# An Aerial Census of Ringed Seals, Northern Coast of Alaska

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ABSTRACT. Aerial surveys of ringed seals, *Phoca (Pusa) hispida* Schreber, in areas of land-fast ice extending along the Alaskan coast from Point Lay to Barter Island were made between 8 and 15 June 1970 in order to establish a base line index of density and distribution. Surveys of 8, 9 and 13 June were used for determining density and estimating the minimum number of seals present within 6 sectors of the total area. The density of seals in sectors east of Point Barrow was low and relatively uniform (2.28, 1.06, 1.38 and 2.43 seals per sq. mile). Within sectors southwest of this point, density was substantially higher (5.36 and 3.70 per sq. mile). The minimum number of ringed seals in all sectors surveyed was 11,612. Comparison of survey results in areas of intensive seismic exploration with undisturbed areas indicated that even with intensive disturbance associated with exploratory activities conducted within the limits imposed by state regulations, ringed seals were not appreciably displaced.

RÉSUMÉ. *Recensement aérien des phoques annelés sur la côte nord de l'Alaska.* Entre le 8 et le 15 juin 1970, les auteurs ont mené des relevés aériens des phoques annelés (*Phoca* (*Pusa*) *hispida* Schreber), dans des zones de glace fixées au rivage, le long de la côte de l'Alaska, de Point Lay à Barter Island, dans le but d'établir un indice de base de densité et de distribution. Les levés des 8, 9 et 13 juin ont permis de déterminer la densité et d'estimer le nombre minimum de phoques présents dans 6 secteurs de la région. Dans les secteurs à l'Est de Point Barrow, la densité était faible et relativement uniforme (2.28, 1.06, 1.38 et 2.43 phoques par *mile* carré). Dans les secteurs du Sud-Ouest, la densité était plus élevée (5.36 et 3.70 par *mile* carré). Le nombre minimum de phoques annelés dans tous les secteurs étudiés était de 11,612. La comparaison des résultats du recensement dans les zones d'exploration sismique intense et dans les zones non perturbées indique que, même avec la perturbation importante liée aux activités exploratrices dans les limites imposées par la législation, les phoques annelés n'ont pas été déplacés.

РЕЗЮМЕ. *Учет поголовья нерпы у северных берегов Аляски путем наблюдений с воздуха.* В период с 8 по 15 июня 1970 г. в зоне берегового припая между мысом Лей и о-вом Бартер (северное побережье Аляски) были проведены наблюдения с воздуха для определения плотности населения нерпы (тюлень Phoca hispida Schreber) и пространственной изменчивости этой плотности. Съёмки 8, 9 и 13 июня дали материал для решения указанной задачи, а также для оценки минимального числа тюленей во всех 6 секторах района исследований. Плотность населения нерпы в секторах, лежащих восточнее мыса Барроу, оказалась низкой и относительно равномерной (2,28; 1,06; 1,38 и 2,43 тюленя на кв, милю), тогда как в секторах, расположенных к юго-западу от мыса, эта плотность была значительно выше (5,36 и 3,70 тюленя на кв.милю). Общая численность нерпы во всех изученных секторах составляет минимум 11 612, голов.

Сравнение результатов съёмок, проведённых в девственных районах и в районах интенсивной сейсмической разведки, показало, что даже самые напряженные работы по исследованию Севера (не выходящие, однако, за пределы, предписанные официальными инструкциями) не оказывают заметного влияния на расселение нерпы.

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## INTRODUCTION

The ringed seal, *Phoca* (*Pusa*) *hispida* Schreber, is the most abundant pinniped of near shore areas of northern Alaska during months when land-fast ice is present. That these seals are well adapted to living in the fast ice is indicated by their decreasing density with distance from shore and, especially, with changes from land-fast to drifting pack ice (McLaren 1958, 1966; Burns 1970). This seal is an important resource to the northern coastal Eskimos because of its abundance and availability during a large part of the year when other resources are scarce.

McLaren (1958) discusses the relationships between the influence of coastline complexity on land-fast ice, and ringed seal density in relation to extent and stability of land-fast ice. The north coast of Alaska includes a basically simple coastline with no incursions of deep water, as in fiords or deep embayments. Numerous very shallow bays are present most of which are bounded on the seaward side by barrier islands. However, during months of ice cover, these are not generally available to ringed seals because of their shallow depth and continuous overflow which subsequently freezes (on top of the ice already present) to considerable thickness. Furthermore, except in river and tide channels, the ice is usually anchored to the bottom.

Recent exploration, development and initial exploitation of the northern coastal regions of Alaska, primarily for fossil fuels, has resulted in an influx of men and equipment necessary to find and extract natural gas and oil. A considerable amount of exploration has been carried out over the sea, using land-fast ice as a stable platform. Heavy equipment has been commonly driven or dragged over the ice, holes have been drilled and occasionally blasted through it and explosive charges detonated in the shallow ocean floor in conjunction with seismic profiling. Much of this activity has been within areas of ringed seal concentrations and the timing frequently coincided with periods of pupping and mating of these seals.

An aerial census of ringed seals in areas of land-fast ice along the north coast of Alaska was undertaken during June 1970 in order to: 1) develop and document a method for census of ringed seals along the northern coast of Alaska, the procedures for which could be duplicated in future years; 2) establish a base line index of ringed seal abundance during late spring, prior to the seasonal influx of migrating seals; 3) determine comparative density and distribution of ringed seals in different areas along the northern coast; 4) determine the effects of human activity in areas of land-fast ice occupied by ringed seals.

## PROCEDURES

The total area censused extended from Point Lay to Barter Island. This was subdivided into 6 sectors as follows: I. Point Lay to Wainwright; II. Wainwright to Barrow; III. Barrow to Lonely; IV. Lonely to Oliktok; V. Oliktok to Flaxman Island; and VI. Flaxman Island to Barter Island (Fig. 1). Enlarged views of sectors III and IV, which are important due to the number of replicate counts and statistical comparisons employed, are presented in Figs. 2 and 3. These 6 sectors were delineated because the settlements at the boundaries were readily

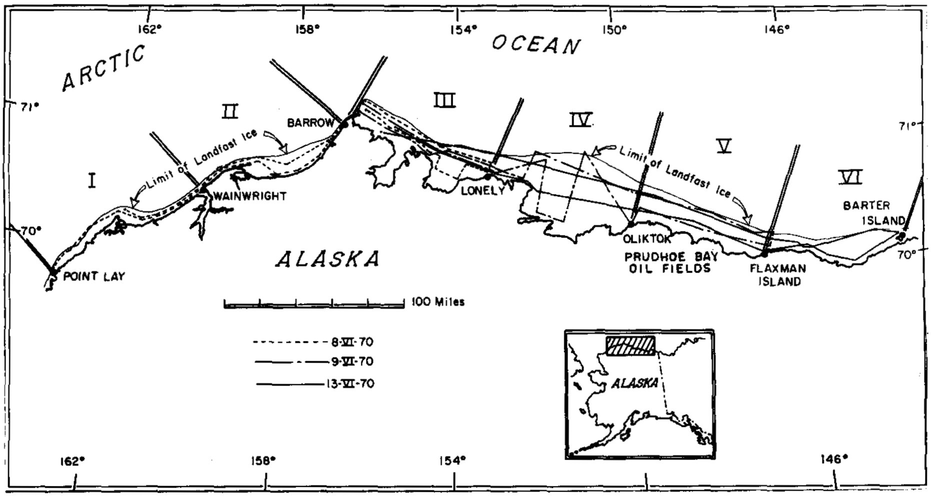


FIG. 1. Map of northern Alaska indicating the 6 sectors surveyed for ringed seals, extent of land-fast ice and the survey tracks of 8, 9 and 13 June 1970.

visible landmarks and also possessed the navigational equipment needed to establish the positions of our aircraft during the census. Each was also able to provide weather reports necessary for planning the daily census flights and for subsequent comparison of conditions during surveys. These settlements are also situated on headlands which, in some cases, mark the boundaries of areas with different oceanographic conditions. Point Barrow delineates sectors showing major differences in characteristics of currents and shore ice. Lonely and Oliktok delineate that portion of the north coast directly influenced by the Colville River.

There are major differences in extent, thickness and conformation of land-fast ice between those sectors southwest of Barrow (I and II) and those to the east (III to VI). This apparently results from the direction of coastal exposure to storms, ocean currents and the influence of drifting sea ice.

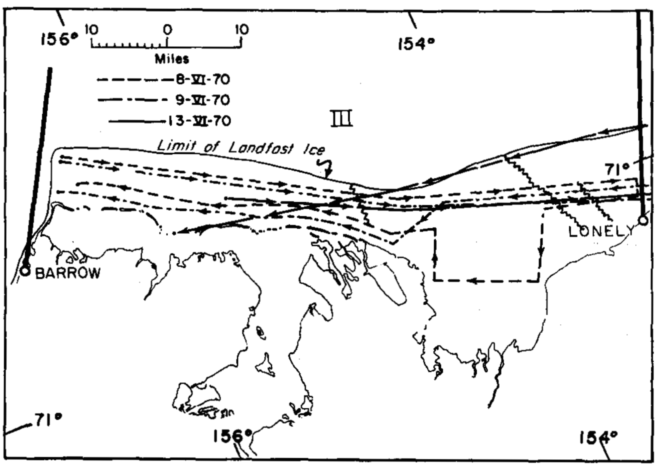


FIG. 2. Enlarged view of sector III indicating the extent of land-fast ice, the location of cracks along which ringed seals were concentrated (jagged lines) and the survey tracks of 8, 9 and 13 June 1970.

Timing of the actual surveys was based on previous experience in the Bering Sea and along the north coast. The second and third weeks of June were judged as the optimum survey period as we assumed, and subsequently verified, the maximum number of resident seals present in the area would be hauling out during that time; the sea ice between Barrow and Barter Island (the area of major interest) had not yet begun to break up; an influx of ringed seals into the area east of Barrow, resulting from seasonal migration (Johnson *et al.* 1966; Burns 1970) had not yet occurred; adverse effects of extensive water on top of the fast ice, from melt and overflow of major rivers, was not yet a problem; and conditions for observing seals were very good owing to the relatively clean ice and snow background.

Surveys were conducted mainly between the hours of 1000 and 1600 when, based on previous general observations of ringed seals, the maximum number were expected to be hauled out. The aircraft used for the surveys were a Cessna 185 equipped with wheels (average true ground speed of 130 mph) or a Cessna 180 equipped with skis (average true ground speed of 115 mph). Survey transects were ½ mile on either side of the aircraft. Therefore, each mile travelled equalled 1 sq. mile surveyed. Transect width was maintained with the use of fixed reference points on both the windows and wing struts of the aircraft. These reference points were checked each day by flying over landing fields of known length, at different altitudes. Optimum survey altitude was 500 feet. This altitude was maintained on all flights except for brief periods when fog or low cloud-cover necessitated a lower flying altitude. During these periods surveys were continued at an altitude of 300 feet. Seals were counted along continuous transects, some in excess of 200 miles long, whenever possible. Censusing was discontinued when conditions were judged as unfavourable for seals to bask (i.e., moderate to high winds, precipitation or both).

During favourable survey days conditions were excellent for counting seals in sectors III to VI. The extensive land-fast ice was flat and bright, providing good contrast. Ringed seals were generally scattered. Land-fast ice extended a

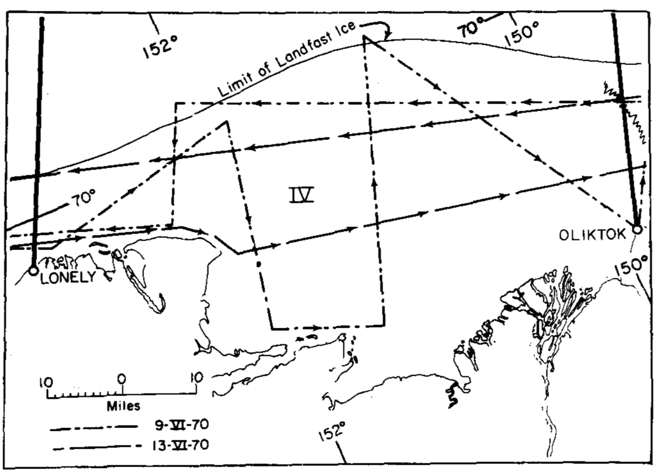


FIG. 3. Enlarged view of sector IV indicating the extent of land-fast ice and the survey tracks of 9 and 13 June 1970. No extensive cracks were present in this sector.

minimum of 6 miles off Point Barrow and 3 miles off Barter Island (both of which are prominent extensions of land) to a maximum of 48 miles off shore from the head of Harrison Bay. Mean seaward extent of land-fast ice in sectors III to VI was 12 to 14 miles.

Ice conditions in sectors I and II were very different from those in sectors III to VI. Land-fast ice was rough, with open water occasionally extending to the beach. Conditions varied from no fast ice at Point Lay, to a maximum extent of 12 miles in the area northeast of Point Franklin. Average extent of fast ice was approximately 2 miles from shore. Ringed seals were concentrated into larger aggregations than were observed in sectors III to VI. However, conditions of favourable contrast and this species' propensity for avoiding rough ice and hauling out in the smooth areas facilitated the census efforts.

All counts were made by two observers: The pilot and Burns, who sat next to him. On one flight a third observer made a replicate count within the transect on the same side of the aircraft as one of the principal observers; and on another flight, an additional observer was taken on to count all seals to the limit of visibility. These counts were compared with those obtained by the principal observers within limits of the 1 mile transect. Secondary observers were hindered by their inability to see directly in front of and directly below the aircraft.

The reaction of ringed seals to the approach of the survey aircraft was variable, apparently depending on proximity to cliffs or high headlands, position of the aircraft in relation to the seals, and weather conditions. In the vicinity of high cliffs, seals were apparently alarmed by noise from the aircraft itself and by the sounds echoing from the cliff face. When transects were within about 2 miles of a rock cliff, most seals went into the water as the plane came directly over or abreast of them. This did not interfere with many of the surveys as there were only a few high cliffs in sectors I and II and none in sectors III to VI.

During periods of marginal weather for basking, seals seemed less tolerant of the aircraft noise and were more apt to go into the water as the airplane approached. Additionally, the aircraft altitude was sometimes lower during surveys undertaken in poor weather, and this contributed to disturbance of the seals. Although several replicate counts were made on days of poor to marginal weather, the data obtained were regarded as unsatisfactory for the census.

Maximal counts along the transects were obtained on 8, 9, and 13 June. On these days some seals directly under the plane dove into the water but most merely shifted position on the ice and looked directly up at the aircraft. Those fleeing into the water were easily counted, as they did not dive until the plane was immediately overhead. The reactions of the seals during the maximal counts were markedly different from those reported by Johnson *et al.* (1966) and McLaren (1966). We assume that the conditions on 8, 9 and 13 June were optimal for basking and perhaps our surveys over large expanses of land-fast ice (as opposed to drifting pack ice or restricted bays and fiords) contributed to the relatively mild reaction of ringed seals towards the aircraft. During previous surveys, mainly in the northern Bering Sea area, from March through April (i.e., before the occurrence of optimal basking conditions), most of the ringed seals sighted had gone into the water as the survey aircraft approached (Burns, unpublished).

In addition to the ringed seal, the bearded seal *Erignathus barbatus* (Erxleben) is the only other phocid which normally occurs in the survey area during early June. This seal was commonly seen on the moving pack ice, but infrequently encountered on the land-fast ice. Only 7 were counted in sectors I and II, and none were seen in sectors III to VI, where extensive land-fast ice was present.

Replicate counts were made in several sectors during subsequent days, some during optimal conditions for basking and others, as previously mentioned, during suboptimal conditions. The numbers of times counts were made during optimal conditions in each sector were I: once; II: once; III: three times; IV: twice; V: twice; VI: once. Replicate counts made during suboptimal or poor conditions were II: twice; III: three times; I, IV, V, and VI: no replicate counts.

Most transects were more or less parallel to the coast line, but a few extended from the coast to the limit of land-fast ice. The latter were made for the purpose of determining ringed seal density in relation to distance from shore, or conversely, from the edge of fast ice.

The count tallies were mainly recorded as seals observed during 1-minute intervals. Distinction was made between individuals and groups and between dispersed seals and those occurring along cracks. Other recorded information included periodic navigation checks, ice and weather conditions, survey altitude, visibility, reaction of seals and the presence of seal holes in the ice.

Using this procedure it was possible to plot exact tracks, subdivide them into distance or time intervals, plot the exact location and extent (based on parallel replicate tracks) of cracks and to treat statistically counts of dispersed and total seals. True ground speed of the survey aircraft was determined after each survey, and again at the time of data analysis. The seaward margin of land-fast ice was plotted on a map, and the area of land-fast ice, beyond any near-shore barrier islands, in each sector was determined by use of a planimeter.

Statistical procedures by Harbo included analysis of variance for: 1) comparison of day to day variation among replicate surveys in sector III; 2) comparison of variation in seal densities at different times of the day in sector III; and 3) comparison of seal densities with respect to distance from the seaward ice edge, based on all tracts within zones 0 to 8 miles from the edge, 8 to 16 miles, 16 to 24 miles and 24 to 32 miles in sector IV.

Comparison of disturbed (intensive seismic exploration) and undisturbed areas (no seismic exploration) was complicated by the general restriction of this exploration of near-shore, shallow-water areas of sectors IV and V, where seals normally occur at very low densities. Comparisons were possible between parts of sector V, which encompasses the area immediately off shore of the Prudhoe Bay oil fields. Analysis of surveys on two different days, within this sector, indicated conflicting results. These comparisons are discussed as comparisons of mean densities.

An additional comparison of seal densities with respect to distance from shore, based on 3 generally north-south tracts in sector IV, was made using linear regression techniques.

Density of ringed seals in sectors III, V and VI was calculated as that of a) dispersed seals and b) total seals, within survey tracks. This distinction was not made for sector IV as no cracks were observed in that area. Seal distribution and ice conditions did not permit such a distinction in sectors I and II.

The minimum population estimate of ringed seals in areas of land-fast ice is basically an expansion of the total seal densities per sq. mile as determined by flights on the 3 optimum survey days, to the total area of fast ice occurring in each sector, realizing that all ringed seals are not hauled out at any one time and that future information concerning seal behaviour will be necessary before total population estimates can be obtained.

## RESULTS AND DISCUSSION

The first aspect of the survey results to be considered was the day to day variation in number of seals counted in relation to weather conditions. A résumé of weather conditions in each sector for the days on which survey flights were made is presented in Table 1. A comparison of day to day variation in numbers of seals counted in sector III is shown (Fig. 4), as it was in this sector that the greatest number of replicate counts was made. However, an additional comparison of observed seal densities recorded on 8 and 15 June in sector II is also of interest. On 8 June, an optimum survey day, the density of ringed seals in sector II was 3.7 per sq. mile. On 15 June, the day of the last survey, it was exceptionally warm and clear; only 0.6 seals per sq. mile were recorded. Conditions that prevailed during that day may have exceeded the upper limits of tolerence with regard to heat stress in ringed seals. Some aspects of the adverse effects of heat on seal pelts are discussed by Øritsland (1970).

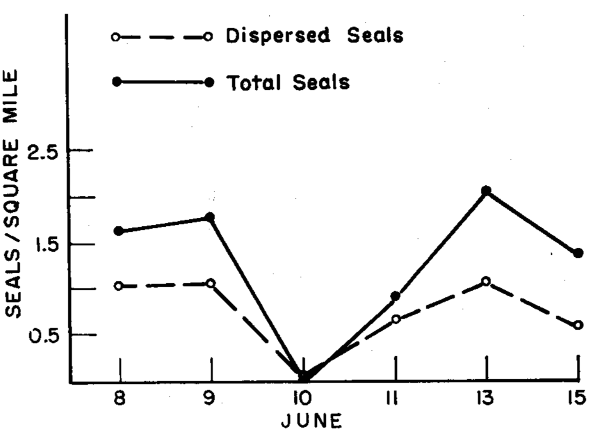


FIG. 4. Comparative density of ringed seals on the 6 days when survey counts were made within sector III. Weather conditions on each day are presented in Table 1.

The comparison in observed density between 3 optimum survey days (8, 9 and 13 June) and the 3 poor survey days (10, 11 and 15 June) showed obvious recognizable differences in means. Additional sophisticated statistical analysis of these differences was not necessary.

Subsequent counts were made in sectors III and IV by Jack Lentfer, Alaska Department of Fish and Game, Barrow, on 6 July. Lentfer reported that the land-fast ice still extended for 13 miles off Lonely at that time, but had decreased slightly from 23 miles to approximately 21 miles in the vicinity of Oliktok. The condition of the land-fast ice had deteriorated, with the formation of many small ponds, so that 10 to 50 per cent of the ice was covered by water and its general coloration had changed from white to dirty brown. The total count in both sectors, on that date, was only 3 seals. Weather conditions during this survey were as

TABLE 1. Weather conditions during survey periods recorded at each settlement.

| *Location* | *Time* | *Sky* | *Visi-bility* | *Wind Direction* | *Wind Velocity* | *Temp. (F.)* | *Chill Factor* |
|---|---|---|---|---|---|---|---|
| 8 JUNE | | | | | | | |
| *Barrow* | 0800 | Overcast | 10 Mi. | 260° | 8 Knots | 25° | 17 |
| *Wainwright* | 0800 | Overcast | 7 Mi. | 340° | 3 Knots | 30° | 27 |
| *Lonely* | 0800 | Overcast | 3 Mi.* | 360° | 10 Knots | 33° | 23 |
| *Point Lay* | 1200 | Partly Cloudy | 30 Mi. | 060° | 4 Knots | 35° | 31 |
| *Barrow* | 1700 | Overcast | — | 330° | 9 Knots | 26° | 17 |
| 9 JUNE | | | | | | | |
| *Barrow* | 0800 | Overcast | 15 Mi. | 010° | 6 Knots | 22° | 16 |
| *Lonely* | 0800 | Overcast | 10 Mi. | 020° | 5 Knots | 30° | 25 |
| *Oliktok* | 0800 | Overcast | 10 Mi. | 330° | 6 Knots | 30° | 24 |
| *Barrow* | 1000 | Overcast | — | 030° | 6 Knots | 22° | 16 |
| *Oliktok* | 1300 | Partly Cloudy | 7 Mi. | 330° | 6 Knots | 34° | 28 |
| *Flaxman Is.* | 1300 | Partly Cloudy | 7 Mi. | — | Calm | 29° | 29 |
| *Barrow* | 1600 | Overcast | — | 030° | 8 Knots | 23° | 15 |
| 10 JUNE | | | | | | | |
| *Barrow* | 0800 | Overcast | 15 Mi. | 010° | 14 Knots | 22° | 8 |
| *Lonely* | 0800 | Overcast (Snow) | 10 Mi. | 060° | 8 Knots | 28° | 20 |
| *Barrow* | 1100 | Overcast (Snow) | — | 350° | 14 Knots | 25° | 11 |
| 11 JUNE | | | | | | | |
| *Barrow* | 0800 | Overcast | 15 Mi. | 040° | 10 Knots | 27° | 17 |
| *Barter Is.* | 0800 | Partly Cloudy | 2 Mi.* | 090° | 10 Knots | 33° | 23 |
| *Barrow* | 1200 | Overcast (Snow) | — | 350° | 7 Knots | — | — |
| 13 JUNE | | | | | | | |
| *Barrow* | 0800 | Overcast | 15 Mi. | 120° | 4 Knots | 26° | 22 |
| *Lonely* | 0800 | Overcast | 10 Mi. | — | Calm | 32° | 32 |
| *Oliktok* | 0800 | Overcast | 10 Mi. | — | Calm | 30° | 30 |
| *Flaxman Is.* | 0800 | Overcast | 10 Mi. | 030° | 8 Knots | 30° | 22 |
| *Barter Is.* | 0800 | Overcast | 20 Mi. | 100° | 7 Knots | 27° | 20 |
| *Barrow* | 1000 | Overcast | 15 Mi. | 130° | 3 Knots | 29° | 26 |
| *Lonely* | 1030 | Overcast | — | 090° | 5 Knots | 31° | 26 |
| *Oliktok* | 1107 | Overcast | — | 010° | 8 Knots | 32° | 24 |
| 15 JUNE | | | | | | | |
| *Barrow* | 0800 | Clear | 20+Mi. | 240° | 5 Knots | 36° | 31 |
| *Wainwright* | 0800 | Clear | 20+Mi. | 090° | 1 Knot | 50° | 49 |
| *Lonely* | 0800 | Clear | 20+Mi. | — | Calm | 48° | 48 |
| *Wainwright* | 1220 | Clear | 20+Mi. | 200° | 3 Knots | 60° | 57 |
| *Barrow* | 1340 | Clear | 20+Mi. | 130° | 9 Knots | 46° | 37 |

*Fog.

follows: wind: 8 knots at Barrow, 5 knots at Lonely and 5 knots at Oliktok; sky: high overcast; temperature in the low 40's (°F.); visibility: 10+ miles.

Other flights in late June and early July, although not quantifiable in terms of seals per sq. mile, clearly indicated substantially fewer ringed seals than during the census (Ehredt, personal communication).

The survey flights of 8, 9 and 13 June were chosen for estimating minimum seal populations in each sector. Comparison of counts made on those days, within sector III, indicated no significant difference at the 5 per cent significance level for either dispersed or total seals ($F<1.0$). Mean densities of total seals sighted were 1.68, 1.83 and 2.15.

The test of effectiveness of the primary observers by addition of secondary observers indicated that the former were adequate. On 9 June the secondary observer (Lentfer), scanning within the transect, sighted no seals that had not been counted by the principal observers. On 13 June the secondary observer (Oscar Ahkinga), counting all seals to the limit of visibility, recorded fewer animals than the principal observers did within the transects (1,043 versus 1,158, on a flight from Barrow to Barter Island and return).

The influence of a) distance from shore, and b) distance from the edge of land-fast ice, on the number of ringed seals sighted per survey mile was examined by analyzing survey results from sector IV, in which land-fast ice was most extensive. Linear regression analysis was employed using number of seals per sq. mile of survey as the dependent variable and distance from shore or the edge of land-fast ice as the independent variable.

Data from the 3 longest tracks of 9 June, which extended from the land-fast ice edge to shore, were analyzed using 2-minute and 4-minute segments of the survey tracks. A positive correlation between seal density and distance from shore was evident. This relationship was significant at the 13 per cent significance level for 2-minute segments and at the 20 per cent level for 4-minute segments. Although these results were not conclusive, they indicated that seal density might have increased slightly with increased distance from shore.

Additional regression analyses were performed to determine whether the observed change in density was related more to distance from the seaward edge of land-fast ice than to distance from shore. The fast ice area of sector IV was subdivided into 4 zones: 0-8, 8-16, 16-24 and 24-32 miles from the seaward edge of the ice. Only data from the first 3 zones of the combined surveys of 9 and 13 June were used in this analysis because sample size within the zone closest to shore (24-32 miles from the ice edge) did not warrant its inclusion in the analysis. Two-minute and 4-minute segments of the survey tracks were used.

No significant relationship between seal density and distance from the seaward edge of land-fast ice existed ($F<1$ for 2 and 4-minute segments across all 3 zones). However, there was a relationship within zones 8 to 16 miles and 16 to 24 miles from the ice edge. Within these two zones, seal density increased slightly as distance from the ice edge increased. The relationship in both of these zones was significant at the 5 per cent level. Within the zone bordering the seaward ice edge (0 to 8 miles) no relationship of seal density and distribution to distance from the ice edge existed. Results of these comparisons are presented in Table 2.

TABLE 2. Results of statistical comparison of ringed seal density in relation to distance from the seaward edge of fast ice within sector IV.

| *Distance from ice edge* | 2-Minute time segments of survey tracks | | | | 4-Minute time segments of survey tracks | | | |
|---|---|---|---|---|---|---|---|---|
| | *N** | $\bar{Y}$ *(Seals)* | *Regress. Coeff.* | *F Test* | *N** | $\bar{Y}$ *(Seals)* | *Regress. Coeff.* | *F Test* |
| 0-8 Mi. | 37 | 1.297 | −0.038 | <1 | 18 | 1.238 | −0.063 | <1 |
| 8-16 Mi. | 18 | 0.947 | 0.172 | 7.81 | 9 | 0.884 | 0.089 | 2.2 |
| 16-24 Mi. | 19 | 1.092 | 0.196 | 4.77 | 9 | 1.153 | 0.224 | 5.65 |

*The number of track segments of the indicated time interval.

The minimum size of the resident ringed seal population in areas of land-fast ice between Point Lay and Barter Island was estimated from the survey data at about 11,600 animals (see Table 3). However, this estimate represents only those seals hauled out on the ice. Additional information concerning ringed seal behaviour is necessary before an accurate population assessment can be made. The observed density of ringed seals, by sectors, showed a close similarity in sectors III through VI, east of Barrow (especially the density of dispersed seals) and a considerably lower density than that in sectors I and II, southwest of Barrow. It may be argued that restricted fast ice in sectors I and II resulted in an increased concentration of ringed seals during the survey period. However, a trend of higher seal density to the south, during the period when ice is present in the southern Chukchi and Bering Seas has been indicated also by previous surveys at the same time of year in such areas as the northwestern coast of the Seward Peninsula and Kotzebue Sound (Burns, unpublished).

TABLE 3. Results of an aerial census of ringed seals between Point Lay and Barter Island, Alaska. Data are from survey flights of 8, 9 and 13 June 1970.

| *Sector* | *Calculated Area of fast ice (sq. mi.)* | *Fast ice surveyed* | *Density of seals/sq. mi.* | | *Estimated population* | *Standard deviation* |
|---|---|---|---|---|---|---|
| | | | *Dispersed* | *Total** | | |
| I | 207 | 69.92% | — | 5.356 | 1,109 | 323.64 |
| II | 483 | 36.97% | — | 3.697 | 1,786 | 298.81 |
| III | 1,088 | 41.19% | 1.445 | 2.278 | 2,479 | 424.07 |
| IV | 2,601 | 15.64% | 1.0582 | 1.0582** | 2,752 | 237.24 |
| V | 1,165 | 26.19% | 0.934 | 1.378 | 1,607 | 292.96 |
| VI | 773 | 19.90% | 1.049 | 2.430 | 1,879 | 525.85 |
| TOTAL | | | | | 11,612 | |

*Includes dispersed seals and those occurring in large groups and/or along extensive cracks.
**No extensive cracks in the fast ice occurred within sector IV.

Differences are also apparent in the biological and oceanographic aspects of these two areas. Sectors between Point Lay and Point Barrow border the Chukchi Sea which is entirely underlain by the biologically rich Bering-Chukchi Platform. Those sectors to the east of Point Barrow are in the less productive Beaufort Sea

(Nansen 1902; Johnson 1956). Zooplankton of the Beaufort Sea are mainly holoplanktonic forms; whereas in the Chukchi Sea, these forms are augmented by an increase in the meroplankton, "showing the more neritic character of the water" (Johnson 1956).

Historically, the relative abundance of ringed seals in areas east of Point Barrow has always been low, as indicated by the small number of prehistoric Eskimo village sites. Comments by contemporary hunters, pilots and other residents also point out the marked difference in abundance (and availability) of ringed seals.

In view of the intensive offshore seismic exploration along the northwest coast, it was desirable to determine whether any adverse effects of this activity on ringed seal distribution could be detected in the survey data. Seismic profiling, using shore-fast ice as a working platform, is accomplished by drilling through the ice and down into the bottom sediments. According to regulations of the State of Alaska, the "shot" hole must be drilled a minimum of 20 feet into the sea floor for a charge of up to 20 pounds of dynamite. Where a larger charge is desired, additional drilling at the rate of 1 foot per additional pound of explosive is required, with a maximum allowable total charge of 50 pounds. Seismic exploration conducted in this manner, over water deeper than 3 fathoms, must be terminated by 15 March of each year according to regulation.

The exploration companies working in this area were contracted by the larger oil companies and were in competition with each other. As a result, successive series of shot lines (as many as 5 in the area under consideration) were laid out and detonated within the span of a few months while favourable ice conditions prevailed. Many of these lines paralleled or intersected one another extensively.

For the purposes of this comparison, all seismic lines detonated between 1 January and 15 March 1970 were plotted on a map. The areas of intensive exploratory activity were delineated, and comparisons of seal densities within and outside of these areas were made. Sector V provided the most suitable basis for comparison due to the greater extent and intensity of seismic exploration than in the other sectors. Comparisons were based on survey flights of 9 and 13 June, in which 76 sq. miles of disturbed area and 83 sq. miles of undisturbed area were surveyed. The calculated mean density of seals in the combined total area of disturbed and undisturbed zones was 1.05 seals per sq. mile on 9 June, and 0.95 on 13 June. On 9 June the density of ringed seals was slightly greater in the disturbed area (1.25 seals per sq. mile) than in the undisturbed area (0.91 seals per sq. mile). On 13 June the reverse was true, with 0.81 and 1.18 seals per sq. mile respectively. Only dispersed seals were included in this comparison, as no cracks with the associated concentrations of seals were present in the zones of seismic exploratory activity. The results indicate that even in areas of intensive seismic disturbance, within the limits imposed by state regulations, ringed seals were not appreciably displaced. Furthermore, most of the dispersed seals within the seismic areas were near individual exit holes in ice ranging in thickness from 1.4 m. to 2.3 m. The presence of these holes before deterioration of the ice and snow cover indicates that they were enlarged breathing holes that had been maintained by the seals throughout the winter.

Although we think our population estimates are reasonable reflections of both density and minimum number of ringed seals within the indicated areas of land-fast ice, they may be only a general indication of the total ringed seal population off the coast of northern Alaska. Additional surveys, including flights over land-fast ice, the adjacent drifting seasonal ice pack, and the polar ice will be necessary to determine relative ringed seal abundance in each of these different ice zones. In the southern areas of its range, the ringed seal occurs mainly along the coast (Burns 1970). However, due to the increased thickness and stability of drifting ice in the northern areas, a higher proportion of ringed seals may occur farther off shore.

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## REFERENCES

BURNS, J. J. 1970. Remarks on the distribution and natural history of pagophilic pinnipeds in the Bering and Chukchi seas. *Journal of Mammalogy,* 51(3): 445-54.

JOHNSON, M. W. 1956. The plankton of the Beaufort and Chukchi sea areas of the Arctic and its relation to hydrography. *Arctic Institute of North America Technical Paper* No. 1. 32 pp.

JOHNSON, M. L., C. F. FISCUS, B. T. OSTENSON and M. L. BARBOUR. 1966. Marine mammals, *In* N. J. Wilimovsky and J. N. Wolfe (editors). *Environment of the Cape Thompson Region, Alaska.* U.S. Atomic Energy Commission, Division of Technical Information, pp. 877-924.

MCLAREN, I. A. 1958. The biology of the ringed seal (*Phoca hispida* Schreber) in the eastern Canadian Arctic. *Fisheries Research Board of Canada Bulletin,* 118: 97 pp.

————. 1966. Analysis of an aerial census of ringed seals. *Journal of Fisheries Research Board of Canada,* 25(5): 769-73.

NANSEN, F. 1902. *The oceanography of the North Polar Basin. Norwegian North Polar Expedition, 1893-1896. Scientific Results,* v. 3, No. 9, 427 pp. (Not seen; cited by Johnson, M. W., 1956).

ØRITSLAND, N. A. 1970. Iceburning of seal pelts. *Saertrykk av Fiskets Gang,* 38: 689-91.