, its type (breathing hole, single-chambered lair, or complex lair) confirmed, and its dimensions measured. Starting in April, some access holes to the snow surface were found. These were treated in a manner similar to subnivean structures.

The manner in which each structure was verified was codified as follows: D = located by dog; P = probed; O = opened; and C = reclosed. Notations of treatment were made when a structure was found and at each subsequent revisit.

Efficiency of search effort by the dog was mainly influenced by wind direction and speed. Acceptable conditions for searching with the dog involved wind speeds greater than 5 miles per hour and directions between 45° and 135° left or right of the direction of travel. Optimum wind conditions were those where velocity was 10 to 20 mph and the direction was at a right angle to the direction of travel along the search trail.

During the early part of the field work (March), factors limiting search effort were short daylight periods and visibility obscured by blowing snow or fog.

Radio Tagging and Monitoring

Equipment employed in the radio-tracking work was purchased from Telonics, Inc., Mesa, Arizona (specific endorsement of these products is neither intended nor implied) and included the following:

Model L2B5 transmitters. Characteristics included dimensions of 4.5 by 3.5 by 2.8 cm, weight 100 g, frequencies between 165.000 and 165.999 MHz, pulse width 15 to 18 milli-see, and pulse rate 75/rein.

Model TR-2 receiver.

Model TS-1 automatic scanner/programmer.

Model TAC-2 RLB antenna control unit.

3 different antennas, including model RA-2A directional “H” antennas, model RA-10 whip antenna, and model RA-1A hand-held receiving antenna.

The different types of antennas were chosen for use at either fixed receiving stations or as part of mobile hand-held units.

For the attachment of small radio transmitters, three seals were captured at three different breathing holes in the vicinity of Reindeer

Island. We chose not to capture seals in lairs in order to reduce the probability of abandonment.

Transmitters were attached to the posterior dorsum, approximately one-half way between the base of the tail and the level of maximum girth. That position was chosen to minimize risk of the transmitter being rubbed off as a seal passed through its access hole in the ice. Transmitters were affixed to the pelage with quick-setting epoxy glue based on methods described by Fedak et al. (1981) and S. J. Jeffries (pers. commun.). The pelage at the attachment site was degreased with acetone and allowed to dry. A piece of nylon-mesh cloth was clamped over one end of a piece of split plastic pipe (8 cm in diameter by 3 cm deep) and was pressed down and forward on the pelage so that hair stood up through the mesh holes. The mesh was covered with a 1.0- to 1.5-cm deep layer of glue which was worked into the hair before imbedding the transmitter. The split plastic pipe formed a mold until the glue set, at which time the halves were split apart and removed. Loose edges of the nylon mesh were trimmed. An electric hair dryer kept the glue warm during curing.

After attachment of transmitters, location of lairs utilized by the tagged seals was ascertained using a mobile receiving unit carried on a snow machine. When the hauled-out seals were located, a temporary camp was established within receiving range of the seals. Antenna arrangement at the camps included first a 7.3-m mast and later a 15-m mast, both of which rotated through 360°. A two-element "H" antenna was mounted atop the mast. A compass rose was drawn on the base plate supporting the rotatable mast as a means of determining the direction from which radio signals emanated.

When location of each lair utilized by a seal was determined, a transmitter was also placed in the snow beside it. This second transmitter provided a constant check that all equipment was working properly.

The frequencies of the deployed transmitters were monitored from the ice camps generally every half hour from 1830 hours on 20 April until 1200 hours on 28 May 1982. Periodically, the frequencies were also monitored from a helicopter. The tagged seals were mostly undisturbed, but, on an opportunistic basis, we determined the distance from a lair at which snow machines, a helicopter, a hovercraft, and men on foot caused the seals to leave the lair.

Aerial Surveys

Aerial surveys were undertaken as in the past (Burns and Harbo 1972, Burns et al. 1981), except that a Bell 204 helicopter rather than a small fixed-wing aircraft was utilized. Flight altitude during surveys was 500 ft unless the ceiling was lower. Minimum altitude during surveys was 250 ft. Speed averaged approximately 80 knots. Surveys were made between 1000 and 1600 hours, the period of maximal haulout in the diurnal cycle of seals at this time of year. Prior to beginning surveys, the three radio-tagged seals were usually monitored from the helicopter to determine how many of them were hauled out.

The survey crew included the pilot (front left seat), who also assisted as an observer, an observer in the front right seat, and an observer, behind the pilot, in the right-rear seat. Occasionally, a fourth person participated as a backup observer. A Global Navigation System (GNS) 500 was used for navigation during surveys as well as for providing point locations.

Surveys were made along strip transects which extended to 1/2 nm on both sides of the helicopter. Since forward and downward visibility from the helicopter was excellent (no blind spot), the strips were not offset to some distance on either side of the aircraft.

For each minute of flight time, all seals visible within 1/2 nm on each side of the strip centerline were counted. Seals were recorded as within either the inner or outer l/4-rim-wide band within the l/2-rim-wide strip on each side. Boundaries of the strips were maintained through use of inclinometers. Thus, seal numbers were recorded for four l/4-rim-wide strips, and each linear mile of transect line equalled 1 nm2 of area surveyed. When discernible, notation was made when seals occurred next to an opening other than a breathing hole (i.e., along cracks or other features resulting from ice movement or disintegration).

Almost all surveys in 1982 were over landfast ice. As a point of reference, part of 1 day's surveys were flown over drifting ice east of Flaxman Island. One of the observers recorded changes in ice features, mainly deformation and snow cover, as they changed.

Weather conditions were recorded at the beginning of each survey and periodically during the flight. Weather reports were obtained from Lonely, Oliktok, Deadhorse, and Barter Island stations.

For each day, components of a given survey were divided into flights and these further divided into legs. A flight was the total amount of survey flying accomplished between takeoff and landing during a day. No more than two survey flights were made in a single day. Each flight was subdivided into a variable number of legs. The legs were basic units of the survey and were flown over a straight line course. Each leg was terminated either at the end point of the line or whenever the direction of flight was changed. Thus, a long survey line might have had several slight changes in course (angle points), and each angle point marked the end of one leg and the beginning of the next.

Three types of transect lines were surveyed: 1) those along seismic trails or access roads; 2) those between or away from lines or ice roads; and 3) duplicates of transects flown in June 1981. The latter transects were surveyed to provide a comparison of overall relative abundance of seals between 1981 and 1982.

Data Management

All data from the three different components of this project (study of seal structure, monitoring radio-tagged seals, and aerial surveys) were recorded in applicable formats on flexible disks, using a Digital VT/78 video data processor. This mini-computer, in combination with a Digital Decwriter II, was capable of providing printed data sheets used for editing and correcting. Our computer also functioned as a terminal for the Alaska statewide computer network and thus provided access to a larger computer on campus at the University of Alaska, Fairbanks.

Statistical programs and analyses used in the various phases of this study are indicated in the appropriate places of the Results section.

VI. Results

Seal Structures Found

In total, 157 seal structures were found by searching with a dog along 144 nm of seismic and control lines shown in Figure 2 and approximately 15 nm of random search lines. Of these, 105 were found from search lines along seismic trails, 36 from control lines, and 16 during non-systematic searches. The type of structure was determined in 148 cases, and this sample included 68 (46%) breathing holes, 62 (42%) simple resting lairs, 16 (11%) complex lairs, and 2 (l%} access holes to the snow surface. There was a strong sampling bias involved in locating access holes to the snow surface as our sampling effort was terminated prior to the beginning of the main molt period when seals haul out on the snow.

In our sample of 78 lairs, 62 (79%) were single-chambered resting lairs, and 16 (21%) were multi-chambered complex lairs (not to be confused with “lair complexes” as defined by Smith and Stirling 1975). Of the complex lairs, 11 were confirmed pupping lairs. Therefore, pupping lairs comprised 7% of all verified structures found or 14% of all lairs found. Lairs occurred in the physical settings described by Smith and Stirling (1975) and Smith (1976): in snow drifts which form around ice hummocks; or along pressure ridges.

The Labrador retriever used in this effort was very consistent in his ability to locate subnivean seal structures. In all instances that he indicated, by digging, the presence of a source of seal odor, we found a structure or at least were able to detect the seal odor ourselves. The dog found six of 142 structures at distances greater than 1,000 m and two at greater than 1,500 m from search lines.

We attempted to test the statistical significance of differences in the number of structures found by the dog in relation to distance from

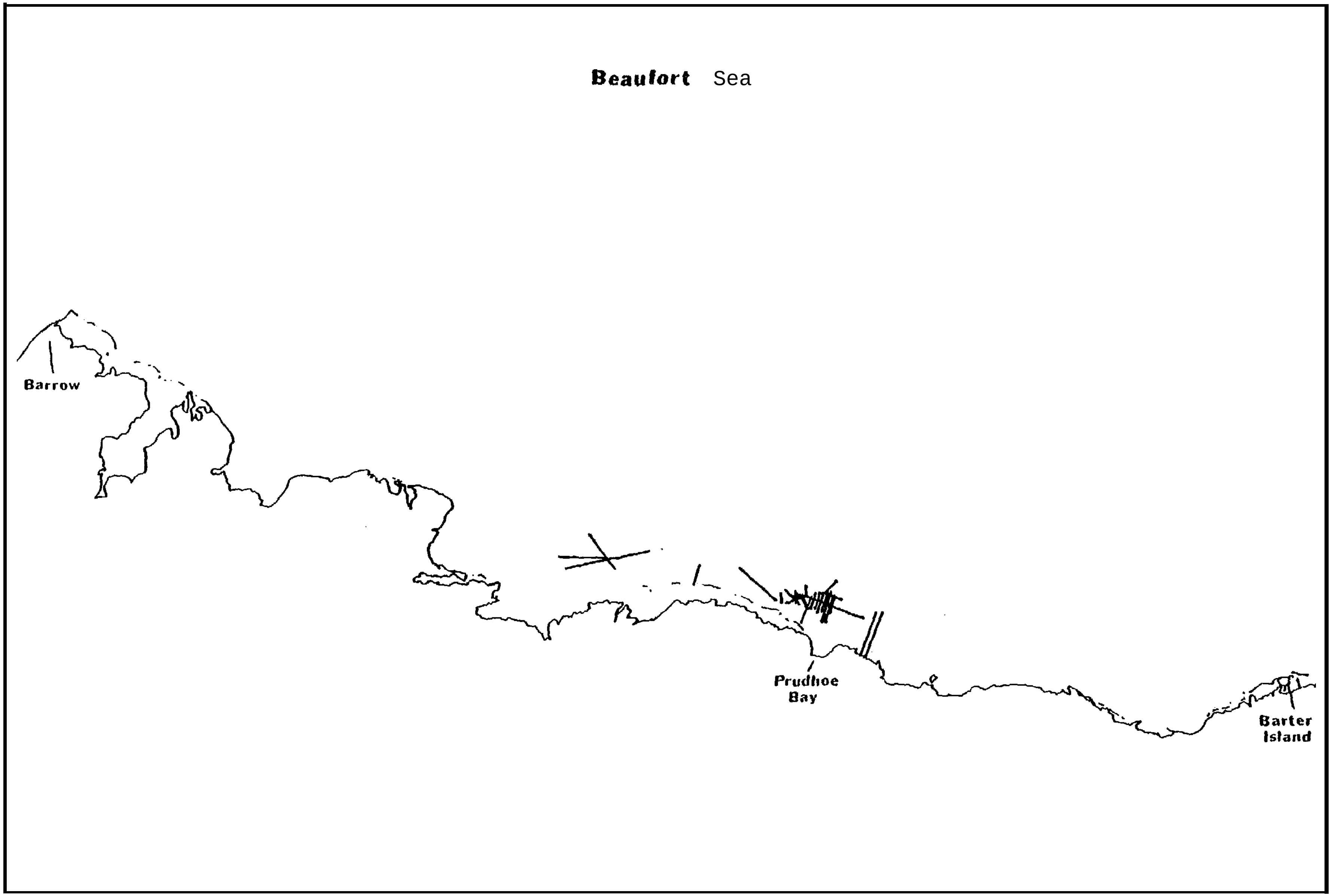

Figure 2. Geographical location of seismic and control lines searched with the dog. Total linear distance of lines was 144 nm.

search lines. Our first consideration was of all structures within 50 m of all fixed search lines combined. A total of 35 structures was found within that distance. Their observed frequency by increasing 10-m intervals was 6, 8, 7, 4, and 10 (expected mean = 7), suggesting that search efficiency was uniform. After considering the factors relating to unbiased and uniform sampling effort within each strata, it was found that the data as obtained do not lend themselves to statistical analysis of this question. One would have to assume that seal structures were randomly distributed throughout the study area. They were not. Another assumption is that the different test strata received similar search effort. That may or may not be the case as variables such as ice deformation, wind direction, and wind speed were highly variable among areas and days, and these are factors which could affect search efficiency.

Unbiased searches for structures at varying distances from search lines are not a requisite of this study. The location of a large enough total sample of structures was.

Physical Parameters of Structures

Extent of surface deformation in which structures were situated varied from O (flat ice) to 75% for breathing holes and from 4 to 75% for lairs. The mean ice deformation, however, for breathing holes and all types of lairs varied only from 26 to 28%. We did not record differences in height of deformed ice features. Our search pattern was largely dictated by the layout of seismic lines, which were ultimately limited by rough ice. Thus, our search effort was not necessarily equally distributed with respect to ice deformation.

The greatest depth of snow and dimensions of different components of each type of structure are presented in Table 2.

Fate of Structures Over Time

Abandonment of breathing and access holes in lairs was considered to have occurred if the holes became completely closed by freezing. Access holes were considered altered, though still used by a seal, if they froze to a smaller diameter, the size of which permitted access to air, although it precluded a seal from passing through it. In some instances, lairs were abandoned as haul-out sites even though the access hole was maintained unfrozen as an active breathing hole. This was evident when ice built up in the roof of a lair to a thickness which did not permit a seal to pass into the chamber.

Revisits were made to 11 structures after it was found that" the breathing or access hole was frozen closed. Revisits were to one structure after 1 week, eight after 2 weeks, one after 3 weeks, and one after 5 weeks. In all instances the holes remained frozen,

Of 12 structures which developed partially frozen (altered) holes, five remained partially frozen (revisits were of two within 2 weeks, two

Table 2. Parameters of seal-made structures, including breathing holes, lairs, and access holes to the snow surface.

Parameter (measurements in cm)	Statistic	Type of structure: breathing holes	resting lairs	complex lairs	pupping lairs	access holes to snow surface
Snow depth at structure	N	64	61	5	11	2
	$\bar{x}$	38.4	77.2	90.8	93.0	19.5
	S.D.	20.7	26.8	22.4	17.4	6.4
	MIN	0	29	70	66	15
	MAX	116	> 150	123	119	24
Diameter of hole	N	47	32	6	4	2
	$\bar{x}$	34.9	42.6	42.0	65.0	49.5
	S.D.	12.8	11.5	1.2	32.2	14.8
	MIN	10	18	41	29	39
	MAX	62	66	43	118	60
Length of lair	N		53	5	10	
	$\bar{x}$		165.2	268.0	245.0	
	S.D.		66.7	90.4	81.4	
	MIN		78	160	145	
	MAX		467	389	455	
Width of lair	N		53	5	10	
	$\bar{x}$		98.0	94.4	154.6	
	S.D.		25.1	17.9	57.4	
	MIN		52	76	84	
	MAX		165	115	250	
Greatest height of lair	N		54	5	10	
	$\bar{x}$		35.3	37.4	33.1	
	S.D.		9.1	16.6	7.8	
	MIN		12	24	25	
	MAX		55	64	53	

within 4 weeks, and one within 5 weeks), and seven became completely frozen (four within 1 week, two within 4 weeks, and one within 6 weeks). The partially frozen holes continued to be used as breathing holes.

The fates of four lairs which were altered but had open access holes were: one access hole frozen within 1 week; one access hole partially frozen within 4 weeks; and two altered lairs cleared and reused for hauling out (one within 3 weeks and one within 4 weeks).

The eventual fates of 96 structures active and unaltered when first found were examined in a three-way analysis (Sokal and Rohlf 1969) which examined: 1) fate of the structure; 2) the observer that found the structure; and 3) the method of initial verification of the structure (probed or partially dug into). There *was* no significant difference in the number of structures opened by each investigator (G = 1.038, d.f. = 2), nor in the fate of structures in relation to which investigator found and initially identified them (G = 2.010, d.f. = 4). However, there was a significant difference in their fate, depending upon whether the structures were simply probed or examined by digging into them. Table 3 indicates fate in relation to initial method of examination. A higher proportion of structures which were merely probed remained unaltered by freezing of access holes and/or partial blockage of lairs. Of equal importance, the fates of structures which showed change were significantly different, depending on examination method. Abandonment (freezing of access holes) in combination with continued but altered use (partial freezing of access holes or blockage of lairs) was 22% for structures which were merely probed, versus 46% for those which were dug into. The effect of examination methods on the eventual fates of structures resulted in statistically significant differences (G = 6.35, d.f. = 2, $0.025 < p < 0.05$).

Fates of structures as a function of distance from seismic lines and control lines were examined. Sample sizes were 85 structures located by searching along seismic lines and 25 from control lines. The sampling period was 7 March to 7 May 1982. Our samples were subdivided into four categories which included structures within and beyond 150 m of seismic and control lines. Fates of structures in this type of analysis are presented in Table 4. These results were probably not significantly influenced by the effect of examination method when structures were first found. As indicated previously, in our total sample, structures which were dug into by an investigator showed a rate of freezing and/or alteration 24% greater than those merely probed. In the interpretation of Table 4, it should be noted that for structures along seismic lines 41.5% of those within 150 m and 53.5% of those beyond that distance were dug into. Along control lines these values were 88.2% and 53.9%, respectively. Thus, differences in eventual fate in relation to distance from seismic lines are real.

There was no significant difference in fates of structures between seismic and control lines (G = 2.233, d.f. = 2). However, there were significant differences in fate in relation to distance from seismic or control lines. The proportions of structures which were abandoned (holes

Table 3. Eventual fate of 96 seal structures, which were active when found, in relation to initial method of examination (probed versus dug into by investigator).

Initial examination method	Sample size	Fate of structures (%) remained open and unaltered	abandoned (frozen)	altered[1]
Dug into	37	54	22	24
Probed	59	78	14	8

[1] partially frozen access holes or blocked lairs.

Table 4. Eventual fate of 110 seal structures in relation to distance from seismic and control search lines.

Type of search line	Distance of structures from lines (m)	Sample size	Fate of structures (%)		
			remained open and unaltered	abandoned (frozen)	altered[1]
Seismic	≤ 150	48	54.2	29.2	16.6
	> 150	37	78.4	10.8	10.8
Control	≤ 150	15	46.7	33.3	20.0
	> 150	10	50.0	30.0	20.0

1 partially frozen access holes or blocked lairs.

frozen) or altered were significantly higher within 150 m of seismic lines than beyond that distance ($G = 5.530$, d.f. = 1, $0.01 < p < 0.025$). In comparison, fate did not differ significantly as a function of distance from control lines ($G = 0.071$, d.f. = 1).

Of structures found by searching seismic lines, we examined whether there was a relationship between fate and the time when the seismic line was worked by vibrosis equipment (i.e., vibrated). Sample groups included: 1) structures initially located after lines were laid out and cleared but before they were vibrated; 2) those initially located within 1 week of vibration; and 3) those found within 2 weeks of vibration (Table 5). No significant difference in fates among the three samples were found ($G = 1.203$, d.f. =4). Abandonment and alteration of structures within 150 m of a seismic line was greater than beyond that distance, but in these samples based on the number of structure visits (not the number of structures) the difference was not statistically significant ($G = 4.767$, d.f. = 2, $0.05 < p < 0.10$).

Fates of 15 complex lairs, including 10 confirmed pupping lairs, are summarized in Table 6. Variables in these data included seismic versus control samples, distance from search lines, method of initial examination, and evidence and nature of fox activity at the structure. Fates were recorded after 3 weeks of the time seismic lines were vibrated. On control lines, one structure was examined 3 days after it was found, and three were examined after 3 weeks. These samples were too small to make any comparisons, although distance from seismic lines appeared to influence fate as indicated in other comparisons.

Arctic Fox Activity at Structures

Arctic foxes were present in relatively low abundance on the fast ice throughout the period of our field work. In early April there was a noticeable increase in the number of fox tracks seen, indicating that more foxes were either moving closer to shore from the drifting ice or onto the fast ice from land to hunt seal pups. Our first definite evidence of the birth of a seal pup was found on 4 April. It was the undigested remains of a pup contained in fox feces. We found the first live pup in a lair on 7 April.

Remains of fox-killed pups scattered near pupping lairs were found on 10 and 26 April and 19 May, the latter being remains of an old kill exposed by melting snow.

In addition to the six pupping or complex lairs entered by foxes, eight resting lairs were entered. Thus, 18.0% of all lairs had been entered by foxes by the time they were checked for the last time. This underestimates disturbance by foxes as there was ample time for structures to be opened by foxes subsequent to our final visits. Considering lairs opened, as well as all structures simply marked by foxes (feces and/or urine present), 32.9% of all structures had been visited by foxes.

Table 5. Fates of seal structures along seismic lines as functions of time found in relation to seismic exploratory activity and distance from seismic lines. Structure visits means the number of structures X revisits to those structures.

Time found in relation to time line was vibrated[1]	Distance from seismic line (m)	Number of structure visits	Fate of structures (%): remained open and unaltered	abandoned (frozen)	altered[2]
Before line vibrated	≤ 150	27	81.5	11.1	7.4
	> 150	17	94.1	5.9	0
Within 1 week of vibration	≤ 150	16	62.5	18.8	18.8
	> 150	21	90.4	4.8	4.8
Within 2 weeks of vibration	≤ 150	12	75.0	8.3	16.7
	> 150	12	91.7	8.3	0

1 Refers to lines searched after being surveyed and cleared but prior to use of vibrosis equipment, and lines searched within indicated time periods after operations of vibrosis equipment.

2 Partially frozen access holes or blocked lairs.

Table 6. Summary of the known fates of 10 pupping and five complex lairs.

Type of search line	Type of lair	Distance from search line (m)	Method of initial examination	Activity of fox	Fate of structure
Seismic	pupping	24	Poc	lair entered	altered
	pupping	50	Poc	none	altered
	pupping	66	P	none	open
	complex	76	Poc	none	open
	complex	77	P	none	open
	complex	161	Poc	none	open
	complex	178	P	none	altered
	pupping	235	Poc	killed pup	open
	pupping	241	-	killed pup	unknown
	pupping	380	O	none	altered
	pupping	958	O	killed pup	unknown
Control	pupping	20	Poc	lair entered	abandoned
	pupping	50	P	marked	open
	pupping	500	P	none	open
	complex	1600	Po	lair entered when found	abandoned when found

1 P = probed, O = dug into by investigator, C = reclosed by investigator.

Radio Tagging and Monitoring

Terminology used in presenting results of the radio-monitoring effort is as follows:

Haulout event (seal in lair). Time interval from first to last continuous reception of signals from an individual seal during a monitoring period.

Non-haulout event (seal in water--or in another lair beyond receiving range?). Time interval within each monitoring period during which signals from tagged seals were not heard.

Monitoring period. Time from initiation of monitoring the radio receiver until there was a break of greater than 1.5 hours in monitoring time. Within a monitoring period, checks for all transmitters were normally made each 0.5 hours.

Three female seals were captured at three different breathing holes in the vicinity of Reindeer Island, and these were equipped with transmitters and released at the sites of capture. For reference, the seals were designated by the wave-length frequency of the transmitters attached to them (i.e., 165.314 mH was seal 314). Information about the three seals is presented in Table 7. All transmitters were operative from the time of attachment until termination of the tracking effort on 4 June.

When the lairs of the tagged seals were located, it was found that they were all within 1,200 m of the breathing hole at which the seals were captured. Specifically, the lair of 314 was approximately 1,000 m from the capture site, that of 515 was approximately 1,100 m, and that of 714 was approximately 900 m. Capture location, lair location, and locations of the monitoring camp are shown in Figure 3. A single monitoring camp was used. However, it was moved three times during the radio-tracking effort.

No signals from these three seals were heard from lairs other than that from which they had first been heard. Thus, each seal had only one lair within the distance over which radio signals were received. Repeated attempts were made to locate alternate lairs of each seal by using a mobile receiver unit during times when seals were away from their known lair. No alternate lairs were found, though we cannot be certain that the seals did not haul out beyond the transmission and receiving range of our equipment (judged to be around 12 km on the ground).

The radio-tracking effort occurred during a period when diel activity patterns are assumed to be undergoing considerable change. Pups are weaned by mid- to late May, thus requiring less attention of the mother. Breeding is underway in May, and the molt and haulout on the snow and/or ice surface intensify as May progresses. The latter activities involve an assumed shift of most seals from haul out in subnivean structures,

Table 7. Information about three female ringed seals captured in the vicinity of Reindeer Island and fitted with radio transmitters.

Date tagged	Transmitter frequency	Time and date first heard	Relative age	Comments
17 Apr	165.714	0530 - 21 Apr	2-4 yrs old?	sexually immature
22 Apr	165.314	1730 - 23 Apr	mature adult	probably with pup
25 Apr	165.515	1330 - 26 Apr	1-2 yrs old?	sexually immature

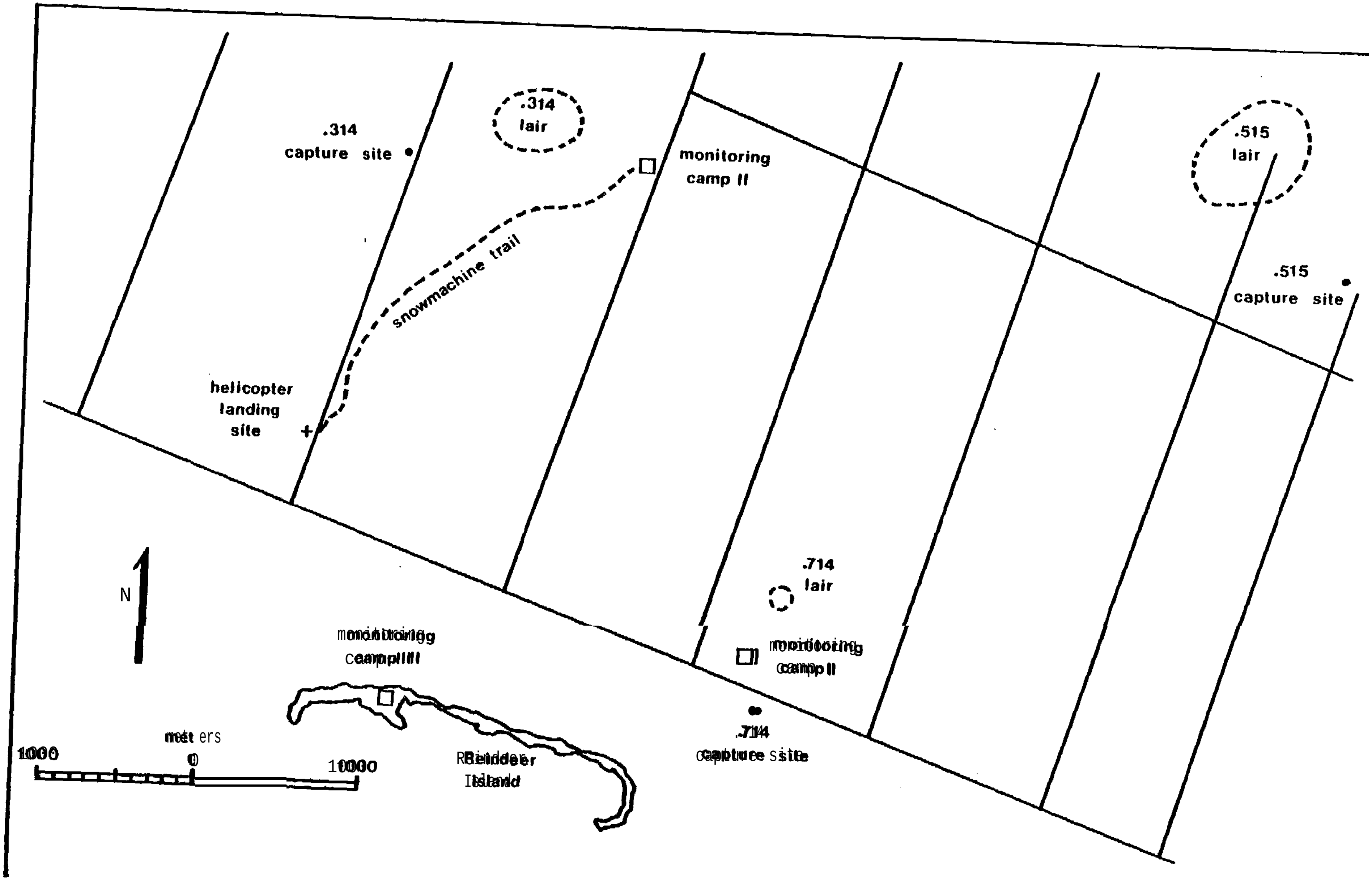

Figure 3. Location near Reindeer Island where three seals were captured, radio-tagged, and monitored. Grid lines are seismic lines searched with a dog.

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often situated in rough ice, to haulout above the snow, mainly in areas of relatively flat ice.

Although radio-monitoring efforts continued to 4 June, our analysis of haulout behavior is based on data through 24 May. This was done for a number of reasons, including the occasionally poor and more erratic reception of tagged seals, indicating that they were probably hauling out (to molt?) at sites other than their lairs; the necessity of moving our camp off the ice and onto Reindeer Island (farther away from the lairs of tagged seals); the initiation of aerial surveys and infrequent airborne monitoring; and the initiation of the intensive molt period. "

During the period between when tagged seals were first heard (see Table 7) and 24 May, number 314, an adult, spent an estimated 24% of 481 monitored hours in her lair. Seal number 515 was in her lair 17% of 484 hours monitored, and number 714 was in her lair 19% of 564 hours monitored. There were great differences in the frequency and duration of haulout events among these seals. Seal 314 had far fewer haulout and non-haulout events, and both types of events were, on the average, of longer duration than those for the immature seals.

Our data were analyzed based on three time periods, which included: all monitoring periods from the time seals were first heard through 24 May, monitoring periods from the time seals were first heard until 11 May (early sampling period), and monitoring periods from 12 through 24 May (late sampling-period): Results are presented in Table 8.

These seals showed a marked shift in diel haulout pattern between the early and late periods. Figure 4 shows haulout patterns of each seal over the entire monitoring period. Plotted points were derived as the percent of the total number of times each half hour of the day was monitored that the seal was in its lair. Figure 5 presents the same data separated into the early and late sampling periods. It is evident that during the early period seals tended to haul out more in late afternoon to midmorning, with little synchrony among them. Number 314 tended to haul out more between 1700 and 0700 hours; 515 between 0500 and 0900 hours, and again between about 1230 and 1400 hours; and 714 at various times but mainly between 1600 and 2100 hours. During the late sampling period, there was much greater synchrony in haulout patterns among seals, and the peak haulout times were roughly between 0800 and 1830 hours.

In the course of normal field operations in the vicinity of the lairs of radio-tagged seals, some information about tolerance to disturbance was obtained. This was based on the response of tagged seals which were known to be in a lair when people and/or equipment were nearby. Responses to helicopters, hovercraft, snow machines, and people on foot are presented in Table 9.

Table 8. Frequency and duration of haulout and non-haulout events for three radio-tagged ringed seals in the Beaufort Sea. Data are for: 1) all monitoring periods combined, from the time seals were first heard until 24 May; 2) from the time seals were first heard until 11 May; and 3) from 12 through 24 May 1982.

	Seal ID Number								
	314			515			714		
	Monitoring periods	Haulout events	Non-haulout events	Monitoring periods	Haulout events	Non-haulout events	Monitoring periods	Haulout events	Non-haulout events
1. All monitoring periods combined									
Number of periods and events	25	12	10	26	19	16	38	34	32
Mean duration of periods and events (h)	19.24	9.70	18.14	18.63	4.34	14.41	14.84	3.22	8.20
Standard deviation (h)	29.39	5.99	13.28	28.96	4.19′	13.99	25.69	3.18	9.95
Maximum (h)	139.75	18.50	39.00	139.75	15.00	44.50	139,75	14.00	43.50
Minimum (h)	0.30	0.50	2.50	0.03	0.50	0.50	0.25	0.33	0.42
2. From time seals were first heard through 11 May									
Number of periods and events	9	7	6	10	10	7	19	21	21
Mean duration of periods and events (h)	27.56	9.93	23.32	25.16	4.51	24.29	16.76	3.31	7.29
Standard deviation (h)	45.88	6.97	14.83	43.93	4.60	15.77	34.22	4.16	8.58
Maximum (h)	139.75	18.50	39.00	139.75	15.00	44.50	139.75	14.00	29.50
Minimum (h)	0.30	0.50	2.50	0.30	0.50	4.50	0.25	0.33	0.42
3. From 12 through 24 May									
Number of periods and events	17	5	4	17	9	9	20	13	10
Mean duration of periods and events (h)	13.67	9.38	10.38	13.67	4.15	6.72	12.24	3.06	6.57
Standard deviation (h)	10.76	5.07	5.38	10.76	3.95	5.36	10.51	3.23	5.83
Maximum (h)	39.38	15.00	17.00	39.38	11.00	13.50	39.38	9.00	17.00
Minimum (h)	0.50	4.00	4.50	0.50	0.50	0.50	0.50	0.50	0.50

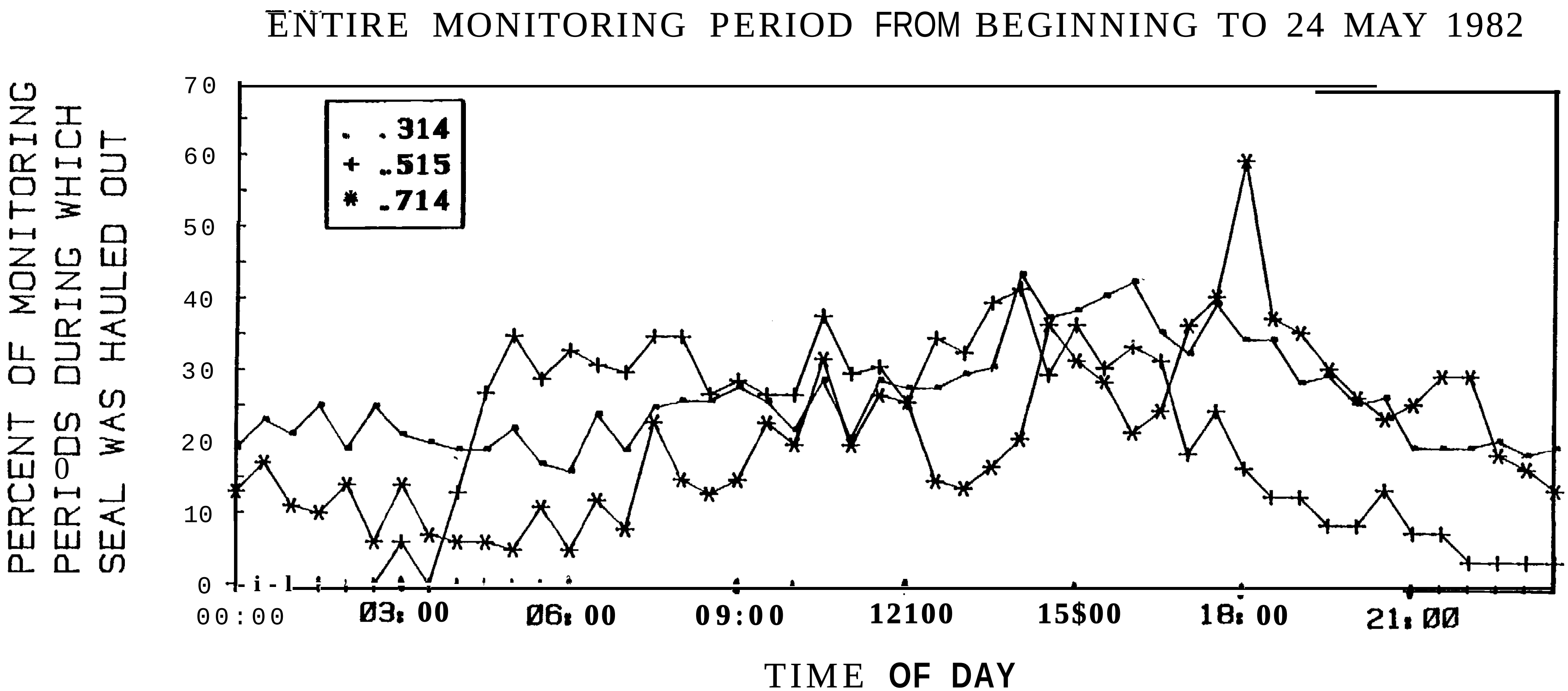


Figure 4. Haulout patterns of three radio-tagged ringed seals over the period late April to 24 May 1982. Data points are percent of the total number of times each half hour of the day was monitored that each seal was in its lair.

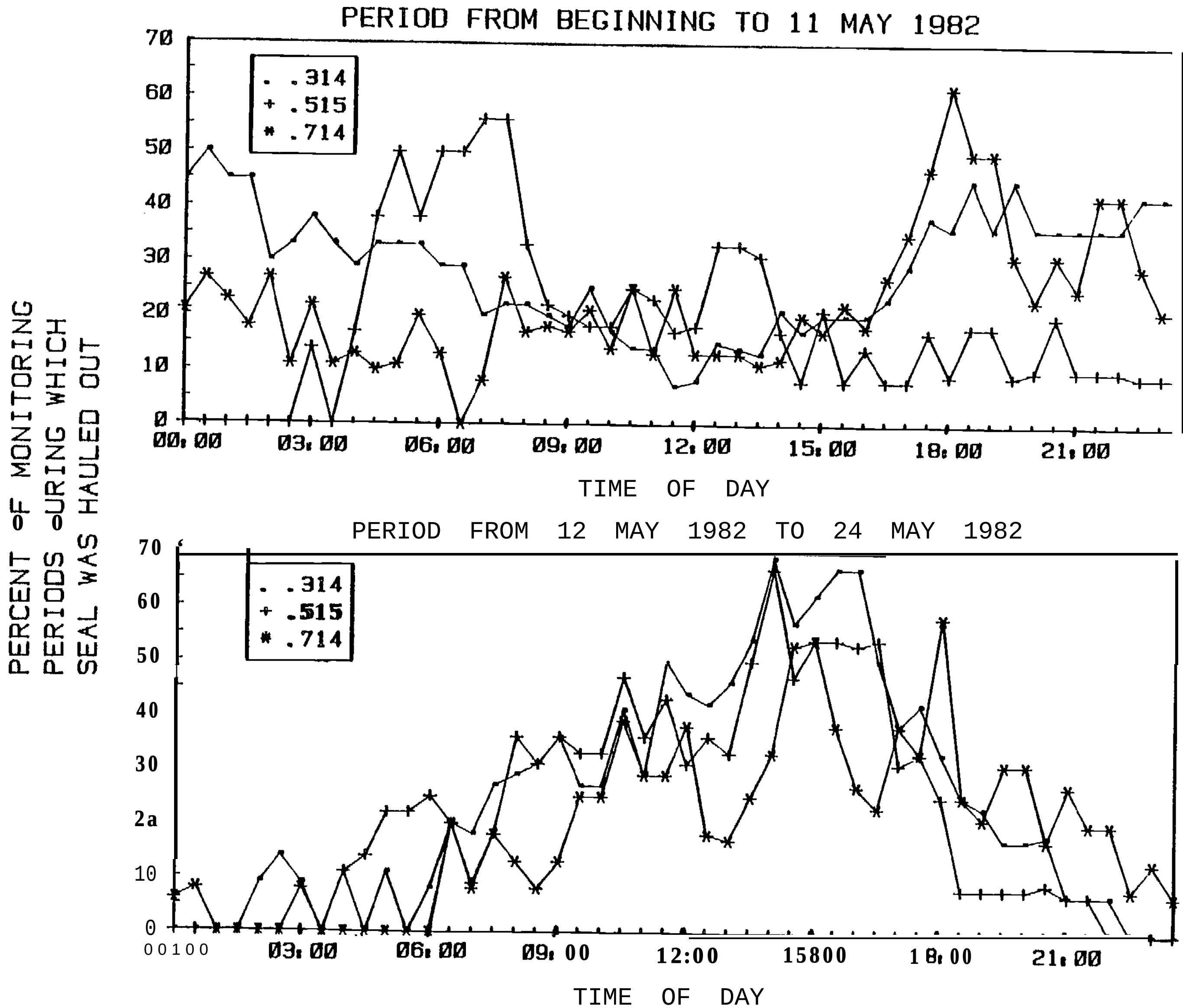


Figure 5. Haulout patterns of ringed seals analyzed as two separate sampling periods: to 11 May and 12 to 24 May. Percents derived as in Figure 4.

Table 9. Responses of radio-tagged seals in lairs to approaches of equipment or people on foot.

Sound source	Date and time	Distance from lair	Seal	Response[1]
Helicopter - landing	4/24 - 1020	± 1.0 km	714	departed
	4/30 - 1800	± 2.5 km	314	remained
	5/23 - 1030	± 3.0 km	714	remained
Helicopter - takeoff	5/23 - 1430	± 3.0 km	714	remained
Helicopter - landing	4/29 - 1140	± 3.0 km	714	departed
	5/23 - 1036	± 4.0 km	515	remained
Helicopter - flying (500')	4/26 - 1330	directly over	515	departed
Helicopter - flying (1000')	4/30 - 0945	directly over	314	departed
Helicopter - flying (1500')	5/28 - 1045	± 4.0 km	314	remained
	5/28 - 1045	± 4.5 km	515	remained
Hovercraft on ice	4/30 - 1500	± 2.5 km	314	remained
Two snowmachines passing	4/30 - 1700	± 0.55 km	314	remained
Snowmachine passing	5/18 - 1530	± 0.55 km	314	remained
Two people walking	4/19 - 1530	± 0.1 km	714	departed
One person walking	5/6 - 1740	± 0.1 km	314	departed[2]
	5/7 - 0741	± 0.1 km	515	departed
	5/14 - 1823	< 0.4 km	315	departed
	4/21 - 0815	± 0.2 km	714	remained
Two people walking	5/28 - 1415	< 0.5 km	315	departed

1 Response was whether the seal remained in the lair or departed.
2 Returned to lair when person was about 0.2 km distant.

Aerial Surveys

All survey flights in 1982 were flown with a Bell 204 helicopter. This was different from previous years in which fixed-wing survey aircraft were used. The helicopter proved to be highly satisfactory, having the advantages of slow flying speed (65 to 90 knots) and excellent forward and lateral visibility. There was initial concern that noise from this turbine-engine rotor-craft would cause seals to flee the ice surface before being seen by the observers. This concern was allayed as during the period of our surveys seals usually remained on the ice unless the helicopter passed very close to them (usually overhead). This was in some contrast to the response of seals in early May when temperatures were cooler and the molt period was apparently just beginning. At that time, seals tended to flee before the helicopter was overhead but not until they were within good visual range. It appears that these seasonal differences in tolerance are somehow related to responses associated with molt. Additionally, there may be some modification of noise from the helicopter resulting from a combination of low cloud cover and warmer temperatures as consistently prevailed during the survey period. In early May it was difficult to land within 1,000 m of a basking seal without it fleeing. During the survey period, landings within 200 to 300 m were possible. Landings and takeoffs of the helicopter produced the highest levels of noise and vibration.

Three types of survey transects were flown: those along a course which precisely replicated a series of transects surveyed in 1981; those along a series of transect lines; and those between or adjacent to seismic lines. Three legs of one flight were over drifting ice. For a single flight, direct comparisons of seismic and control transects are valid as both types of transects were adjacent to each other, usually flown as alternating legs which were temporally and spatially close and affected by the same weather conditions. Such similarities did not necessarily prevail among days or between two flights in a single day.

Survey flights were made on 25, 26, 29, 30, and 31 May, and 1, 3, and 4 June. The total length of all transects combined was 1,082.7 nm. This included 221.4 nm along the 1981-82 replicate transect, 406.2 nm along seismic transects, and 380.8 nm along control transects. Total distance of legs over drifting ice was 74.3 nm. The 1981-82 replicate line was over a course having the following waypoints: 1) 75°25.7'N, 148°15.1'W; 2) 70°34.4'N, 149°24.5'N; 3) 70°37.2'N, 149°55.2'W; and 4) 70°43.8'N, 151°56.1'W.

Sporadic monitoring of radio-tagged seals was accomplished from the helicopter (29 May to 4 June) during the survey effort. This was done mainly upon departure or return to the Deadhorse airport, when the helicopter passed close enough to receive radio signals from the tagged seals. Table 10 indicates the number of radio-tagged seals which were hauled out at the time they were monitored from the helicopter. We have no way to determine how long the seals had been or remained hauled out since airborne monitoring efforts during surveys were brief. Also, we

Table 10. The number and proportion of radio-tagged seals which were hauled out during the time of aerial surveys, 29 May to 4 June 1982. Monitoring was from a Bell 204 helicopter.

Date	Time	Flight altitude (ft)	Seals hauled out (number)	(%)
29 May	1258	1500	3	100
	1604	500[1]	1	33
30 May	1330	2000	2	66
	1501	> 1500	3	100
	1555	± 1000	2	66
31 May	1018	3500	3	100
	1210	2500	2	66
	1441	2500	3	100
	1600	2500	2	66
1 June	1015	2000	3	100
3 June	1125	510	3	100
4 June	1340	2000	2	66

1 Distance from seals and low flight altitude may have affected reception in this instance.

did not approach radio-tagged seals close enough to determine if they were in subnivean lairs (not visible) or hauled out on top of the snow. We assume the latter as the seals were apparently not in the lairs each had used through 24 May. This assumption was based upon intermittent and erratic reception of tagged seals at the ground monitoring station after 24 May, although reception of test transmitters near lairs continued to be good, and reception from the helicopter was good. Of the 12 instances of airborne monitoring in conjunction with surveys, all three seals were "up" on six occasions, two were up on five, and one was up on one occasion. The average for these monitoring periods combined was 2.4 seals or 80.6% up at any monitoring time between 1018 h and 1604 h from 29 May to 4 June.

Figure 6 shows the spatial distribution of all survey transects flown in 1982. Figure 7 shows the 1981-82 baseline transects, and Figure 8 shows the seismic and control transects. Results of this survey effort are presented in Table 11.

Replicate flights along the 1981-82 reference transects indicated a mean density (all legs combined) of 1.84 ringed seals/nm^2 in 1982, compared with a mean density in 1981 of 1.28 seals/nm^2 in a combined total of 379.4 miles of transects (Burns et al. 1981). The higher density observed in 1982 was not significantly different than that recorded in 1981 ($t = 1.0296$, $df = 32$, $p > 0.1$).

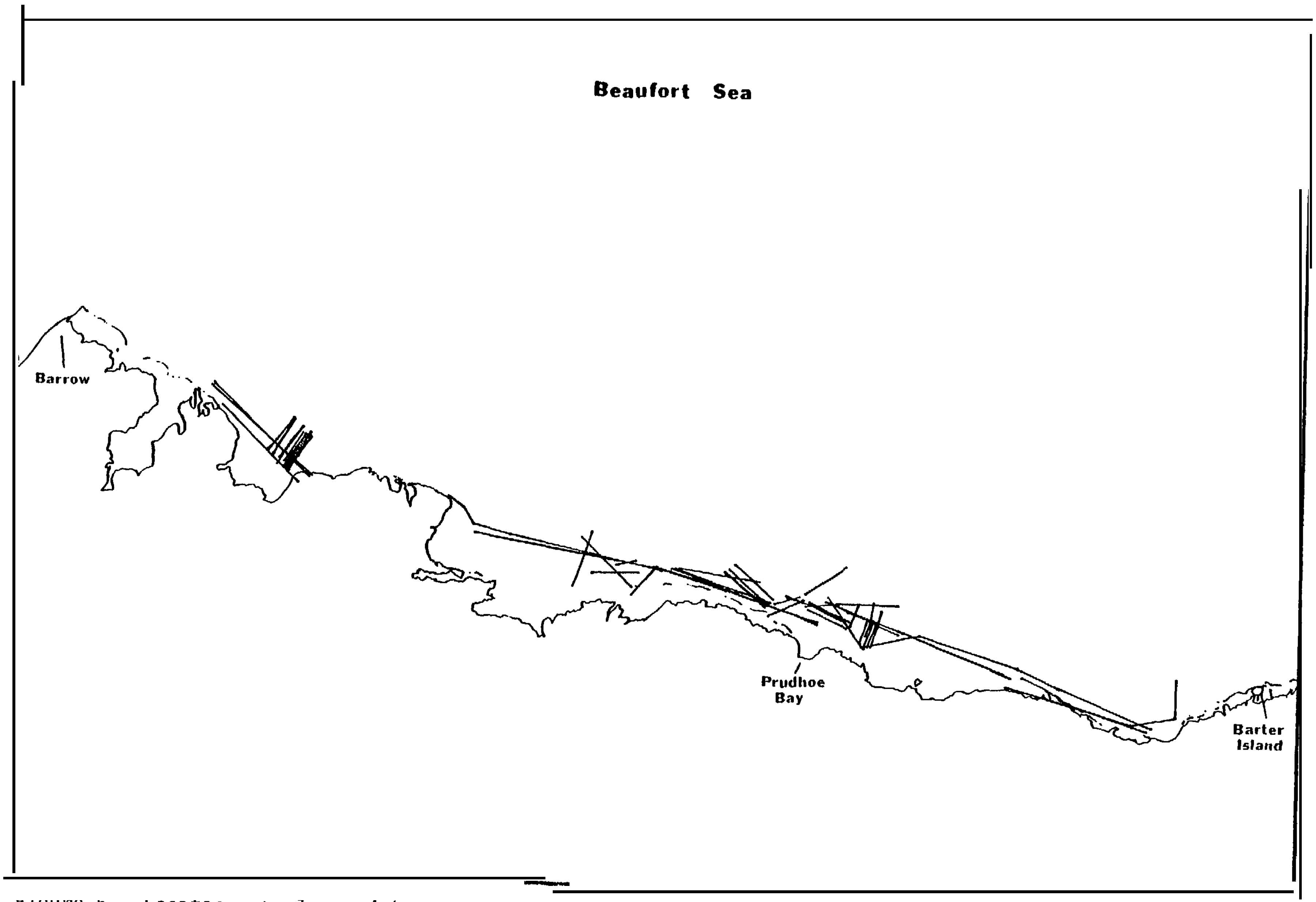
Comparisons of seismic and control transects flown in 1982 were made in two ways; firstly by comparing the pooled results from all legs of transect types flown in 1982, and, secondly, based on each flight during which both types of transects were flown.

Based on comparison of the pooled results for all seismic and control transects flown in 1982, the statistical probability that results were the same was greater than 90% ($t = 1.0296$, $df = 32$).

Comparison of individual flights during which both types of transects were flown in 1982 indicated that in all but one instance the probabilities were that there was no difference between seismic and control transects (Table 12).

In 1982, three transect legs, totaling 74.3 nm, were flown over drifting ice in the region between Flaxman Island and Barter Island on 29 May. Density of observed ringed seals in this ice type was 0.38/nm^2, considerably less than observed on most transects over the fast ice. Lower density of seals in the drifting ice was in line with results obtained in previous years in this area (Burns et al. 1978).

As in 1981 (Burns et al, 1982), we also examined the relationship between seal density and extent of deformation of fast ice. Results are presented in Table 13. Highest densities of basking seals occurred in less deformed fast ice, a correlation which has been consistent for all years in which data are available. Highest densities were in areas where deformation was less than 40%.



rıgure b. Locatıon o⁴ al aeria' survey transects f'own in May-June 1982.

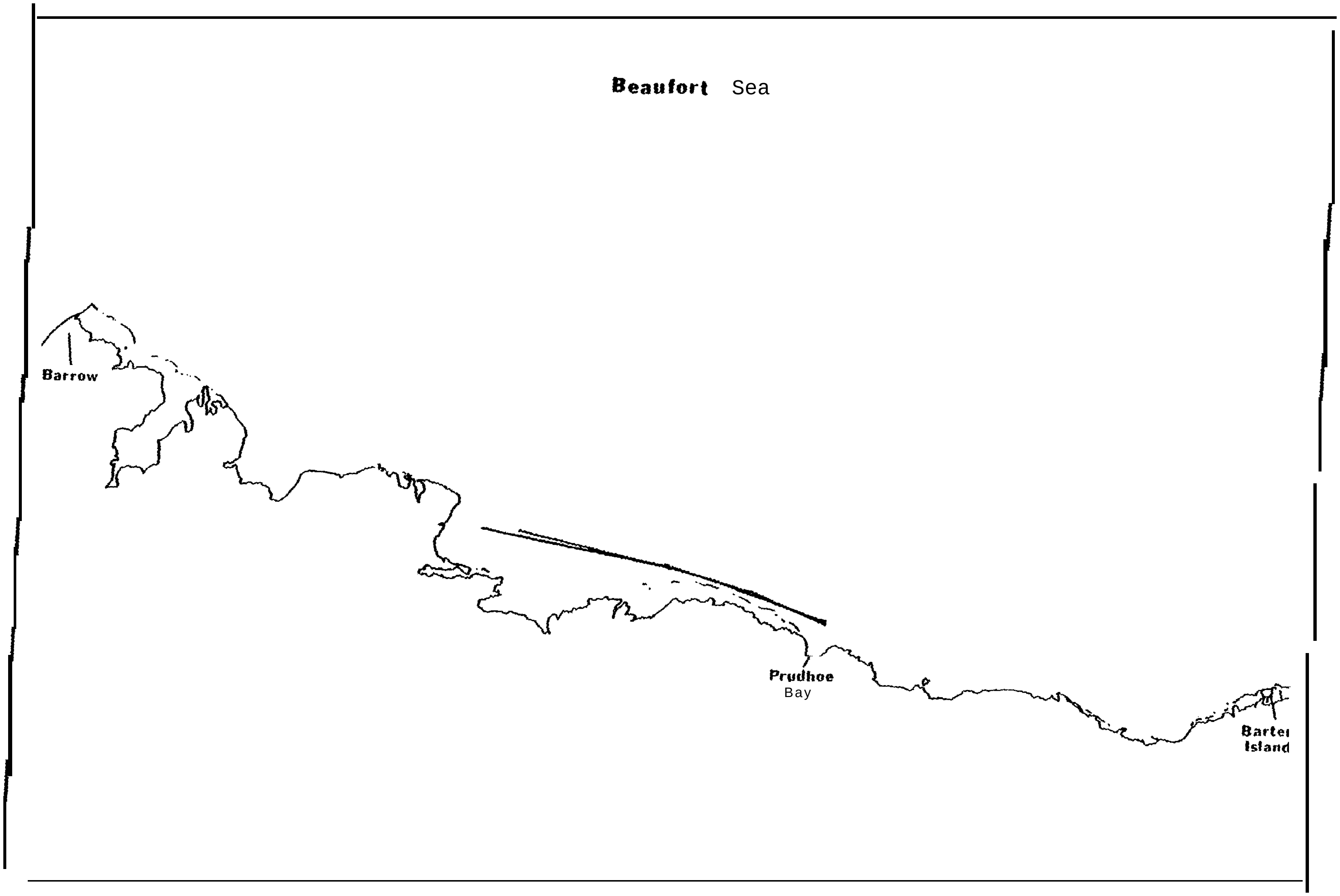


Figure 7. Location of the 1981-82 replicate baseline flown for purposes of comparing seal densities in both years.

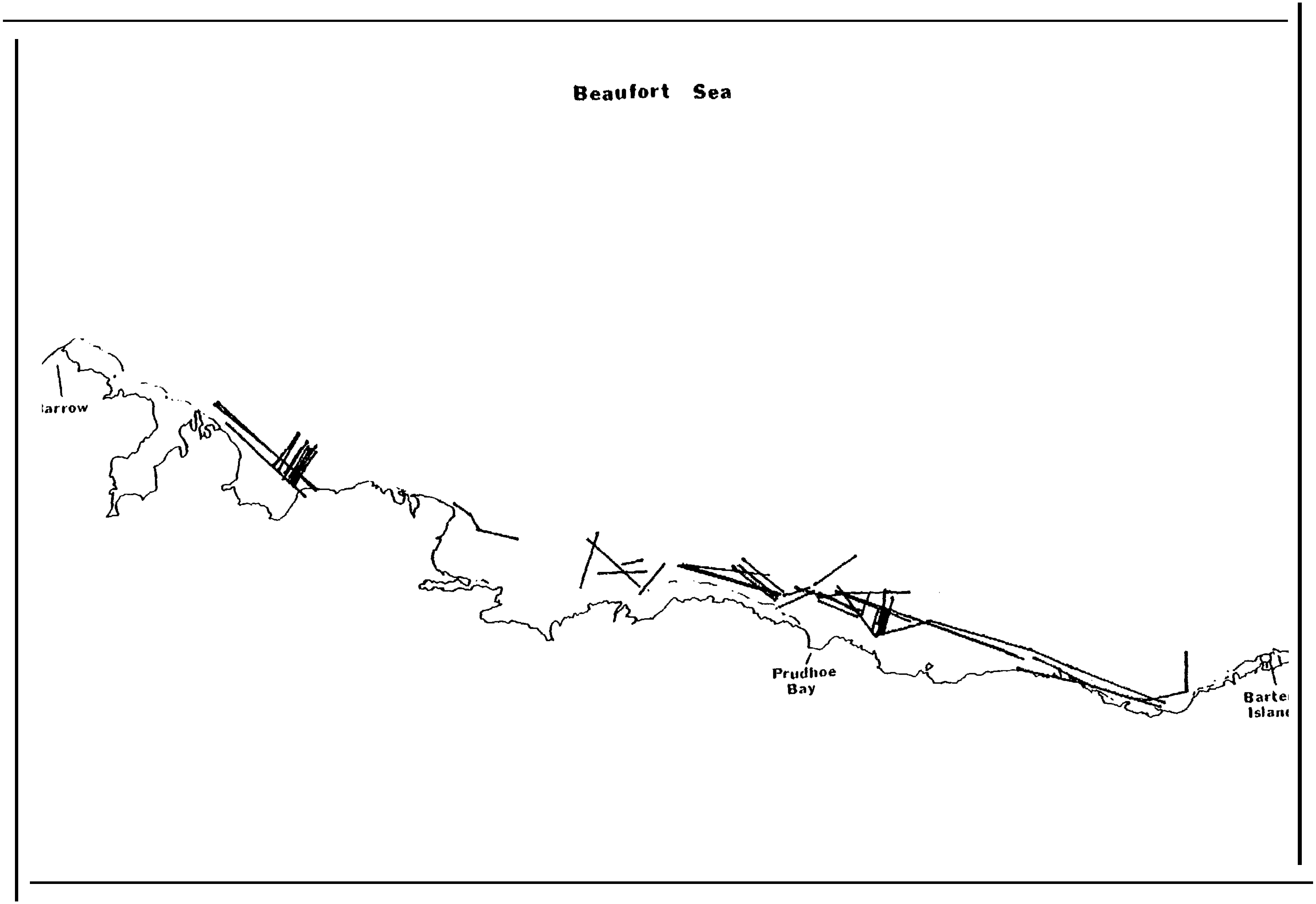


Figure 8. Location of all seismic and control transects flown in May-June 1982.

Table 11. Results of aerial surveys of ringed seals in nearshore (fast-ice) areas of the Beaufort Sea, 25 May to 4 June 1982. Samples are treated as transects along seismic lines, control transects, and transects along a baseline established in 1981.

Date and flight	Seismic transects			Control transects			1981-82 Baseline transects			All transects		
	Number of legs	Transect length (rim)	Density of seals/ nm²	Number of legs	Transect length (rim)	Density of seals/ nm²	Number of legs	Transect length (rim)	Density of seals/ nm²	Number of legs	Transect length (rim)	Density of seals/ nm²
25 May, Fit. 1							2	35.3	1.98	2	35.3	1.98
26 May, Fit. 1	7	83,7	1.00	8	71.4	0.48	2	81.2	0.69	17	236.3	0.?4
29 May, Fit. 1	4	48.9	0.41	4	52.3	0.76				8	101.2	0.59
30 May, Fit. 1	9	55.1	1.38	2	16.8	0.48				11	71.9	1.17
31 May, Fit. 1	2	15.8	1.27	3	29.5	1.29				5	45.3	1.28
Fit. 2	2	13.8	1.16	2	14.2	1.41				4	28.0	1.29
1 June, Fit. 1				4	24.8	1.21	4	69.8	2.38	8	94.4	2.07
Fit. 2	5	50.8	1.97	5	56.3	1.99				10	107.1	1.98
3 June, Fit. 1	4	40.7	1.62	6	103.7	2.14				10	144.4	1.99
Fit. 2	5	59.6	3.69				3	35.1	3.30	8	94.7	3.55
4 June, Fit. 1	4	37.8	1.69	1	11.8	1.69				5	49.6	1.69
Totals	42	406.2	1.64	35	380.8	1.38	11	221.4	1.84	88	1008.4	1.58

Table 12. Statistical probabilities that seal densities observed along adjacent seismic and control transects were the same, based on Student's t test.

Date and flight No.	Seismic transects				Control transects				Student's t test
	Number of 1 egs	Transect length (rim)	$\bar{x}$ Density of seals/ nm^2	S.D.	Number of 1 egs	Transect length (rim)	$\bar{x}$ Density of seals/ nm^2	S.D.	
26 May, Fit. 1	7	83.7	1.00	0.42	8	71.4	0.48	0.48	$t = 2.238$, $df = 13$, $p < 0.05$
29 May, Fit. 1	4	48.9	0.41	0.49	4	52.3	0.76	0.76	$t = 0.774$, $df = 6$, $p > 0.1$
30 May, Fit. 1	9	55.1	1.38	1.48	2	16.8	0.48	0.99	$t = 1.051$, $df = 9$, $p > 0.1$
31 May, Fit. 1	2	15.8	1.27	1.37	3	29.5	1.29	0.87	$t = 0.0183$, $df = 3$, $p > 0.1$
Fit. 2	2	13.8	1.16	1.01	2	14.2	1.41	0.11	$t = 0.348$, $df = 2$, $p > 0.1$
1 June, Fit. 2	5	50.8	1.97	0.33	5	56.3	1.99	0.81	$t = 0.511$, $df = 8$, $p > 0.1$
3 June, Fit. 1	4	40.7	1.62	1.20	6	103.7	2.14	1.72	$t = 0.563$, $df = 8$, $p > 0.1$
4 June, Fit. 1	4	37.8	1.69	1.12	1	11.8	1.69	0	$t = 0.00$, $df = 3$, $p > 0.1$

Table 13. Distribution of ringed seals in relation to deformation of fast ice in the study area.

Percent ice deformation	Length of tracks (rim)	Percent of transect area of designated deformation	No. seals seen within inner l/2-rim strip	Density of seals/nm^2
o-1o	505.0	50.1	423	1.68
> 10-20	202.5	20.1	211	2.08
> 20-30	129.0	12.8	88	1.36
> 30-40	76.5	7.6	40	1.05
> 40-50	32.1	3.2	11	0.69
> 50-60	49.3	4.9	21	0.85
> 60-70	11.0	1.1	5	0.91
> 70-80	3.0	0.3	0	0
> 80	0	0	0	
Totals	1,008.5	100.0	799	1.58

Comparisons of seal density in different sectors in the nearshore Beaufort Sea over several years are presented in Table 14.

VII. Discussion and Conclusions

Seal Structures

During the course of this study, we found a relatively small number of structures, particularly pupping lairs, in fast-ice regions of the central Beaufort Sea. Birth lairs comprised 7% of all structures found and only 14% of all lairs found. As yet we have no precise measure of the density of pupping lairs per nm^2, but we can say it is very low, less than 0.2 per nm^2. We found no birth lair complexes as described by Smith and Stirling (1975). Smith and Hammill (1981, p. 980) defined the birth lair complex as, "an aggregation of subnivean lairs probably maintained by the parous female as a subterritory within the area dominated by a male." The presence of such aggregations of lairs greatly increases the number and proportion of pupping lairs in a sample.

Lukin and Potelov (1978) indicated that in the White Sea there are specific regions where ringed seals apparently congregate in areas of favorable habitat to whelp. They reported finding 647 subnivean structures in one area, of which 77% were holes, 13% were simple lairs (described as "unfinished" lairs), and 9% were birth lairs. Of the 147 lairs they found, 41% were pupping lairs. The authors do not refer to lair complexes; thus, it is not possible to determine if they were present or how their presence might have influenced the proportional composition of lairs.

Density of structures in the region of the White Sea investigated by Lukin and Potelov (1978) was very high in comparison to our findings in the central Beaufort Sea. In a bay near the Solovetski Islands, they found that in waters between about 3 and 10 m deep there were 13.1 structures of all types and 1.5 pupping lairs per km2. In deeper waters of the central part of the bay, the density of all structures was 27.0 per km^2 and that of pupping lairs was 9.0 per km2.

In the eastern Canadian Arctic, Smith and Hammill (1981) reported that in an area of 1.64 km2 they found 48 structures, of which 15 (31%) were birth lairs. Of the 48 structures, as many as 35 may have been parts of seven birth lair complexes which included the birth lairs and associated structures.

Clearly, the density of all types of structures we found in the Beaufort Sea is very low. We assume that favorable habitat is the limiting factor. Ice conditions, particularly deformation and depth of snow accumulation, appeared favorable. Availability of food during winter is unknown but may be low and possibly the limiting factor.

Table 14. Average density of ringed seals per nm2 in four sectors along the Beaufort Sea coast, 1970-1982.[a]

Year	Average density in sector			
	Sector III Pt. Barrow to Lonely	Sector IV Lonely to Oliktok	Sector V Oliktok to Flaxman Is.	Sector VI Flaxman Is. to Barter Is.
1970	2.3	1.1	1.4	2.4
1975	2.8	1.4	1.0	1.8
1976	1.4	1.1	1.4	0.4
1977	1.0	0.5	0.7	1.2
1981	1.3	1.4	1.1	1.1
1982[b]	1.3	1.7	1.7	1.2
Mean	1.7	1.2	1.2	1.4

a Based on all sightings during respective surveys.

b Total miles of transects flown in 1982 were: sector III - 218.1; IV - 185.9; V - 521.7; and VI - 82.7.

The average snow depth in which single-chambered resting lairs were found during our study was 77 cm, with a range between 29 and more than 150 cm. Complex lairs, including pupping lairs, were found in snow drifts a minimum of 66 cm deep. Average snow depth at these structures was 91 cm for complex lairs and 93 cm for pupping lairs. Pupping lairs differed from complex lairs mainly in the presence of small tunnels and the greater width of the main chamber and access hole. In the former, chamber width averaged 155 cm, and width of the access hole averaged 65 cm. This compares with 94 cm and 42 cm, respectively, in complex lairs. We have no explanation for these differences other than the possibility that a pup and its mother spend more time in the lair and in scratching the snow and ice.

The question of disturbance to ringed seals resulting from seismic exploration and other activities of man within ringed seal habitat is very difficult to address. We are faced with a situation in which some degree of disturbance results from all on-ice activities of man, including those of the investigators. Thus, analyses of the effects of disturbance become examinations of degrees of difference, in a natural setting which is also changing to some extent.

Slight movements of the fast-ice cover along the Beaufort Sea coast can open cracks at any time during the winter. Such movements result from strong impingement of the drifting ice, tidal surges associated with storms (often at some distance from the study area), and perhaps even because of major changes in barometric pressure. New openings such as cracks are used by seals. We have no measure of the rate of natural abandonment and initiation of new subnivean structures throughout the freezing seasons, but this dynamic process was ongoing and structures were found along newly formed cracks.

In the study of the fate of subnivean structures as conducted, there were, in actuality, no “control” lines, only lines along which seismic activity did not occur. The so-called control lines were frequently traversed by our light snow machines and were within several miles of a shore-based construction site at which an artificial gravel island (Seal Island) was being built. Assuming that all human activities disturbed seals to some degree, our major test of potential impact becomes an analysis of structure fates in relation to distance of structures from the search lines. Biases resulting from differences in the way structures were examined were considered in such an analysis. Differences in structure fates in relation to initial method of examination by us were rather marked. Structures which we opened sustained a 24% higher incidence of abandonment or alteration.

Completely refrozen holes indicated irreversible abandonment. Once completely frozen, none were reopened by seals during the course of our field work. Altered structures (partially blocked lairs and/or partially frozen access holes) apparently represented a lesser response of seals to disturbance. Unless they became completely frozen, such altered structures continued to be used as breathing holes and in several instances were reopened and normal use resumed.

The sphere of high noise and vibration levels from seismic exploration appears to be limited to rather close proximity of the activity (A. Blix and J. Lentfer, pers. commun.). This is also suggested by our results. Abandonment and/or alteration of seal structures within 150 m of seismic lines occurred in 22 (45.8%) of 48 structures. In comparison, 21.6% of structures beyond 150 m from seismic lines were abandoned or altered. Of the affected structures within 150 m of seismic lines (N = 22), 14 were abandoned and eight were altered. These fates compare with four of eight affected structures beyond 150 m from seismic lines being abandoned and four of eight being altered. Fates of structures along control lines did not differ as a function of distance from the lines. We conclude that seismic exploration does result in displacement of seals in rather close proximity to the lines.

Our test of structure fates in relation to time when seismic lines were vibrated and distance from seismic lines was an attempt to determine whether vibrosis equipment caused the disturbance. There were no apparent differences in fates of structures found and revisited after lines were laid out but before they were shot, and those found and revisited after seismic lines were shot. These results suggest that vibrosis equipment is not necessarily the major source of disturbance, but the heavy equipment and human activity are. The impact of vibrosis equipment may, in effect, be no different than that of a bulldozer or other heavy equipment.

As indicated by Smith (1976), arctic foxes are major predators on ringed seal pups. In a study conducted in the Holman area of western Victoria Island in March through June of 1972 to 1975, he found that 34.1% of 370 lairs were marked (feces or urine present) and 30.5% were entered by foxes. The successful predation rate on seal pups over the 3-year study period was estimated to have been 26.1% (30 kills in 115 pupping lairs entered by foxes; Smith, 10C. cit.).

Although density of ringed seals in our study area was vastly lower than that occurring in the Holman area, the extent of fox activity at subnivean seal structures and the incidence of predation on pups were quite similar to that found by Smith (op. cit.). Of 157 structures found by us, 32.9% were marked by foxes. Of 15 complex lairs we followed over a period of several weeks (10 of which were pupping lairs), six (40%) had been entered by foxes, and pups were killed at three of 10 (30%) pupping lairs.

Radio Telemetry

Three ringed seals, all females, were live captured and radio transmitters attached to them. Of this very small sample, two were juveniles. We had assumed that most would have been sexually mature adults. Additional sampling of seals inhabiting the Beaufort Sea fast ice would be necessary to verify that a high proportion of young seals overwinter there. It appears probable as suggested by the seals we captured and by the low proportion and density of pupping lairs found during searches by the dog.

The method of attaching radio transmitters to the seals with epoxy glue was quite satisfactory. All transmitters remained attached through the end of our study on 4 June. The transmitters themselves had a rather limited range when the receiving station was on the ground. If possible, radio reception over a longer distance would be desirable in future studies. The use of "dummy" transmitters located near structures used by radio-tagged seals was found to be essential for verifying that equipment was functioning normally when tagged seals were not heard for long periods of time.

Until 24 May, the three tagged seals showed 100% fidelity in use of their respective lairs. Each lair was relatively close to the breathing hole at which each seal was captured. These findings support the idea of territoriality in ringed seals, as long believed by Eskimo hunters and most investigators familiar with this species.

Our data suggest that after 24 May the three radio-tagged seals began hauling out at sites other than the lairs each had previously occupied. Reception at the ground station from the dummy transmitters remained good, while that from the seals became poor and erratic. Ground monitoring was discontinued when no seals were heard at the ground station, yet all of them were heard while monitoring from the helicopter. The seals were hauling out at different locations which were either shielded . (by ice ridges) from line-of-sight reception on the ground or at locations beyond the receiving range of our equipment on the ground.

Thus, it appears that territories of the three tagged seals began to break down after about 24 May. The first basking seal-we saw in our study area was on 3 May. They did not begin to appear in numbers until 21 May, after which date they were quite ubiquitous. An independent, weaned, and molted pup was encountered on 19 May, basking on snow above a pupping lair. The access hole in this lair had refrozen to a diameter which precluded passage of an adult seal and hindered that of the pup.

Changes in the diel haulout pattern of the three tagged seals were evident between the last decade of April and 24 May. There was little synchrony in haulout behavior during the monitoring period ending 11 May. Increasing synchrony occurred after 11 May, and it appears probable that it would have been even more marked during the peak period of molt, which occurred after termination of our ground-monitoring effort. During aerial surveys conducted between 29 May and 4 June, the three seals were monitored 12 times on an irregular basis between 1018 h and 1604 h. On the average, 2.4 seals (80.6%) were hauled out.

Duration of haulout events remained the same during the early and late sampling periods (approximately 20 April to 11 May and 12 to 24 May). The average duration of haulout events of seal 314 (an adult female) was

9.9 h in the first sampling period and 9.4 h in the second period ($\bar{x}$ = 9.7 h). For 515, it was 4.5 h and 4.2 h ($\bar{x}$ = 4.3 h), and for 714 it was 3.3 h and 3.1 h ($\bar{x}$ = 3.2 h). However, the time of day during which these haulout events occurred changed from mainly late afternoon through morning in the first sampling period to midmorning to early evening during the second sampling period. There was great variation in the number of haulout events for each seal over the entire sampling period ending 24 May. Seal 314 hauled out 12 times in 32 days, 515 hauled out 19 times in 29 days, and 714 hauled out 34 times in 34 days.

Aerial Surveys

In 1982, aerial surveys were conducted using procedures which were basically identical to those employed in previous efforts within the study area. However, a turbine helicopter rather than a fixed-wing aircraft was used. We noted no differences in response of the seals during the survey period to the helicopter, provided it was flying straight and level. Previous experience (Burns and Harbo 1972) showed that the response of ringed seals to aircraft noise was highly variable, depending on time of the year, prevailing weather, and proximity to bluffs, cliffs, and headlands. In the vicinity of bluffs and cliffs, seals were apparently alarmed by the noise of the aircraft in combination with reflected noise from elevated coastlines. The coastline in our study area was uniformly of low relief, In the period 25 May to 4 June, when surveys were conducted, it was found that seals could be approached quite closely. Often the helicopter passed 500 ft directly overhead, and seals remained on the ice. This was not the case in the instances when seals were resting in their lairs or when the survey helicopter began passing back and forth in circles.

Overall mean density of basking seals on the fast ice in 1982 was slightly higher but comparable to results obtained in previous years. Along a 1981-82 baseline transect flown specifically for the purpose of comparing seal densities in these 2 years, higher but comparable numbers of seals were counted in 1982. The density in 1982 was $1.84/nm^2$ compared to $1.28/nm^2$ in 1981. The difference between years was not statistically significant. Densities along almost the entire coast from Dease Inlet to Barter Island were also similar to those recorded in several previous years and were uniformly low.

Extent of ice deformation is an important factor with respect to where seals haul out to bask. Higher densities are found in the less deformed ice. Even in areas of highly deformed ice, seals lie on the widely scattered flat pans, where their ability to see around them is not obstructed. There appears to be a threshold size of open area around seals basking in rough ice areas, although we did not investigate this question.

Seal lairs were invariably in or closely adjacent to ice hummocks and ridges. Basking seals were seldom seen in these settings. Obviously,

VIII. Future Study Needs

Our studies in the Beaufort Sea have shown that very low densities of ringed seals occur in this region and that perhaps it represents an extreme case in comparison to other coastal areas. At present it is desirable to encourage initiation of surveys designed to quantitatively assess regional differences in the density and kinds of subnivean structures present in different parts of the coastal zone. Important whelping areas are not randomly or uniformly distributed. Those which may exist should be identified.

If continued investigation of the potential impact of seismic exploration as it affects use of subnivean structures by ringed seals is contemplated, such work should not be undertaken until a more appropriate opportunity arises. In this instance, the appropriate opportunity involves on-ice seismic exploration in a region where the density of ringed seals is significantly higher than in the Beaufort Sea. Our studies have indicated a rather narrow sphere and limited duration of impact, and the results may be adequate for purposes of regulating seismic exploration.

Telemetry studies should be continued with the major objectives of:

1) describing different patterns of lair use by seals of both sexes and various ages;

2) determining tolerances of seals in lairs to different kinds of man-caused disturbance, as indicated by whether seals remain in or depart from lairs when subjected to different circumstances; and

3) examining the frequency, duration, and diel patterns of haulout events over a time period from late March to mid-June.

The latter objective is of major importance from the standpoint of determining what proportion of ringed seals is hauled out and visible at times when aerial surveys are conducted.

The applicability of bioacoustical methods as a means of censusing ringed seals and determining responses to disturbance (as may be indicated by changes in the kinds, frequency, and duration of vocalizations) remains to be adequately tested. Pending availability of funds and appropriate expertise, such an approach should be attempted.

IX. Literature Cited

Burns, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi seas. J. Mammal. 51:445-454.

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

Burns, J. J. and T. J. Eley. 1978. The natural history and ecology of the bearded seal (Erignathus barbatus) and the ringed seal (Phoca hispida). Pages 99-160 in Environmental Assessment of the Alaskan Continental Shelf, Annu. Rep. Principal Investigators, Vol. 1. Outer Continental Shelf Environmental Assessment Program, Boulder, Colo.

Burns, J. J., B. P. Kelly, and K. J. Frost. 1981. Habitat use and winter ecology. Pages 42-81 in J. J. Burns, L. F. Lowry, and K. J. Frost. Trophic relationships, habitat use, and winter ecology of ice-inhabiting phocid seals and functionally related marine mammals in the Arctic. Annu. Rep. RU #232 to Outer Continental Shelf Environmental Assessment Program, Juneau, Alaska.

Cummings, W. C. and D. Van Holliday. 1981. Interim report of preliminary bioacoustical studies. Appendix I in J. J. Burns, L. F. Lowry, and K. J. Frost. Trophic relationships:habitat use, and winter ecology of ice-inhabiting phocid seals and functionally related marine mammals in the Arctic. Annu. Rep. RU #232 to Outer Continental Shelf Enviornmental Assessment Program, Juneau, Alaska.

Fedak, M. A., S. S. Anderson, and M. G. Curry. 1981. Attachment of a radio tag to the fur of seals. Nat. Environ. Res. Count., Sea Mammal Res. Unit, Cambridge, England.

Johnson, M. L., C. H. Fiscus, B. T. Ostenson, and M. L. Barbour. 1966. Marine mammals. Pages 897-924 in N. J. Wilimovsky and J. N. Wolfe, eds. Environment of the Cape Thompson Region, Alaska. U.S. Atomic Energy Comm., Oak Ridge, Term.

Lukin, L. R. and V. A. Potelov. 1978. Living conditions and distribution of ringed seal in the White Sea in winter. Biologiya Morya 3:62-69. (Transl. by Plenum Publ. Corp., 1979. USC 599. 745.3:574.9. Ecology).

McLaren, I. A. 1958. The biology of the ringed seal (Phoca hispida Schreber) in the eastern Canadian Arctic. Fish. Res. Board Can. Bull. No. 118. 97pp.

Reimnitz, E. and P. W. Barnes. 1974. Sea ice as a geologic agent on the Beaufort Sea shelf of Alaska. Pages 301-353 in J. C. Reed and J. E. Sater, eds. The Coast and Shelf of the Beaufort Sea. Arctic Inst. N. Am., Arlington, Va.

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

Smith, T. G. and M. O. Hammill. 1981. Ecology of the ringed seal, Phoca hispida, in its fast ice breeding habitat. Can. J. Zool. 59:966-981.

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

Smith, T. and I. Stirling. 1978. Variation in the density of ringed seal (Phoca hispida) birth lairs in the Amundsen Gulf, Northwest Territories. Can. J. Zool. 56:1066-1070.

Sokal, R. R. and F. J. Rohlf. 1969. Biometry. W. H. Freeman and Co., San Francisco, Calif.

Stirling, I., R. Archibald, and D. DeMaster. 1977. Distribution and abundance of seals in the eastern Beaufort Sea. J. Fish. Res. Board Can. 34:976-988.

Stirling, I., H. Cleator, and W. Calvert. 1982. Underwater vocalizations as a tool for studying the distribution and relative abundance of wintering pinnipeds in the High Arctic. Rep. prepared for the Arctic Pilot Project and the Arctic Islands Operating Advisory Committee. Can. Wildl. Serv., Edmonton. 54pp.

Stringer, W. J. 1974. Morphology of the Beaufort Sea shorefast ice. Pages 165-172 in J. C. Reed and J. E. Sater, eds. The Coast and Shelf of the Beaufort Sea. Arctic Inst. N. Am., Arlington, Va.

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