A Survey of the Breeding Habitat of Ringed Seals and a Study of Their Behavior During the Spring Haul-out Period in Southeastern Baffin Island

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No. 1561

February 1980

A SURVEY OF THE BREEDING HABITAT OF RINGED SEALS AND A STUDY OF THEIR BEHAVIOR DURING THE SPRING HAUL-OUT PERIOD IN SOUTHEASTERN BAFFIN ISLAND

Addendum to the Final Report to the
Eastern Arctic Marine Environmental Studies (EAMES) project

by

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DISCLAIMER

The data for this report were obtained as a result of investigations carried out under the Eastern Arctic Marine Environmental Studies (EAMES) program, sponsored by the Department of Indian Affairs and Northern Development (DIAND) to provide information necessary for the assessment of oil and gas exploration and development proposals.

Any opinions including conclusions and recommendations in this report are those of the authors and are not necessarily shared by the Government of Canada or those funding the studies.

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ABSTRACT

Smith, T. G. and M. O. Hammill. 1980. A survey of the breeding habitat of ringed seals and a study of their behavior during the spring haul-out period in southeastern Baffin Island. Addendum to the Final Report to the Eastern Arctic Marine Environmental Studies (EAMES) project. Can. MS Rep. Fish. Aquat. Sci. 1561: 47 p.

A survey of the breeding habitat of ringed seals *Phoca hispida* in the fast ice was carried out between Loks Land and northern Brevoort Island on the southeastern Baffin Island coast. Maximum densities of birth lairs were found in the hummocky ice of Cyrus Field Bay and in one small bay on the south coast of Brevoort Island. Polar bear predation at birth lairs was found to be a significant mortality factor for ringed seals. Most of the seals killed were pups born between mid March and mid April. Rain and a thaw in early April melted the sub-nivean birth lairs, causing the pups to be exposed, and resulted in some mortality both by exposure and increased predation. Wind and low temperatures, expressed as wind chill, were significantly negatively correlated with numbers of seals hauled out on the ice in May. Peak diel densities were seen from 09:00 to 18:00. The sex ratio in the study area showed a predominance of female ringed seals. Seals orient with their heads pointed in the direction of the prevailing wind, which could be an adaptation for examining the area for polar bears. Aggressive behavior occurred between a mother and a weaned pup, and between a presumed mother seal and an adult seal lying near her pup. Seals use olfaction, sight and hearing to examine their surroundings for potential threats. They appear to become habituated to their surroundings and to various disturbances, including the sight of observers moving on the land. A hole-to-seal ratio of 6:1 (48:8) was calculated for part of the study area. However a utilized hole-to-seal ratio was calculated as 2.5:1. An independent calculation involving identified seals showed that they utilized 2.09 haul-out positions on the average. One ringed seal identified in 1978 was resighted in 1979, the first known record of site fidelity in this species.

Key words: Ringed seal, predation, mortality, behavior.

RESUME

Smith, T. G. and M. O. Hammill. 1980. A survey of the breeding habitat of ringed seals and a study of their behavior during the spring haul-out period in southeastern Baffin Island. Addendum to the Final Report to the Eastern Arctic Marine Environmental Studies (EAMES) project. Can. MS Rep. Fish. Aquat. Sci. 1561: 47 p.

Un inventaire de l'habitat de reproduction du phoque annelé, *Phoca hispida*, dans les glaces côtières, a été effectué sur la côte sud-est de la Terre de Baffin, entre Loks Land et la partie nord de l'Ile Brevoort. Les densités maximum de repères de naissance ont été observées dans la glace hummockée de la Baie Cyrus Field et dans une petite baie de la côte sud de l'Ile Brevoort. La prédation aux repères de naissance par l'ours polaire représente un facteur de mortalité significatif pour le phoque annelé. Les bébés phoques nés entre la mi-mars et la mi-avril constituent la majorité des proies tuées par l'ours. Tôt en avril un dégel, accompagné de pluies, a fait fondre les repères de naissances sousnivaux, exposant ainsi les bébés phoques et entrainant des mortalités à la fois par exposition et par prédation. On a obtenu une corrélation significativement négative entre le vent et les basses températures exprimés en terme de facteur de refroidissement, et les nombres de phoques étendus sur la glace en mai. Le maximum journalier des densités a été observé entre 0900 et 1800 heure. Le rapport des sexes dans la région étudiée indique une prédominance des femelles phoques annelés. Les phoques s'orientent tête pointée dans la direction du vent dominant et ceci pourrait bien être une adaptation pour déceler la présence des ours polaires dans leur environnement. Un comportement agressif a été observé entre une mère et un phoque sevré de même qu'entre une présumée mère phoque et un adulte étendu près de son bébé. Les phoques utilisent la vue, l'ouie et l'odorat pour explorer leur environnement à la recherche de menaces possibles. Il semblerait s'habituer à leur milieu de même qu'à quelques perturbations incluant la vue des observateurs se déplaçant sur la terre ferme. Un rapport trou: phoque de 6:1 (48:8) a été calculé pour une partie de la région étudiée. Toutefois, un rapport trou utilisé: phoque a été calculé comme étant de 2.5:1. Indépendamment, un calcul incluant des phoques identifiés montre qu'ils utilisent une moyenne de 2.09 points de sortie de l'eau chacun. Un phoque annelé identifié en 1978 a été revu en 1979, démontrant ainsi une certaine fidélité quant au site occupé; ceci constitue la première évidence de fidélité à un site chez cette espèce.

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INTRODUCTION

This report deals with the assessment of the fast ice breeding habitat of the ringed seal, *Phoca hispida* in the coastal region of southeastern Baffin Island (see Fig. 1), between Loks Land (62°30'N, 64°30'W) and the northern tip of Brevoort Island (63°40'N, 64°20'W). Surveys were carried out between 19 March and 22 April 1979 from our camp at Winton Bay (64°28'N, 64°42'W) near the southern end of Beekman Peninsula. The period 25 April to 2 June 1979 was spent at Popham Bay (64°17'N, 65°30'W) conducting a second year of behavioral observations on seals resident in the land fast ice of the area. This study should be considered as an addendum to the final report (Smith, Hammill, Doidge, Cartier and Sleno, 1979), originally submitted to the EAMES project in January 1979.

MATERIALS AND METHODS

The sea ice breeding habitat of ringed seals was searched with a trained dog followed by a snowmobile, using the method described by Smith and Stirling (1975). In this way both inshore and offshore ice, including the nearshore tidal crack zone, hummocky ice and pressure ridges, were examined. A total search time of 19.65 hours was accumulated over a 35 day period. The majority of searches were made from our central camp at Winton Bay. Searches of Cyrus Field Bay and the area north and east of Brevoort Island were carried out from small mobile camps.

Biological specimens were collected on an opportunistic basis; altogether 20 ringed seals were sampled, either adults shot as they lay hauled out on the ice, or pups caught in the birth lairs. Notes were kept on all kills of seals and scavenging by polar bears, *Ursus maritimus*, and arctic foxes, *Alopex lagopus*. Biological measurements, weights, ageing and reproductive tract analyses follow the methods of Smith (1973).

Behavioral observations totalling 236 hours were made at Popham Bay over a period of 24 days. Two observation points were used on the north coast of South Bay, including the original observation point of the 1978 study (Fig. 2). The methods used in this study and schedule of observations are essentially the same as outlined in Smith, Hammill, Doidge, Cartier and Sleno (1979). At the end of the observation period the South Bay observation area was thoroughly searched for seal holes by use of the dog and a snowmobile. The locations of all holes were mapped using a theodolite and a measured base line. Distances between some holes were verified with a Truemeter measuring wheel.

RESULTS

Birth Lair Survey

The survey region between Loks Land and Brevoort Island was divided into four search areas (Table 1). Within each area several categories of ice were searched, including flat offshore ice, pressured nearshore tidal zone ice, small bay ice, and consolidated pack ice along the edge of the fast ice, or floe edge.

Table 1 shows the type and number of subnivean structures found in the four survey areas. The number of minutes of search per subnivean structure and the search time per birth lair are also given.

The Robinson Sound area (Fig. 1) includes Winton Bay and three other bays to the north on the mainland coast, plus the small bays on the west and south coast of Brevoort Island. The offshore ice of Robinson Sound contained very few breeding females. Most of the structures found in the flat stable ice, which had a minimum of snow cover, were simple breathing holes. Fourteen of the 30 structures found were occupied by rutting males, which probably indicates that some mature females were somewhere in the near vicinity.

The four bays on the mainland side of Robinson Sound contained no birth lairs at all. Again, roughly half of the breathing holes were occupied by rutting males.

The small bays of Brevoort Island contained variable numbers of subnivean lairs. One bay on southern Brevoort Island that contained many ice hummocks, previously recognized by us as the ideal type of ice for breeding (Smith and Stirling, 1975), had the highest density of birth lairs found in the study. This bay, which was only about 4.4 km^2 in area, yielded one lair every 1.34 minutes of search time and one birth lair every 1.84 minutes. No rutting males were found, even though the flat ice in Robinson Sound, immediately adjacent, contained a high number.

The second most productive ice type, in terms of birth lairs, was found along the nearshore, pressured tidal zone of Robinson Sound. There one birth lair was found for every 20.01 minutes of search and one subnivean structure for every 6.67 minutes. Again the majority of structures (14 of 18) were occupied by non-rutting animals.

A search of 16.55 minutes along the consolidated pack ice within one-half mile of the floe edge on the southeastern side of Brevoort Island yielded no lairs at all. The unstable, recently fractured ice was clearly unsuitable habitat for the building or maintenance of subnivean lairs.

The second survey area was Cornelius Grinnell Bay (Fig. 1), from Allen Island (Ukulialuit) in the west to Roger Island in the northeast, and Butler Bay (Kangertukuta) in the southeast.

In this region two main categories of ice types were searched: flat offshore ice in Cornelius Grinnell Bay; and the ice of smaller bays, including the nearshore, pressured tidal zone. In this area the flat offshore ice contained one birth lair every 37.39 minutes of search compared to one per 33.29 minutes for the nearshore, pressured ice. The offshore ice contained 12/27 or 44.4% lairs used by rutting males as compared to 12/45 or 26.6% in the bays and tidal zone. A large proportion of birth lairs in the flat offshore ice were found within 300 to 400 m of land and along old cracks that had formed across the mouths of bays.

Searches in the region to the northeast and east of Brevoort Island were made on flat offshore ice as well as in the pressured ice of the tidal zone along the shoreline of islands.

Very few subnivean structures were found in the offshore ice (one every 9.05 minutes of search), but birth lair densities in the tidal zone were similar to those found in Cornelius Grinnell Bay. More search time is required to adequately describe this area since the existence of open water, caused by strong currents between the islands, restricted the area of search and limited the effectiveness of the survey.

Apart from the one small bay on southern Brevoort Island, Cyrus Field Bay was the only other area in the whole survey region that contained highly productive hummocky ice. The area searched was bounded to the northeast by George Henry Island and extended to the edge of the fast ice between Cape Farrington (Tuarparjuararjuin) and Lupton Channell (Ikirasirkuta). One birth lair was found for every 3.87 minutes of search and one subnivean structure for every 1.76 minutes in an area of ice of approximately 256 km^2. Only 7/44 or 15.9% of the structures had been occupied by rutting males.

The inner or westward part of Cyrus Field Bay was much less densely occupied. There, birth lairs were found both in flat offshore ice and in the nearshore, pressured tidal zone. Densities of birth lairs (one every 15.8 minutes of search) were comparable to densities found in the tidal zone in the Robinson Sound area. Again few rutting males occupied the subnivean lairs in this area.

A search was conducted along the hummocky fast ice within 500 m of the floe edge. Birth lair densities dropped from one per 3.87 minutes of search in the hummocky ice to one per 40.7 minutes; and total subnivean structures from one per 1.76 minutes of search to one per 9.0 minutes. This gives a clear demonstration that ringed seals tend to avoid constructing their subnivean lairs in areas of greatly unstable ice.

Table 2 shows the percentages of the different kinds of lairs found in the three major ice categories: flat ice, tidal zone ice, and hummocky ice. Since Cornelius Grinnell Bay contained no ice hummocks, direct comparison with the other two search areas of Robinson Sound and Cyrus

Field Bay are not altogether appropriate. It is evident that areas of ice hummocks are the most productive, containing the highest proportion of birth lairs; thus, in Robinson Sound, 72% of all birth lairs were concentrated in hummocky ice, even though it was found only in a few small bays. The second most important ice type for birth lairs in both Robinson Sound and Cyrus Field was flat offshore ice. In Cornelius Grinnell Bay, which differed in not having any ice hummocks, most birth lairs were found in flat offshore ice (64.3%) while the remainder (35.7%) were found in the tidal zone along the shore line.

In Robinson Sound and Cornelius Grinnell Bay subnivean structures occupied by rutting males (*tiggak*) were mainly found in the flat ice areas, whereas in Cyrus Field Bay most male-occupied lairs were found in hummocky ice. It is possible that this difference could have resulted from mistakes in identification of adult males in Cyrus Field Bay since the survey there was made later in the season at a time when a large proportion of them had ceased rutting, making their odor difficult to distinguish from the ordinary smell of seal. A weak decreasing trend of male-occupied lairs with time is shown by the plot of the number of these structures found during the period 19 March to 22 April (Fig. 3). Better data on numbers and distribution of rutting males could be obtained by starting surveys as early as the beginning of February.

Bear predation of ringed seals, especially at birth lairs, was a significant factor in the present study. Table 3 summarizes the number of predation attempts and kills in the three main ice types for all the survey areas. Most predation attempts were made in hummocky ice (84%), and involved structures recognized by us as birth lairs (73.3%). An overall predation success of 33.3% was measured, whereas in 42.4% of birth lairs dug open the bear succeeded in killing at least the pup. Only one kill of an immature female (a 5-year-old) was recorded in a structure other than a birth lair. Thirteen seals were killed in birth lairs, only one of which was a mother (7.7%). Most of the carcasses of the 12 pups found appeared to have been eaten by scavengers rather than the bears.

Very few predation attempts were made by arctic foxes. Only six digs were seen, four of these on birth lairs. The only pup killed by a fox was found on the ice well away from any subnivean structure. It is likely that the pup had wandered away from its breathing hole when it was killed. The low incidence of digs and signs of foxes at seal lairs in this study area contrasts sharply with the situation in western Victoria Island (see Smith, 1976).

Bears hunting in all habitats except hummocky ice appeared to search for birth lairs mainly in the tidal zone. Few bear tracks were seen in the areas of offshore flat stable ice, except where they were crossing to and from the pack ice at the floe edge. Large numbers of bear tracks were seen along the floe edges of Cyrus Field Bay and on southeastern Brevoort Island.

In the hummocky ice of Cyrus Field Bay, study of bear tracks gave us some insight into the bears' hunting behavior. The low number of excavations of structures other than birth lairs indicated a strong selection for lairs containing pups. In two cases the combination of bear tracks and previous history of wind direction showed that bears must have scented haul-out lairs occupied by rutting males and had not bothered to dig them out. One birth lair complex was apparently scented but no predation was attempted, indicating that the bear could probably tell if the lair was occupied. However, it could also simply mean that the bear had recently fed and was not actively hunting.

Bears prey upon subnivean lairs by one of two approaches. Often, as soon as the lair is scented, the bear will run to it and break in the roof by jumping on it, thus pinning and killing the pup before it can escape into the water. Another method, well supported by evidence from tracks, is for the bear to dig open the two or three lairs in a birth-lair complex, and wait for the pup. In both cases the pup is usually not consumed by the bear, whose real prey is the mother seal. Bears are known to consume mainly the blubber layer of adult seals which is almost nonexistent on neonates.

In the one instance cited where both the female and pup were killed in the same birth lair, the bear had eaten an estimated 29 kg of fat and skin from the large female, which weighed about 64 kg. The pup carcass was not found, but lanugo in fox scats found on the ice near the birth lair indicated that a pup had been killed. Both foxes and ravens still present in the area must have carried the remains of the pup away from the kill site.

The two principal scavengers of seal remains left by bears are the arctic fox and the raven *Corvus corax*. Of the two, the raven is most abundant in this area of southeastern Baffin Island and appears to utilize the major portion of pup carcasses left by bears. Ravens were often sighted in the vicinity of bears and appear to follow them as they travel over the sea ice. Up to six ravens at a time were seen as early as late March on bear kills. Ravens are known to remain in the area during the winter.

Ringed seal pups, scavenged or killed by arctic foxes, can be distinguished by the way in which the foxes skin the carcasses. One carcass was found with the skin turned inside out and cleaned almost completely of flesh and fat. Kumlien (1879) states that the Inuit of Cumberland Sound believed that foxes skinned seal pups by starting at the mouth and gently peeling the skin back, thus avoiding eating any of the long white lanugo. Three other parts of pup carcasses, possibly torn up by ravens after the foxes had done with them, had been carefully skinned and cleaned of fat and flesh. This behavior is surprising in the light of much evidence from the western arctic which indicates that the whole pup carcass is consumed by the foxes, with the exception of skull, bones and claws (Smith, 1976).

Certainly no skins of the type described above were ever found in the Amundsen Gulf area, and are unknown to the Inuit of the western arctic. This difference in the behavior of foxes in the two widely separated regions is probably attributable to the much greater number of foxes in the western arctic.

Biological Specimens

Twenty specimens were collected during the birth lair survey, of which 10 were seals older than one year of age and 10 were pups. Of the eight whole pups that were weighed, six showed an umbilicus of between 3.0 to 6.5 cm in length, indicating that they were not more than a week old. They were collected between 21 March and 14 April 1979 and weighed on average 6.07 kg (range 4.50-9.10 kg). Two older pups were collected in mid April, neither of which had an umbilicus evident. One, a male, weighed 14.9 kg and the other, a female, weighed 13.4 kg (Table 4).

Only four older male seals were collected, all while lying hauled up on the ice near their breathing holes. Two were rutting males (*tiggak*), as evidenced by their smell; both were 13 years old and measured 139 cm and 149 cm from nose to tail respectively. Two other males, one 8 years old and the other 6 years old, did not appear to be in reproductive condition. The 6-year-old was shot on the flat ice off Nuvuit in Cyrus Field Bay. It had extensive fresh bite marks in the axilla, ventral and hind flipper areas and was very thin, with a blubber thickness over the sternum of only 3.5 cm. The 8-year-old, which apparently was not in rut, was in much better condition with a 6.5 cm blubber layer and no fresh scars.

Five older female seals were collected. One 5-year-old was still a virgin while all others were sexually mature. Three of the females were caught with their recently born pups while one other had been killed by a bear and the pup had also probably been caught. Of the four females caught with their pups none had yet ovulated. One of these females caught on 13 April was with a pup that had no umbilicus evident and was therefore possibly 2-3 weeks old. Thus ovulation after parturition might take place later in the season than previously thought. In two of the four seals, the largest follicles (11 X 7 mm and 10 X 7 mm) occurred in the ovary not involved in the previous pregnancy. In another female the largest follicles were of equal size in each ovary. In the remaining female one ovary contained the corpora albicantia of two previous pregnancies plus one follicle measuring 6 X 5 mm. The other ovary contained no follicles and showed no signs of post-reproductive activity.

Seven of the ten pups collected during this study were caught on the ice after their birth lairs had collapsed. Five of these were newborn pups with the umbilicus still evident, all of which were caught between 10 and 17 April. Weather conditions prevailing during this period ranged from -14.5 to +8.9°C with wind chill values ranging from 251.9 to 1288.6 kcal/m^2/sec.

Behavior Study

Average daily weather conditions at Popham Bay for the period 1 to 31 May are shown in Table 5. Counts and meteorological notes were made at each hour during the period of observation. The mean windchill (Siple and Passel, 1945) was calculated by averaging windchills computed for each hourly wind and temperature recording. All meteorological measurements were made at the observation tent which was situated on the north shore of the study area approximately 20 m above sea level. Because of this, the wind and temperatures recorded are not considered to be entirely accurate representations of the conditions experienced by the seals lying near their breathing holes on the surface of the sea ice.

It is likely that the shelter created by the depressions resulting from the melting of the snow surface in which the seals were lying produced more favorable microclimate conditions. Nonetheless the number of seals hauled out in South Bay and Outer Bay showed significant negative correlations with windchill. Regression analysis of the numbers of seals on values of windchill for South Bay gave a regression equation of $y = 10.82 - 0.006\ X$ ($F = 54.20$, $P < 0.001$). Correlation analysis for the same data gave a correlation coefficient of $r = -0.444$ ($t = 7.32$, $P < 0.001$). Similar analyses for South Bay for the period 25 to 31 May, during which continuous observations were made, gave a regression equation of $y = 9.35 - 0.006\ X$ ($F = 32.68$, $P < 0.001$) and a correlation coefficient of $r = -0.487$ ($t = -0.487$, $P < 0.001$). Analyses for Outer Bay for the same continuous observation period gave a regression equation of $y = 44.7 - 0.017\ X$ ($F = 10.76$, $P < 0.001$) and a correlation coefficient of $r = -0.312$ ($t = 3.27$, $P < 0.01$).

The number of different haul-out locations in South Bay used by seals on any day in May varied from two to 13 (Table 6). In 1978 the maximum number of positions occupied by seals on a single day during the period 8 May to 2 June was also 13. In that year a noticeable increase in numbers occurred thereafter, due to rapid melting of the ice at the southwest corner of South Bay. In 1979 the same melt pattern was observed and it is likely that a similar sudden increase in density occurred during the early part of the month of June.

Altogether 32 positions were occupied by seals in South Bay during May 1979. Figure 4 shows their frequency of use, expressed as a percentage of the total number of days of observations, and Figure 5 shows the percentage of total positions occupied as the season progressed.

The seasonal increase in the daily maximum density of hauled-out ringed seals on the ice of South Bay and Outer Bay, and for the combined areas, is shown in Figure 6. Densities in both South Bay and Outer Bay were similar to those seen at the same dates in the 1978 study. Since the observations in 1979 terminated on 2 June we did not observe the marked increase in densities seen to occur after that date during the 1978 study. The maximum density of 6.93 seals per km^2 occurred in South Bay on 21 May 1979 (Fig. 6). In 1978 the maximum density of 7.36 seals per km^2 was recorded on 2 June, indicating a very similar abundance of seals in the study area at the same time of year. In Outer Bay the peak density of 15.82 seals per km^2 occurred on 2 June 1979 (Fig. 6). In 1978 the peak density before 2 June occurred on 31 May and was seen to be 16.08 seals per km^2, again a remarkably similar abundance of seals. The combined densities for South Bay and Outer Bay for the period ending 2 June was 12.71 seals per km^2 in 1979 and 13.81 seals per km^2 in 1978.

As in 1978, observations were made mainly during the period 08:00 to 16:00 each day. Generally, the maximum number of seals was reached before the observations terminated. A continuous watch was maintained from 11:05 on 25 May to 18:00 on 31 May 1979. Figures 7 and 8 show the hours of the day when the maximum numbers of seals were hauled out in South Bay and Outer Bay respectively. For both areas the peak of the diel cycle of haul-out occurred between 09:00 and 18:00. This contrasts somewhat with the results obtained from the continuous watch done later in the season in the period 13 to 16 June 1978. Then, a much greater variation in the time of the peak of haul-out was observed, with maximum numbers often seen in the late hours of the night.

Except for the period from 11:00 on 25 May to 18:00 on 31 May, observations were not made continuously but were made hourly between 08:00 and 18:00. Because of this it is not possible to give accurate figures for the total time spent at a haul-out session by an individual seal. Figure 9 shows the longest period of time spent on the ice by seals observed each day during the observation season. There appeared to be a trend toward an increasing amount of time spent on the ice as the season progressed. On 26 May during the period of continuous observation, one seal was seen to stay on the ice for 40.5 hours, which is almost twice the maximum time spent at one session recorded in the 1978 study, much later in the season.

As in 1978, individual seals were identified by making line drawings of their distinctive pelage markings. Table 7 lists 13 seals which were identified and resighted on at least one other day. The maximum number of resightings of an individual animal was of a female pup, often accompanied by her mother. This seal was seen for a total of 14 days at the same position from 11 to 31 May. In 1978 one individual, an adult female, was resighted 18 times during the period 11 May to 6 June. In 1979, resightings were made at 12 different haul-out positions in South Bay as opposed to resightings at only eight positions in 1978.

The maximum number of nursing pairs seen in Outer Bay on a single day was four, observed on 13 May. Nursing pairs were seen throughout the observation period ending on 2 June. In 1978 the maximum number of nursing pairs observed was three and none was seen after 16 June. In South Bay a maximum of four nursing pairs was observed on 2 June 1979. Sightings of nursing pairs in South Bay were made on 23 of the 24 days of observations, the last being observed on 30 May. In 1978 only three sightings were made in South Bay which indicates a definite increase in the number of parturient females in the immediate study area in 1979.

A gradual increase in the number of groups of seals occurring at haul-out positions was noticed as the season progressed. The first group of two seals was sighted on 4 May in Outer Bay, with a maximum of eight groups of two seen on 29 May. In 1978 the peak time of haul-out for groups of two or more seals occurred on 29 June.

The sex of the seals sighted in South Bay was recorded whenever possible. In 1979, 40% of the individual seal sightings in the area (129/324) were successfully sexed, as opposed to 24% (47/200) in May 1978. This increase in successful sexing is thought to be attributable to the greater experience of the observers in the second year of study, and the greater amount of time spent at the two different observation points.

The sex ratio of seal sightings in South Bay in 1979 was 14 males : 72 females. A chi-square test showed this to be a significant departure from unity (chi-square = 39.12, $P < 0.005$). The sex ratio of sightings in May 1978, 19 males : 28 females did not show this difference (chi-square = 1.79, $P > 0.05$). When the sex ratios of the 1978 and 1979 May sighting samples are compared they are seen to be significantly different (chi-square = 9.50, $P < 0.005$).

The disparate sex ratio of sightings in 1979 is borne out by the sex ratio of seals identified and resighted in South Bay during May (2 males : 7 females, plus two probable females).

The two male seals, PHD-79-1 and PHD-79-3, differed in their spatial distribution, neither seal apparently ever occupying a position used by the other. Seal PHD-79-1 was the most frequently sighted. He preferred haul-out position B (Fig. 10), occupying it five of the ten times he was sighted. He occupied position I three times, and positions M and L once only. This seal was definitely recognized throughout the period 3 to 30 May. Seal PHD-79-3, the other male, occupied positions C and O in the area more to the east of positions A, M and L used by PHD-79-1. He was definitely recognized at each of these positions only once. Both positions C and O were fairly distant from the observation point, making positive identification difficult. Position C was occupied by seals 16 times between 1 and 21 May and could well have been frequently used by PHD-79-3 during this period, though we have no positive evidence of this. Position C was seen to be utilized by a male seal of unknown identity on 4 May. Position O was occupied on 14, 15, 17, 19 and 20 May. Each time the lone seal sighted there was an adult. The only time the sex was ascertained was on 20 May when the male PHD-79-3 was definitely identified there. On three other days (14, 15 and 16 May) a different seal, PHD-79-6, occupied the position, but its sex was not determined.

The maximum distance covered by male PHD-79-1 between the different holes which he occupied (I to L) was 1130 m. Seal PHD-79-3 covered a distance of 373 m between position C and O.

The female seals that were identified during the study did not appear to move around in the study area as much as the males, at least in the earlier part of May. Female PHD-79-5, which was first sighted 5 May and later accompanied by a pup PHD-79-11, was never sighted at any position other than location G and was seen a total of 11 times. The pup also remained at the same position and was seen on 14 separate days. Female PHD-79-4, first seen on 5 May and a further nine times up to 30 May, emerged at positions A, L, M and AD, which were all in close proximity to each other. Female PHD-79-7 also occupied holes A, L and M, being sighted four times between 19 and 27 May. In the more easterly sector of the study area, female PHD-79-6 was seen three times at position O, between 14 and 17 May. Female PHD-79-7, again in the more easterly sector of South Bay, was sighted four times between 26 and 30 May, always at position I. One female, PHD-79-10, sighted on 28 May near the end of the study, was first seen twice at position B and then moved into the western end of South Bay to positions A and AE. This was the longest observed movement made by any female.

Only one seal was seen to occupy more than one position on a single observation day. Female PHD-79-10 moved from position AE to A on 30 May. This seal was apparently scared into the water at 12:08 by the movement of one of the observers. She reappeared at the closely adjacent hole AE at 13:00.

On only three occasions during the study were two seals, not mother and pup, seen hauled out at the same hole. One instance involved the male PHD-79-1, hauling out at position L beside a female. No interaction between the seals was observed. The two other instances are described in the section dealing with agonistic behavior.

An hourly record was kept of the direction in which the head of each seal was pointed during the entire study, as well as hourly records of wind direction and strength. Mean wind and seal orientation for each day, or divisions of each day when an obvious wind shift occurred, were calculated from the formulas in Batschelet (1965).

A non-parametric sign test (Batschelet, 1965) was used because of the indication that a large number of the mean observations did not exhibit a circular normal distribution. Using this approach 47 mean observations supported the null hypothesis that seals orient in the same direction as the prevailing wind, while 22 mean observations did not support it. When mean windchills associated with the above observations were compared, using an analysis of variance, no significant differences were found.

Vigilance behavior was not studied in detail in 1979. Results from 1978 indicated conclusively that there was a great variation in vigilance between seals and that no sentinels existed in groups of seals hauled out together at the same hole. This year the observations of vigilant behavior supported the same conclusions. One aspect not investigated thoroughly in either year was the change in vigilance as the seal became used to lying on the ice at a particular site. In one instance, on the first day that a seal hauled out at a newly observed position, it was significantly more vigilant than another seal which had become accustomed to lying out at a nearby position. This suggests that habituation is important in affecting the degree of vigilance of individual seals.

Seals appear to use sight, olfaction and hearing in order to examine their surroundings for potential threats. Practical knowledge gained from hunting seals shows that a human's movement can be detected easily by a seal at distances of 200 m or less, but that actual recognition of a human by a seal probably does not occur at distances over 75 m. Olfaction appears to be a quite important sense and Inuit are careful to stalk seals from downwind. On two occasions seals were scared down by one of the observers who was over 200 m away. In both cases the seals appeared to smell his presence on the wind but not see the source of disturbance. On another occasion it was obvious that a seal had detected the odor of burning rubbish from the camp, over 1000 m away. The seal changed its position very quickly as soon as the smell reached the area and continued to remain vigilant for some time. Noises from such sources as rifles, aircraft (especially helicopters), snowmobiles and rock slides all caused disturbance of seals; sometimes they would elicit only a glance toward the source while at other times they would result in the seal's diving into the water. Helicopters flying in the area appeared to cause the greatest disturbance, resulting in some seals as far away as 2.3 km from the flight path leaving the ice. None of the above mentioned sources of disturbance caused a long lasting decrease in seal numbers. Seal densities appeared to return to normal the following day.

Activities of seals can be divided into four main categories: emergence from and re-entry into the water; behavior of nursing pairs; agonistic behavior; and miscellaneous actions while lying out on the ice.

The greatest amount of information on the activity of seals is obtainable when individuals can be identified from their pelage patterns. Eleven seals which were positively identified in this way yielded information on activities at the breathing holes on 24 days during the period 1 to 31 May. When a seal was seen to emerge from a hole, it was usual for the animal to re-enter the water one or more times before it settled down for its stay on the ice. The frequency of emergence onto the ice during an observation day ranged from two to six times. Lengths of haul-out times ranged from 1 to 606+ min and for periods under the ice from 0.5 to 180 min.

Mother-pup pairs were seen throughout the study period, with a maximum number of four being present in South Bay. At least two pups were first seen as partially moulted whitecoats, but all pups were fully moulted by the end of the study. Pups in three of the four pairs were observed to suckle. Suckling was first seen on 5 May and was last observed on 29 May. Pups were still in the area when the study ended on 2 June, and there is a possibility that some were still suckling. Suckling was observed on 16 different occasions. Suckling periods lasted from 5 to 21 min, with several pauses of 0.5 to 1 min duration during each bout. Suckling was seen at all times of the day, with no apparent diel regime. There did not appear to be any particular trend in the frequency of suckling observations with date, although this is most certainly severely biased by the small number of nursing pairs under observation and the early termination of the study. Apart from suckling, mothers and pups would interact by gently nuzzling each other and by making non-aggressive flipper scratchings toward each other. The pup was often seen to rapidly move around the exit hole, sometimes moving away several metres from it. The pup would invariably turn back and eventually take up position again near its mother.

Of the three pairs in which suckling was observed, the mother spent from 6 to 600 min on the ice with from one to three emergences onto the ice in a single day. The pups with their mothers spent from 17.5 to 848 min on the ice with from one to seven emergences onto the ice in a single day. The mothers spent from 2.5 to 440 min alone on the ice, while pups were seen on the ice without their mothers for periods of one to 471 min. Near the end of the study period the time spent by the pups hauled out alone appeared to be increasing.

One apparent mother-pup pair, always located at position G, were never seen suckling. This pair was the one most easily observed, being located very close to one of the observation points. The female, PHD-79-5, was first seen to haul out at position G on 5 May. On 6 May an adult female and pup were seen to exit and re-enter the water four times at a location 20 m from position G. On this occasion the pup emerged from the water first and the female gave the impression that she was following it. In retrospect it is thought that these two seals were the ones seen at position G. On 11 May the female and pup, both positively identified, were seen at position G. On 12 May the pup made aggressive movements, involving bites and slaps, at the adult female. The female and pup were seen together at G until 17 May. After this date the adult female was not resighted but the pup continued to be observed at G until 29 May. Since no suckling was observed at all it is thought that the pup had been weaned in the early part of the period during which these two seals were observed together. It is evident that the agonistic behavior prior to separation of the pair, was purely on the part of the pup.

Aside from the agonistic behavior seen on two occasions between the mother and pup at position G, aggressive actions were witnessed only three times in 1979. In one instance a pup had hauled out beside a seal of undetermined sex. Another seal quickly emerged from the water twice and bit the large seal on the neck. This was interpreted to be an example of a mother seal directing aggression at another adult seal lying in close proximity to her pup. A similar situation was witnessed on one occasion in 1978.

Another instance involved a hauled-up seal of undetermined sex, slapping towards a seal in the breathing hole. Water was seen to splash up from the hole, indicating an aggressive response from the other seal. A further observation involved two female seals. One female slapped at another emerging at her position, but this did not deter the second seal from hauling up.

A greater number of aggressive acts between adult seals was seen in May 1978 (8 in 17 days) than in May 1979 (3 in 31 days). The explanation is not obvious, but the observations might indicate a different composition of seals occupying South Bay, with the greater number of female-pup pairs in 1979 being the key factor.

Other activities of seals lying on the sea ice include scratching, rolling in the snow, shivering by pups and snow eating. Scratching increased in the first few days after seals first emerged from the water. Seals typically would emerge from their breathing holes, move around, roll in the snow presumably to dry off, dig a depression in the snow with their fore-flippers and settle into place. Scratching of all parts of the body except the back with the claws of the front flippers was a common activity. Wriggling on the back was often seen in conjunction with other scratching activity. Quantities of shed hair and skin where the seals had hauled up indicated they were moulting heavily at this time.

One pup at position G was observed to shiver for a period of at least 25 minutes after emerging from the water at 1735 hours on 12 May 1979; the temperature at the time was 7.2°C with no wind. This was the second day on which the pup was seen to haul out.

Snow eating was seen on several occasions and involved three different seals. The female and pup at position G were seen to take mouthfuls of snow and swallow it. This behavior occurred at different times on three separate days when the air temperatures were mild. On these occasions the seals appeared to be using the snow as a source of water. On another occasion a seal, which was breaking through a fresh snow dome formed over its exit hole, bit at the snow and butted it with its head in order to clear it out of the way.

Figs. 10 and 11 show the locations of all seal positions observed in South Bay during the 1979 observations. These are indicated by letters. The area to the east of the dotted line (Fig. 11) was searched for additional seal holes on 31 May after the behavior study was terminated. These are indicated by numbers.

A total of 48 holes was found during the search, sixteen of which corresponded to the positions previously identified in the behavior study. During the study a maximum of eight positions had been occupied by seals on a single day, yielding a hole-to-seal ratio of 6:1.

Of the holes found in the search, 20 of 48 had been recently used for hauling out. Sixteen birth lairs were located, twelve of which had not recently been used for hauling out. Six of these birth lairs were located on a crack going roughly north-south across the eastward extremity of South Bay. Three other haul-out lairs were also observed on this same crack. In addition three of the holes located were not yet open to the surface.

A subjective evaluation, involving assessment of the spatial distribution and structure of the subnivean structures found, indicates that there were seven birth lair complexes involving 35 of the 48 holes found in the area (Fig. 11). The fact that only three mother-pup pairs were seen in this part of the Bay and the apparent lack of activity at the majority of birth lairs could indicate that some mothers, and possibly pups, had already moved out of the area. That this does happen is supported by the sudden disappearance of the female PHD-79-5, which left her pup on 17 May and was not seen again in the study area. In addition to the seven subjectively described birth lair complexes, two male seals were seen to occupy positions B, I, C and O, bringing the total of positions utilized by a possible eight separate adult seals to 40. Some of the other positions adjacent to those known to have been occupied by the males could also have been utilized by them.

Of the 48 positions found in the actual search, only 20 showed signs of recent utilization, and the maximum number of positions occupied in the area on any one day was seen to be eight. If these were all the seals in the area, this indicates that individual seals at this time of the year utilize 2.50 holes on average. This is supported by a separate calculation of the average number of different positions utilized by seals that were successfully identified and resighted. The calculation, based on males, females and pups, showed them to utilize a mean of 2.09 positions during the study period.

One resighting made at the very end of the behavior study on 2 June, at position 30 or N indicates that site fidelity exists in ringed seals. Fig. 12 shows drawings made in 1978 and in 1979 of two seals. The points of similarity and orientation of the marks are such that we are convinced that the drawings represent the same seal. Although it was only seen once in 1979, this adult male seal (PHD-78-2) was sighted 18 times during the period 11 May to 5 June 1978. It was the most frequently sighted seal that year and was possibly the dominant male of the study area.

DISCUSSION

It is felt that the present breeding habitat survey has adequately covered the region between Loks Land and northern Brevoort Island, with the exception of the offshore Leybourne Island area which was inaccessible because of undercut ice and open water patches.

Areas containing ice hummocks proved to be the most productive type of breeding habitat. This was only seen in one small bay on southern Brevoort Island, measuring 4.6 km^2, and in a larger area of approximately 256 km^2 extending to the edge of the consolidated pack ice in Cyrus Field Bay. The latter area yielded a density of one birth lair per 3.87 min of search time, similar to the high densities in the same type of ice studied in other parts of the arctic (Smith and Stirling, 1975; Smith, Hay, Taylor and Greendale, 1979).

In other areas within the present study region no ice hummocks were seen. These areas, which were characterised by stable flat offshore ice, contained birth lairs at a much lower density. The inner region of Cyrus Field Bay between the islands and the western shoreline of Robinson Sound had similar densities of birth lairs along the tidal cracks formed in the pressured nearshore ice. This was the second most productive type of ice for birth lairs. In the very flat stable ice of Cornelius Grinnell Bay, birth lairs were found both in the nearshore tidal zone and along cracks formed across the mouths of small bays.

The least productive areas seen were the small bays and offshore ice of Robinson Sound. Almost no birth lairs were found there, although a fair number of breathing holes were located, many occupied by rutting males.

Two areas of the floe edge were searched. One along the southeast coast of Brevoort Island, consisting of consolidated pack ice, contained no subnivean structures at all. The other, an area of unfractured ice within 500 m of the floe edge, just east of the hummocky ice of Cyrus Field Bay, contained only 15% of the number of birth lairs found in the immediately adjacent ice further away from the edge of the shifting pack. This is a clear indication that ringed seals tend to avoid making lairs in or near areas of unstable ice.

In areas such as Robinson Sound and Cornelius Grinnell Bay, the rutting males appear to occupy the offshore flat ice and are rarely found in the tidal zone where most birth lairs occur. In no instance in any of the areas, was the odor of rutting males found in a subnivean structure recognized as a birth lair.

In the small bay on southern Brevoort Island which contained many birth lairs in hummocky ice, only two of a total of 20 lairs (1 positive, 1 possible) had been used by a rutting male, and these were on the periphery. In the hummocky ice of Cyrus Field Bay, 10 of 57 subnivean lairs (17%) had been used by rutting males. Thus there appeared to be a definite segregation of males and females, the dominant males probably occupying a space around the birth lair complexes of the parturient females, but never actually entering into these structures.

It is not known how consistent the distribution of hummocky ice is from one year to the next. It is conceivable that more extensive areas of hummocky ice occur in Cornelius Grinnell Bay and Robinson Sound in other years, given different weather conditions during the freeze-up period. Whether this would lead to a much higher overall productivity in the study region is not yet known. Large changes in annual ringed seal production over a large geographic area have been shown to occur in other arctic localities (Smith and Stirling, 1978), but this is not thought to be entirely controlled by the annual differences in ice cover or snow depth.

Bear predation, especially in hummocky ice, is a significant source of mortality. The relatively small area of fast ice along the coast of Hall and Beekman Peninsulas is heavily hunted by a resident population of bears. The greatest proportion of kills were of the highly vulnerable neonate pups and in some cases, of their mothers. Only one kill of an adolescent non-breeding female was seen, but more such seals may be taken in the consolidated and moving pack ice which was not covered in our survey. The largest number of bear kills was found in Cyrus Field Bay, which is known by the local Inuit as a good area for bears in the spring months.

Another important cause of pup mortality in this area is the melting of the snow covering the birth lairs. The exposed pups are then vulnerable to increased predation by bears, foxes and ravens, and to the possibility of death by exposure because of the extreme temperatures still prevalent at this time of year.

It appears that ovulation and copulation may occur as late as the end of May in this area, even though the peak of pupping probably occurs around the third week of March. Evidence from female ringed seals killed with their pups, and later from observations during the behavioral study, seems to indicate that copulation may not occur until close to, or after weaning of the pup, approximately two months after pupping.

Mean daily windchill (kcal/m^2/hour), as calculated by the formula of Siple and Passel (1945), was significantly negatively correlated with the total number of ringed seals counted in both South Bay and Outer Bay. However, meteorological measurements taken at an observation point not on the sea ice, and in a situation not exactly duplicating the physical locality of a seal lying in a depression near its breathing hole, can only give a crude indication of the factors influencing the hauling-out behavior. The windchill factor used in this study, which combines hourly measurements of wind and temperature, is thought to be the most biologically meaningful climatic measurement.

Smith (1973) and Finley (1978) both indicated that wind speed was the most significant weather condition affecting seal numbers in their studies. Finley (1978) further indicated that later in the season excessive thermal input might actually cause seals to retreat to the water. Our crude meteorological observations and notes on seal orientation show that seal numbers are definitely negatively influenced by both wind and low temperatures. Later in the season it is possible that excessive temperatures may also increase the variability of the hour of peak haul-out. Our 1978 observations showed that peak numbers occurred at various times throughout the day in mid-June, while peak numbers in late May 1979 were always seen between 09:00 and 18:00. When low values of windchill become prevalent later on in the season, factors other than excessive thermal input might also influence the daily maximum number of seals on the ice. The opening up of new exit holes in a bay and the relatively rapid influx of seals from other areas, as was seen in our early June 1978 observations, could add to the variation in the time of day when peak numbers are seen. It is also felt that the previous history of basking of individual seals can influence the length of a haul-out bout. On a few occasions identified animals that did not haul out for several days because of extremely bad weather were seen to spend a longer time on the ice when weather conditions again became more favorable.

A comparison of densities of seals hauled out in the two years of this study showed a remarkable similarity. In 1978, a rapid increase in the number of seals in South Bay occurred after early June and was seen to be due largely to an influx of seals from the ice just outside the bay. In 1979, our observations terminated on 2 June when ice conditions in South Bay were just beginning to resemble those prevailing on the same date as in the previous year. We feel that if these observations had been continued we would have seen the same influx of seals that was observed in 1978. Densities in 1979 were within less than 1 seal per km^2 of those seen in 1978 on the same dates. These similar densities strongly suggest that we are dealing with resident seals up to this date, which tend to partition the ice habitat in a similar way from year to year.

Peak diel densities of seals were seen in the daytime hours between 09:00 and 18:00 in May 1979. The continuous observations made in mid-June 1978 showed a greater variation in the time of peak densities. This is thought to be caused by several factors: the decrease of the effect of windchill; the possibility of temperatures exceeding the thermal tolerance of seals during periods when there is no wind; the possibility that the moult is over for some seals and they begin to move off the ice; and the influx into the area of seals which have just begun to moult.

More information was obtained from identified and resighted seals in 1979 than in 1978 because of the increased experience of the observers in identifying seals. Also more time was spent at two observation points, increasing the number of positions from eight in 1978 to 12 in 1979, at which seals could be identified.

Two real changes were noticed in 1979 concerning the composition of the seals occupying South Bay. In 1979 the majority in the observation area were females, and there were more mother-pup pairs observed. The difference in sex ratio between the two years for the same period was statistically significant. No large change was noticed between years in the ice features of the Bay. It is not known if the melting period in mid-April and the subsequent heavy snow experienced in May might have caused shifts of mother-pup pairs in some areas of the study region. The birth lairs found in the search of South Bay at the end of the survey strongly indicates that the four mother-pup pairs seen in the behavioral study were there from the beginning of the observations. One lair, containing remains of a placenta, showed definitely that pupping occurred there. Since most of the birth lairs were found along the old refrozen crack at the mouth of South Bay, it is possible that these types of local features influence the number of pups produced within specific bays from year to year. The number of mother-pup pairs observed in Outer Bay in 1979 and 1978 were similar.

Of the 13 identified seals in South Bay only two were males. One seal, PHD-79-1, was seen throughout the study and occupied two main positions. This seal was seen to move to two other positions at the west end of the bay usually occupied by adult females. The other male seal, PHD-79-3, was definitely sighted only at two positions to the east of those used by PHD-79-1. The impression gained by the spatial distribution of these two males, never occupying the same positions, was that they might have been occupying adjacent territories made up of their usual haul-out sites and the hauling-out areas of several females. Our sample of positive resightings is still too small to enable us to speculate on the extent or structure of territories. However, there is enough evidence to indicate that males appear to hold a territory around one or more birth lair complexes, which might also contain subterritories actively maintained by females. Our observations show that females keep males out of birth lairs and are aggressive to all seals coming close to their pups. Territorial activity probably ceases shortly after copulation, which appears to occur at or near weaning of the pups; sometime in the first week of June in the present study area.

Seals appear to orient with their heads pointed in the direction of the prevailing wind; that is, with their tails to the wind. Degerbøl and Freuchen (1935) and Finley (1978) also point this out. In our study this behavior appeared to be statistically significant only when windchill was above a certain value. A possible function of this behavior, other than its being a reaction to cooling or simply an avoidance of wind in the face, is that facing downwind will allow the seal to visually examine that direction for predators, such as polar bears, which hunt the seal by olfaction. Since these predators are most likely to approach from a downwind position this could be of significant survival value to the seal.

Seals were observed to vary greatly in their vigilance. As in 1978, individuals varied significantly in the duration of their lying and looking phases. One difference was noted between the vigilance of seals newly hauled out at a position and seals already accustomed to hauling out at a closely adjacent hole. It appeared that habituation influenced the degree of vigilance.

Sight, olfaction and hearing are all involved in the vigilant behavior of seals. Seals were seen to react to noises caused by aircraft, rockslides and the smell of the observers even when they were not seen. None of these occasional disturbances appeared to cause a long lasting decrease in numbers. Indeed certain seals, exposed to the sight of the observers approaching the observation tent, appeared to become habituated to their presence.

Seal activities indicate that adults emerge from their breathing holes onto the ice very cautiously. A seal's head was seen several times prior to the seal's emergence and it was common for an individual to re-enter the water and emerge several times before settling down on the ice. Mother-pup pairs were observed throughout the study. In three of the four pairs the pups were still suckling at the end of the study and interactions were gentle, consisting of mutual nuzzling, non-aggressive scratches with the fore-flippers and movement around the breathing hole. One mother-pup pair, first seen on 12 May, stayed together until 17 May, after which the female was no longer seen. No suckling was ever seen, indicating that the pup was already weaned. The pup appeared to initiate the separation, acting aggressively towards the female on at least two occasions.

Agonistic actions between adults were seen only on three other occasions. Two occurred between what were, most likely, adult animals and one could have been between a mother and another adult which was hauled up near her pup. Only three agonistic acts in 31 days were seen in 1979 compared to eight in 17 days during the same period in 1978. The decrease in 1979 could be attributable to the fact that more breeding females occupied the area that year. This might have resulted in better defined territories which would have excluded potential intruders and decreased the number of aggressive acts observed on the surface of the ice.

A search of the behavior study area at the end of the observations resulted in a hole-to-seal ratio of 6:1 (48:8). However, of the 48 subnivean structures found only 20 appeared to have recently been used as hauling-out sites. This therefore suggests that seals in this area utilize an average of 2.5 positions during the haul-out period in May. A separate calculation involving identified animals indicates that seals haul out at an average of 2.09 locations. It appears that the hole-to-seal ratio might be of some use in estimating population numbers, but that it might vary greatly from one area to the next depending on the number of parturient females in the area. This in turn could depend on the age of the ice or the number and distribution of such features as cracks, hummocky ice and pressure ridges. Breeding females maintain birth lair complexes which sometimes include as many as five subnivean structures. Thus it appears likely that areas containing breeding females and territorial males could have a higher hole-to-seal ratio than areas occupied by non-breeding animals. This appears to be supported by Finley (1978) who obtained a hole-to-maximum seal ratio of 1.12:1 in an area containing maximum densities of 4.64 seals per km^2. He indicates that the majority of ice in his behavior area was two years old. There is no indication in his study of the number of resident mother-pup pairs. Our study area was made up entirely of first-year ice, contained a maximum density of 6.93 seals per km^2 and had at least four mother-pup pairs.

Seal PHD-78-2, which was probably the dominant male in the 1978 study, was resighted in 1979. This is taken as conclusive proof of site fidelity and strongly indicates that male ringed seals are instrumental in the partitioning of breeding habitat. It is not surprising or unexpected that ringed seals come back to the same general locality from one year to the next. This direct evidence of site fidelity in a long-lived mobile species could well indicate the dependence of seals on a limited amount of favorable breeding and feeding areas and further underlines the concept of critical habitat.

RECOMMENDATIONS

The Canadian arctic with its miles of pristine coastline is soon to enter a new era. Present indications are that there will soon be large scale development in the form of offshore oil and gas wells, ports and shore based terminals, and year-round shipping in the form of cargo, gas and oil laden ships. Until now activities along the arctic coastline have been mostly restricted to hunting near the 30 or so Inuit villages.

Populations of marine mammals and polar bears occupying arctic coastal areas have been inventoried, and much is known about their distribution and areas of aggregation. Most of this knowledge has been gained in the last ten years as a direct result of impact studies such as the EAMES program which have been concerned with specific types of development in different localities. We are now at the point where we can begin to build upon this store of knowledge and start to understand the mechanisms and processes of the arctic marine ecosystem. This, of necessity, must be a multidisciplinary approach based on a good quantitative design and of a long term and continuing nature. With this next level of environmental studies in mind the following recommendations are appropriate:

1) Continuation of behaviour studies, such as those conducted at Popham Bay, with emphasis on the way in which the ringed seal partitions its breeding habitat. Studies of the microclimate of the birth lair complex and activity patterns of ringed seals during the ice covered period are also necessary in order to understand the energy budget and winter resources of the seal population.

The remarkably similar seal densities observed in Popham Bay in the two years of study, combined with strong indications of territorial partitioning of the breeding habitat and homing of seals to the same area from year to year, suggest that a continuing behavior study will yield new information, important to management and conservation of ringed seal populations. Accurate estimation of seal numbers must be based on proper timing of aerial surveys and utilization of corrected hole-to-seal ratios for different ice types. Experimental assessment of seal perception in the wild and quantitative evaluation of different types of disturbance will be possible once the normal variation in numbers, population composition and behavior have been described.

2) Survey results show that prime breeding habitat exists in areas of ice hummocks. In 1979 only one extensive area, in Cyrus Field Bay, contained this type of ice. No information is available on the variability from year to year of this type of ice cover. More information is needed on this subject in order to identify and quantify the prime breeding areas of this coastline. This could be obtained using a combination of satellite imagery, ice observers' reports and low-level aerial reconnaissance.

The ice among the Lemieux Islands could not be adequately surveyed using oversnow transportation because of weak ice and open water areas. Such inter-island ice can only be properly surveyed for birth lairs by use of a helicopter supported ground survey. Biological samples should also be collected to determine the age structure and feeding habits of seals occupying the areas around polynyas.

SUMMARY

1) The breeding habitat survey showed that birth lairs were distributed throughout the study area. Hummocky ice in Cyrus Field Bay contained the highest density of birth lairs. Flat ice at the mouths of small bays and in the pressured tidal zone throughout the area contained a lower density of birth lairs. The flat offshore ice in most areas contained mainly breathing holes occupied by both rutting males and non-breeding seals.

2) Polar bear kills of neonate seal pups in their birth lairs is thought to be a significant cause of mortality in the seal population of this region. Early thaws could contribute to mortality by exposing newborn pups to predators and cold temperatures.

3) Wind and temperature appear to negatively influence the number of seals hauled up on the sea ice in May.

4) Densities of seals hauled up in the study area were remarkably similar in 1978 and 1979.

5) Peak diel densities in May were seen to occur between 09:00 and 18:00. Continuing observations showed some seals to remain hauled out for as long as 40 hours.

6) A hole-to-seal ratio of 6:1 was seen in part of the study area. A utilized hole-to-seal ratio of 2.5:1 was calculated after examining the breathing holes and haul-out lairs.

7) A disparate sex ratio, favouring females, was observed in South Bay. Two males in the bay were seen to occupy an area where seven or more birth lair complexes were situated.

8) One adult ringed seal, thought to be the dominant male in South Bay during the 1978 study, was resighted in 1979. This is the first direct evidence of site fidelity in this species.

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TABLES

Table Number and type of subnivean lairs found in the fast ice between Loks Land and northern Brevoort Island during searches with a trained dog.

	Type of subnivean structure								
Search area	Breathing hole	Male breathing hole	Haul-out lair	Male haul-out lair	Birth lair	Total structures	Total search time	Minutes per structure	Minutes per birth lair
A. Robinson Sound									
1-Offshore flat ice	15	11	--	3	1	30	218.4	7.28	218.39
2-Bays on Baffin Island	3	3	1	--	--	7	87.0	12.42	--
3-Bays on Brevoort I.	--	--	2	2	17	21	28.1	1.34	1.65
4-Tidal zone along Baffin I.	8	3	--	1	6	18	120.1	6.67	20.01
5-Floe edge, consolidated pack ice	--	--	--	--	--	--	16.6	--	--
B. Cornelius Grinnell Bay									
6-Flat ice offshore	9	8	2	4	4	27	151.2	5.60	37.79
7-Bays including tidal zone	23	8	3	4	7	45	233.0	5.18	33.29
C. North and eastern Brevoort I.									
8,9-Flat ice and tidal zone near small islands and on east coast of Brevoort I.	5	2	--	--	2	9	80.4	9.05	40.71
D. Cyrus Field Bay									
10-Flat ice between islands including tidal zone	8	1	--	--	8	17	126.3	7.43	15.78
11-Hummocky offshore ice	9	4	8	3	20	44	77.5	1.76	3.87
12-Floe edge	1	--	1	1	1	4	26.9	6.47	25.87

Table 2. Percentage of different kinds of subnivean lairs found in the three ice types of the main search areas.

Search area	Breathing hole	Male breathing hole	Haul-out lair	Male haul-out lair	Birth lair
1-Robinson Sound					
Flat ice	84.4	85.0	50.0	40.0	20.0
Tidal zone ice	15.6	15.0	25.0	20.0	8.0
Hummocky ice	--	--	25.0	40.0	72.0
Total number	32	20	8	5	25
2-Cornelius Grinnell Bay					
Flat ice	71.4	93.8	75.0	72.3	64.3
Tidal zone ice	28.6	6.2	25.0	27.7	35.7
Hummocky ice	--	--	--	--	--
Total number	49	16	4	11	14
3-Cyrus Field Bay					
Flat ice	45.0	17.0	--	20.0	25.0
Tidal zone ice	--	--	--	--	2.0
Hummocky ice	55.0	83.0	100.0	80.0	73.0
Total number	22	7	9	5	36

Table 3. Predation attempts () and kills of ringed seals by polar bears in the three ice types surveyed.

Ice type	Site of predation attempts () or kill: Breathing hole	Male breathing hole	Haul-out lair	Male haul-out lair	Birth lair	Total digs	Total kills
Flat ice	(1),-	--	--	--	(2),1	3	1
Tidal zone	(1),-	--	--	--	(3),3	4	3
Hummocky ice	(4),-	--	(4),1	(2),-	(28),10	38	11

Table 4. Ringed seal pups collected during the birth lair survey from 21 March to 17 April 1979.

Date	Sex	Nose-tail length cm	Length of umbilicus cm	Weight kg	Remarks
21/3/79	M	70	4.00	4.52	Killed in lair by dog
3/4/79	F	70	6.00	6.00	Killed in birth lair
10/4/79	M	72	3.00	6.80	Killed in birth lair
10/4/79	F	80	none	13.40	Caught on surface of ice; birth lair caved in
13/4/79	M	80	none	14.93	Caught on surface of ice; birth lair caved in
13/4/79	M	71	4.50	9.10	Caught on surface of ice; birth lair caved in
14/4/79	F	63	6.50	4.90	Caught on surface of ice; birth lair caved in
14/4/79	F	75	6.00	5.07	Pup found dead in tidal zone
17/4/79	?	81	?	8.30	Partially eaten by ravens; killed by bear

Table 5. Mean daily weather conditions during the behavioral study at Popham Bay.

Date	Range of visibility (km)	Mean cloud cover (%)	Mean maximum windspeed ($m \cdot s^{-1}$)	Mean temperature (°C)	Mean windchill ($kcal \cdot m^{-3} \cdot hr^{-1}$)
1.5.79	8.0	100	2.2	0.0	766
2.5.79	8.0	100	1.2	-0.4	540
3.5.79	24.0	80	2.0	-1.9	783
4.5.79	3.0- 8.0	100	3.0	-5.8	957
5.5.79	0.0- 3.0	100	0.6	0.5	454
6.5.79	2.0	100	2.2	-3.6	849
7.5.79	8.0	100	5.6	-3.1	1024
8.5.79	0.0- 8.0	100	5.8	0.7	928
9.5.79	0.0- 5.0	100	8.6	-4.4	1166
10.5.79	16.0	80	0.0	--	--
11.5.79	24.0	10	2.1	3.0	685
12.5.79	8.0-16.0	40	0.8	6.4	427
13.5.79	1.0-16.0	90	0.7	4.1	531
14.5.79	16.0	30	1.5	3.4	579
15.5.79	0.0- 8.0	100	0.4	2.9	416
16.5.79	5.0- 8.0	100	0.0	1.8	326
17.5.79	8.0	90	1.3	2.7	430
18.5.79	16.0	60	7.1	4.0	906
19.5.79	5.0- 8.0	100	2.8	-0.3	787
20.5.79	8.0	100	3.8	0.7	845
21.5.79	8.0	100	0.8	3.6	478
22.5.79	8.0	100	0.4	0.0	551
23.5.79	8.0	100	7.9	-1.1	765
24.5.79	1.0- 8.0	100	3.4	-1.7	872
25.5.79	8.0	100	0.8	1.8	481
26.5.79	3.0- 8.0	100	1.0	1.0	589
27.5.79	8.0-16.0	50	1.9	2.4	529
28.5.79	8.0-16.0	70	6.2	2.4	830
29.5.79	16.0	30	7.2	1.8	893
30.5.79	16.0	90	4.3	4.7	688
31.5.79	16.0	50	9.1	6.0	842

Table 6. Number of individual positions on the ice at which ringed seals hauled out on the different days of the observation period.

Date	Number of positions
May	
1	4
2	-
3	2
4	5
5	7
6	9
7	6
8	-
9	-
10	8
11	6
12	8
13	8
14	10
15	11
16	11
17	13
18	5
19	11
20	13
21	13
22	-
23	-
24	-
25	8
26	12
27	10
28	7
29	9
30	13
31	9

Table 7. Resightings of identified ringed seals during the behavioral study.

Seal identification number	Sex	Number of days resighted	Positions and frequencies () where sighted	Date period of sightings	Remarks
PHD-79-11	F	13	G(14)	3-5-79 to 30-5-79	Pup of PHD-79-5
PHD-79- 5	F	9	G(10)	5-5-79 to 17-5-79	Mother of PHD-75-11
PHD-79- 4	F	9	A(5),L(3),M(1),AD(1)	5-5-79 to 30-5-79	
PHD-79- 1	M	8	B(4),I(3),M(1),L(1)	3-5-79 to 30-5-79	
PHD-79- 9	F	4	I(5)	26-5-79 to 30-5-79	
PHD-79- 7	M	4	A(2),L(2),M(1)	19-5-79 to 27-5-79	
PHD-79-10	F	3	A(1),B(2),AE(1)	3-5-79 to 30-5-79	
PHD-79-14 and	F	2	V(3)	28-5-79 to 30-5-79	Mother of PHD-79-15
PHD-79-15	F?	2		28-5-79 to 30-5-79	Pup of PHD-79-14
PHD-79- 6	?	2	O(3)	14-5-79 to 17-5-79	
PHD-79- 3	M	2	C(2),O(1)	4-5-79 to 20-5-79	
PHD-79-12	M	1	M(1),L(1)	12-5-79 to 13-5-79	
PHD-79-13	F	1	I(1),R(1)	15-5-79 to 16-5-79	

FIGURES

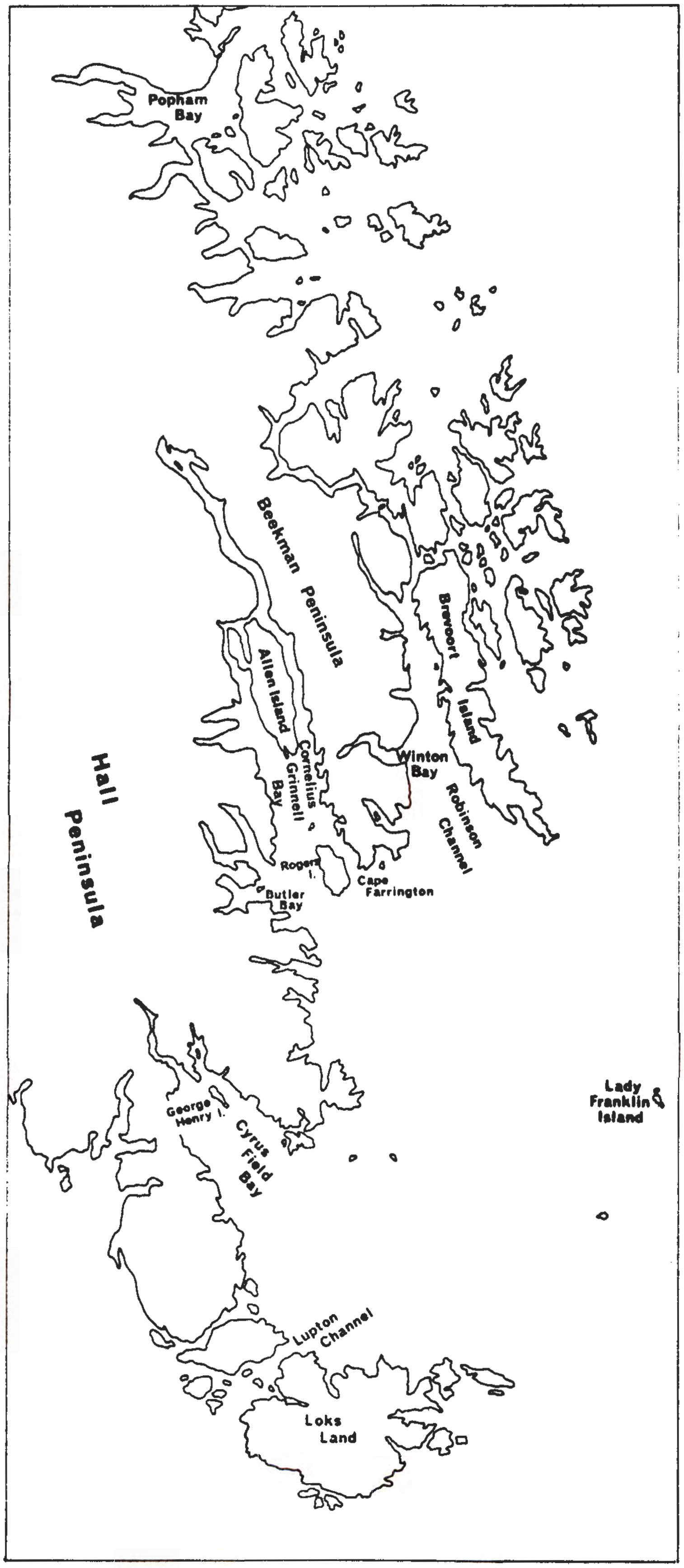

Fig. 1. Map of southeastern Baffin Island showing places mentioned in the text.

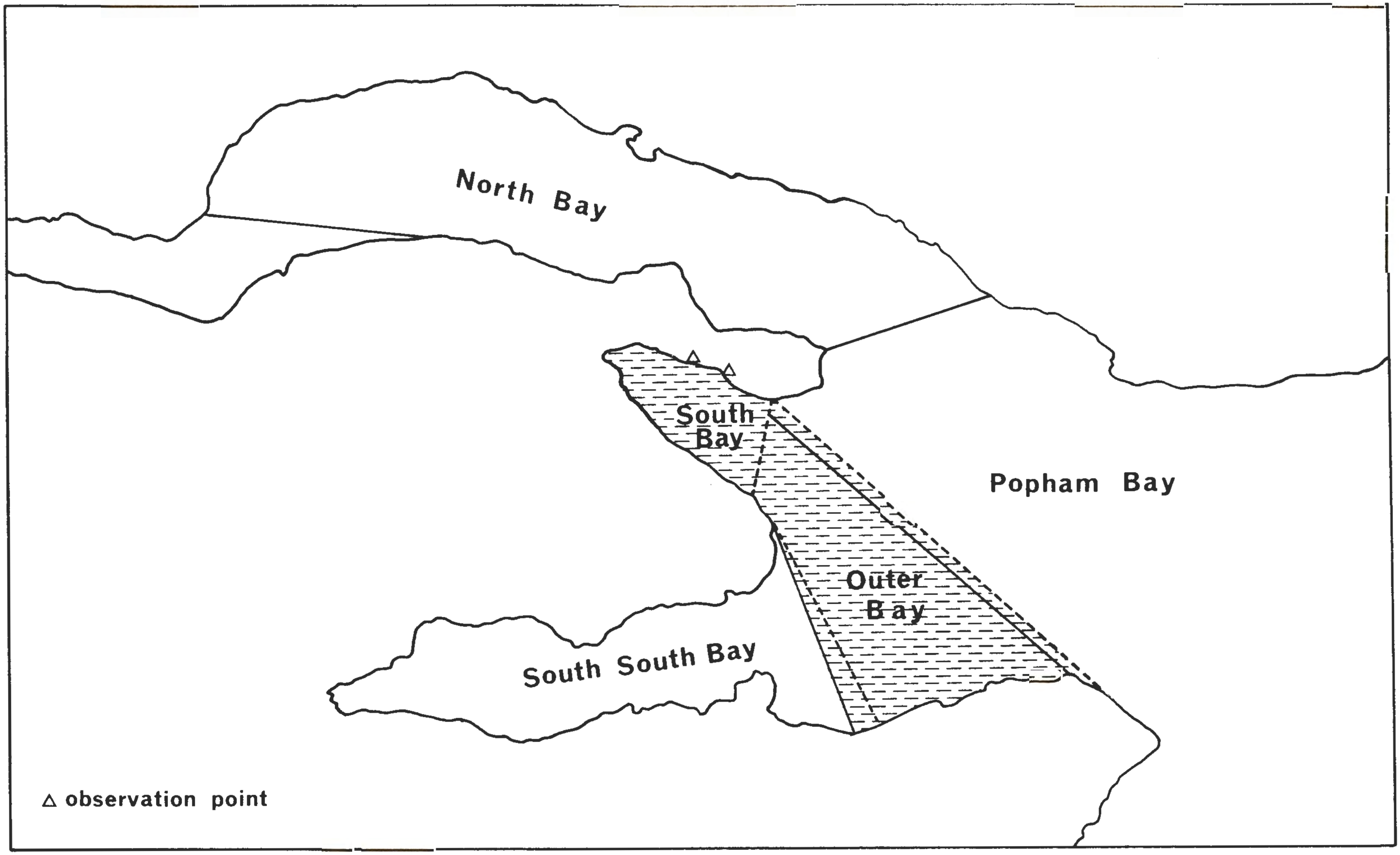

Fig. 2. Popham Bay site of behavioral studies in 1978 and 1979.

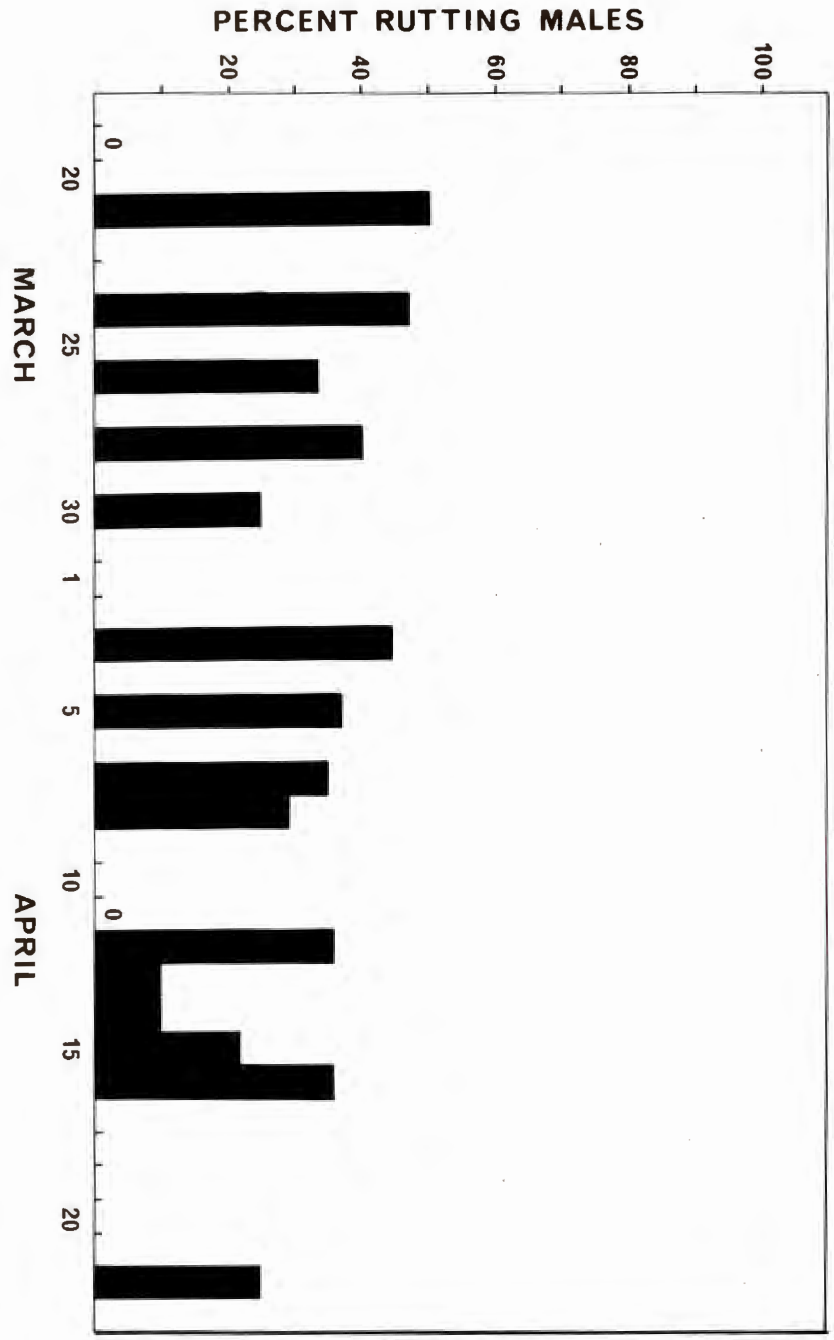

Fig. 3. Daily variation in the proportion of lairs occupied by rutting males.

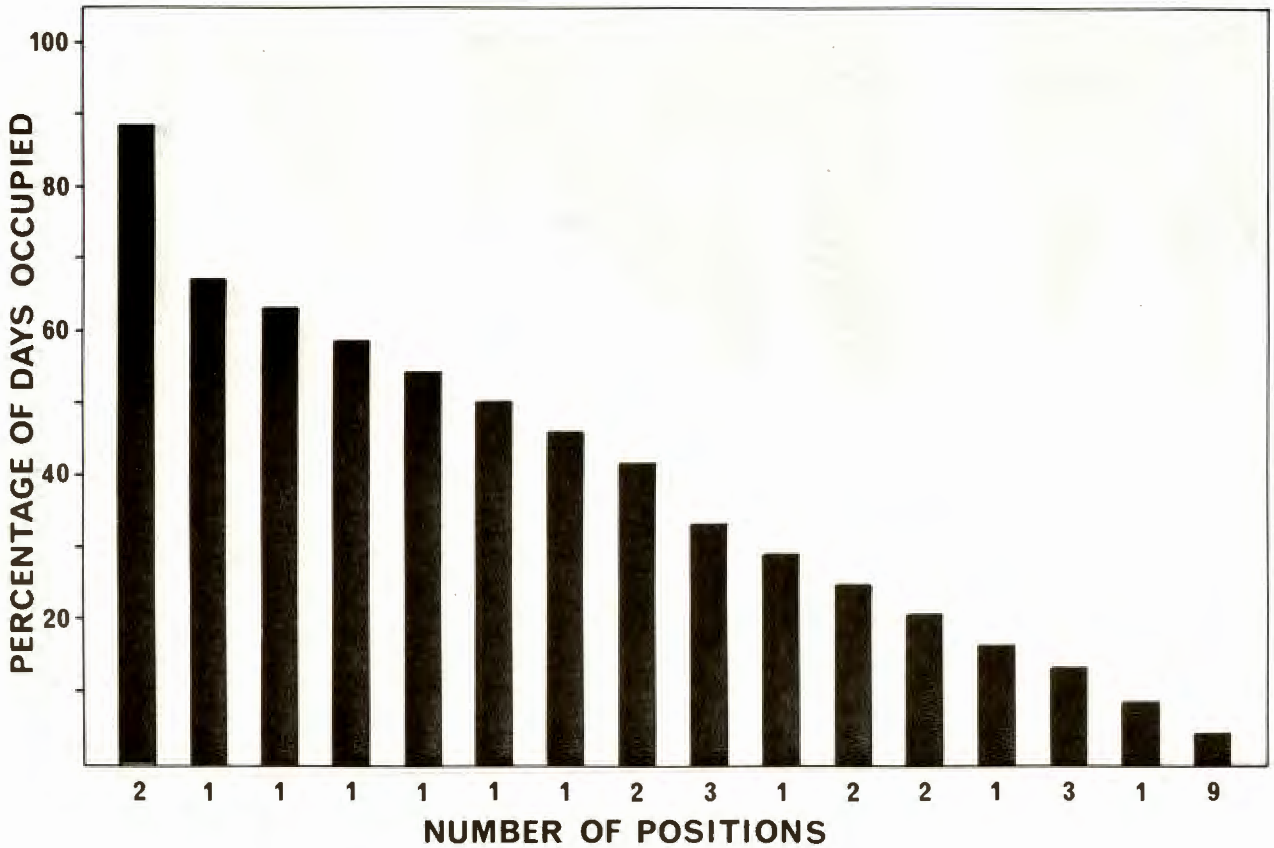

Fig. 4. Frequency of use of the 32 haul-out positions in declining order, expressed as the percentage of days occupied during the observation period.

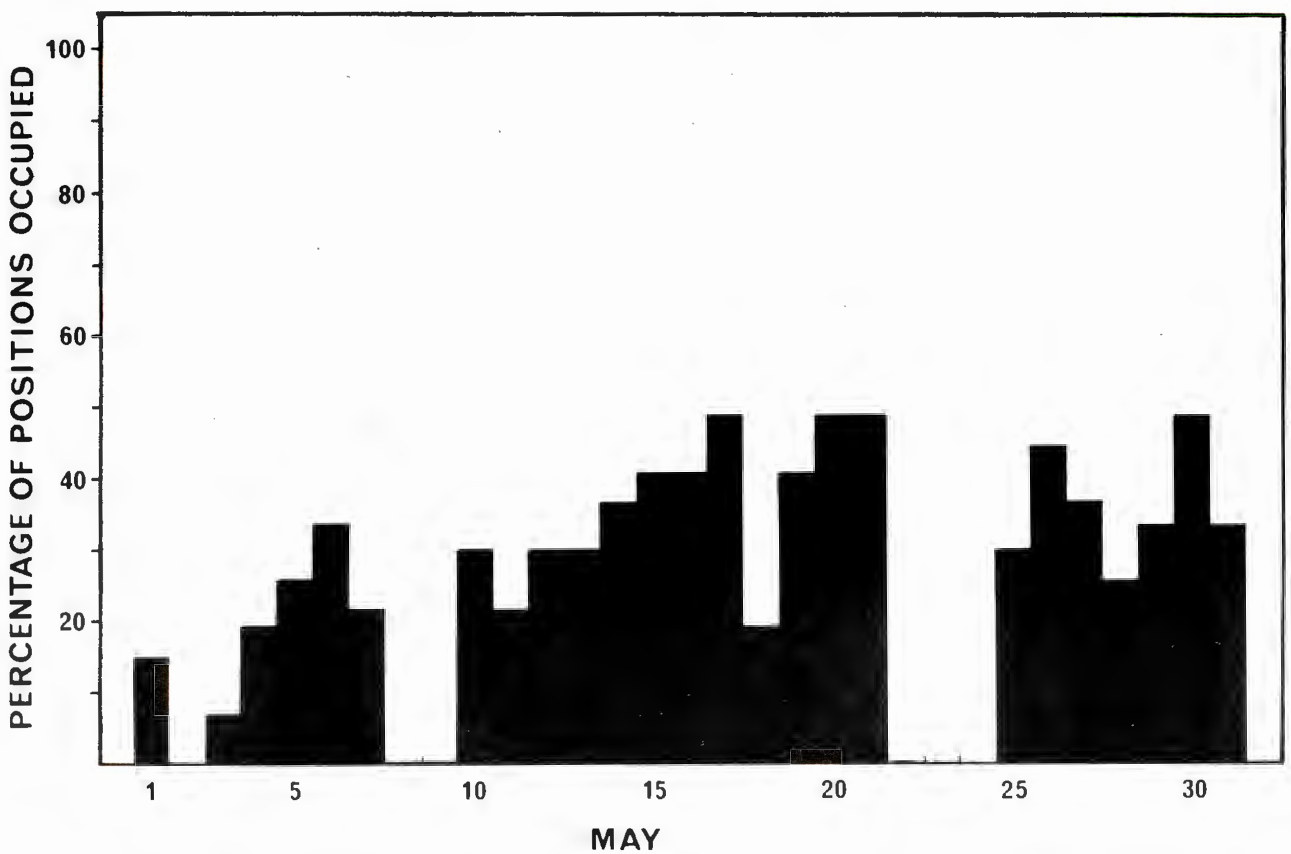

Fig. 5. Daily variation in the percentage of all haul-out positions used by seals in South Bay.

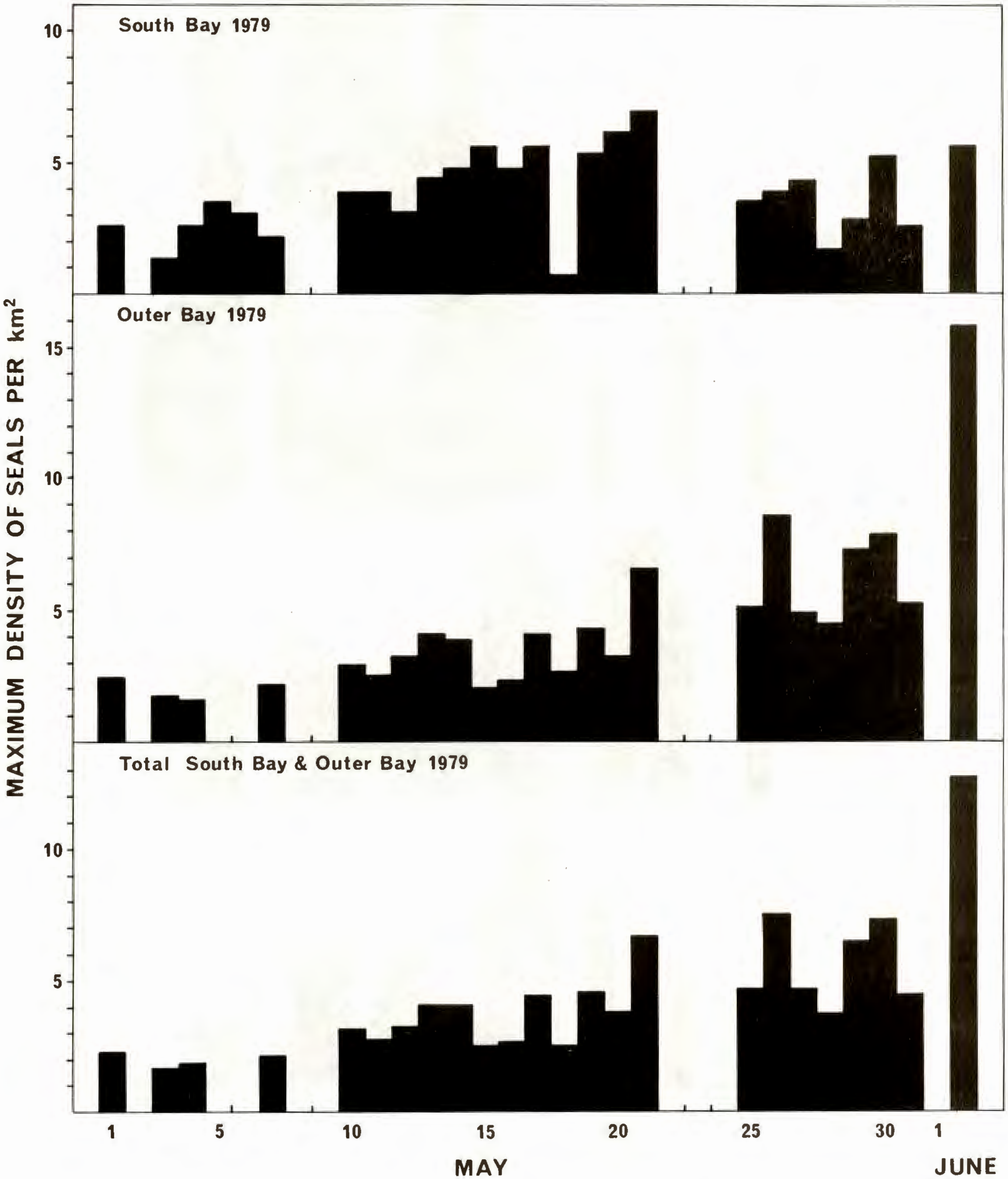

Fig. 6. Daily variation in the density of seals in South Bay, Outer Bay and both bays combined, in 1979.

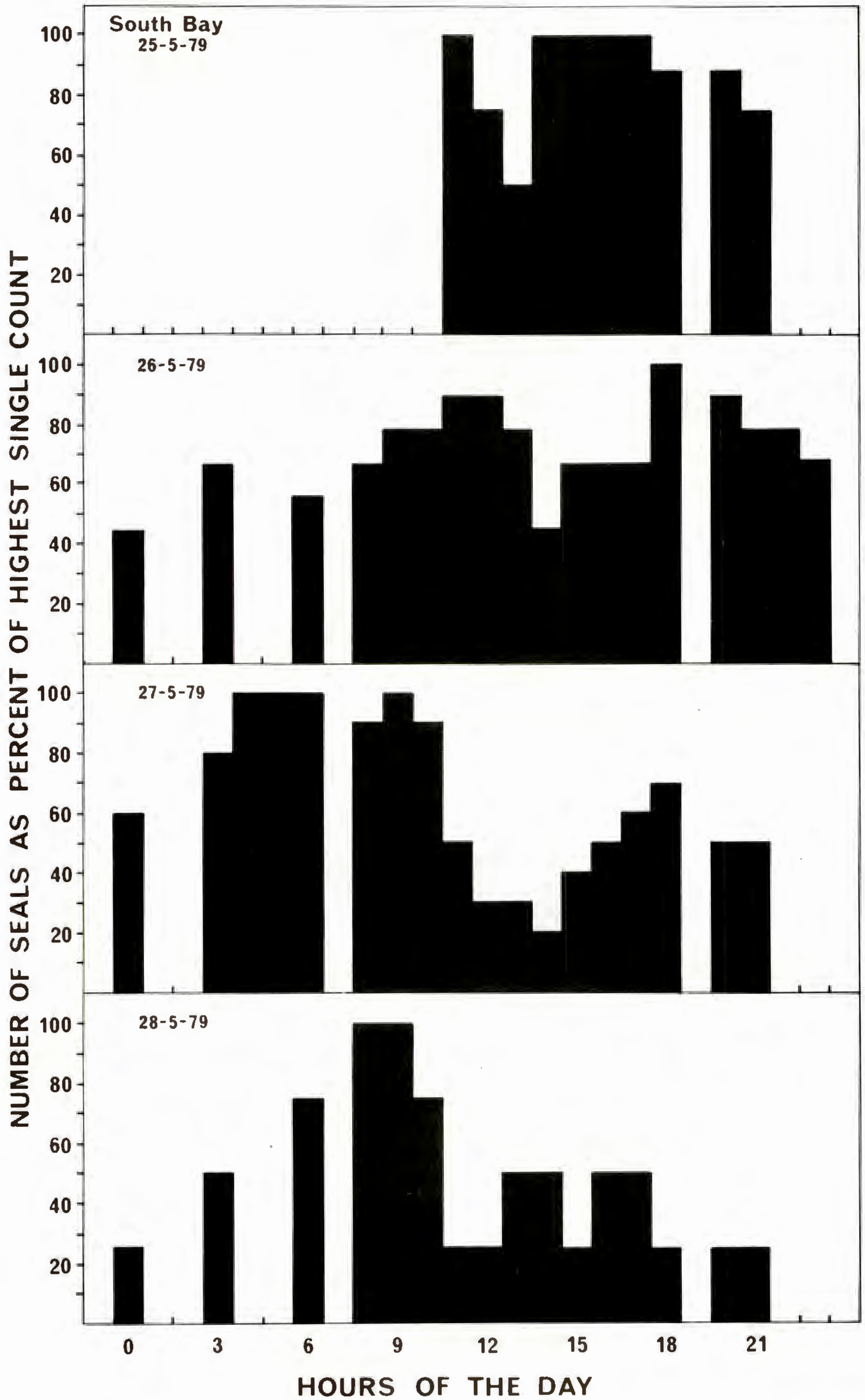

Fig. 7. Daily variation in numbers of seals observed in South Bay, expressed as a percentage of the highest single daily count.

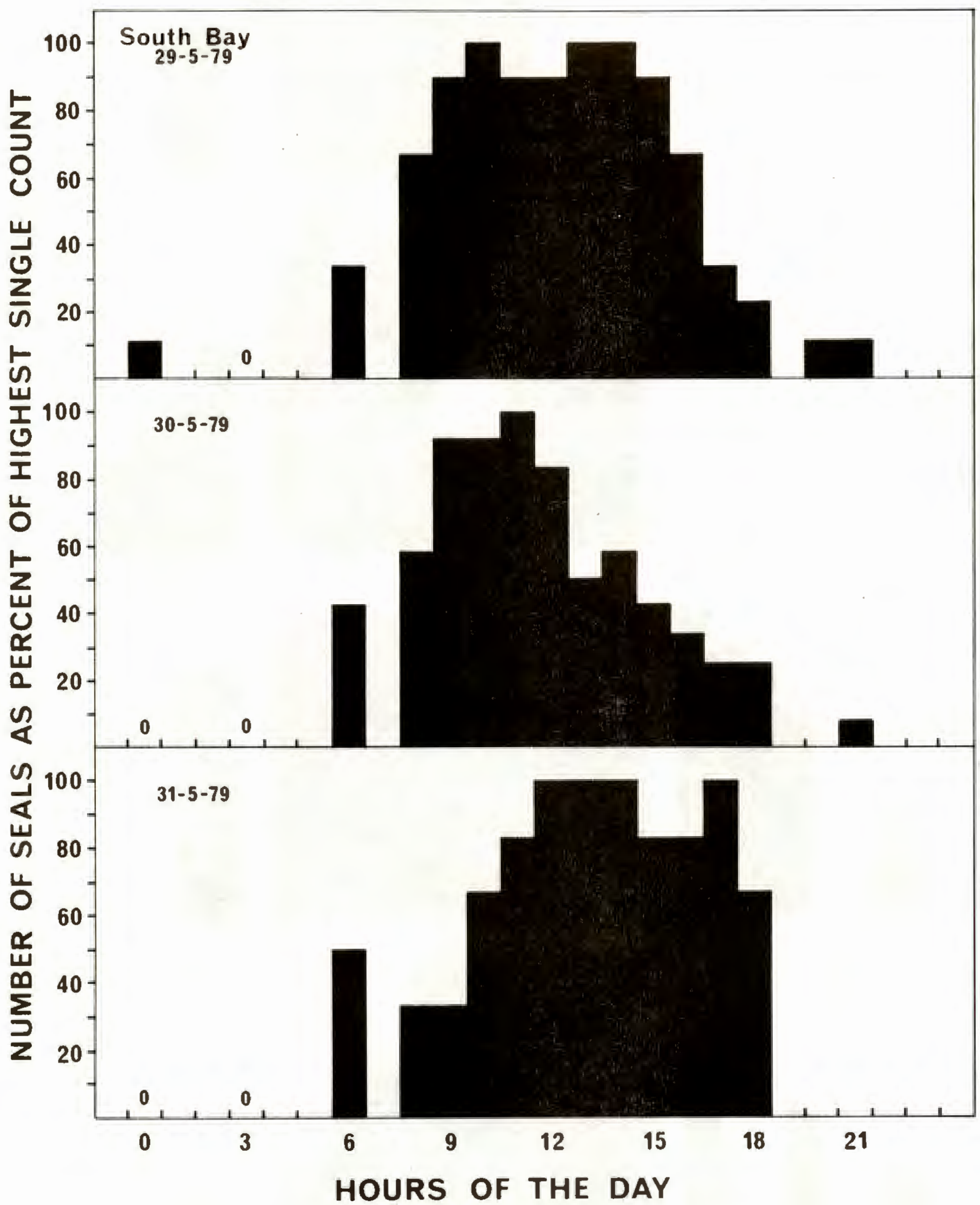

Fig. 7 continued
Daily variation in numbers of seals observed in South Bay, expressed as a percentage of the highest single daily count.

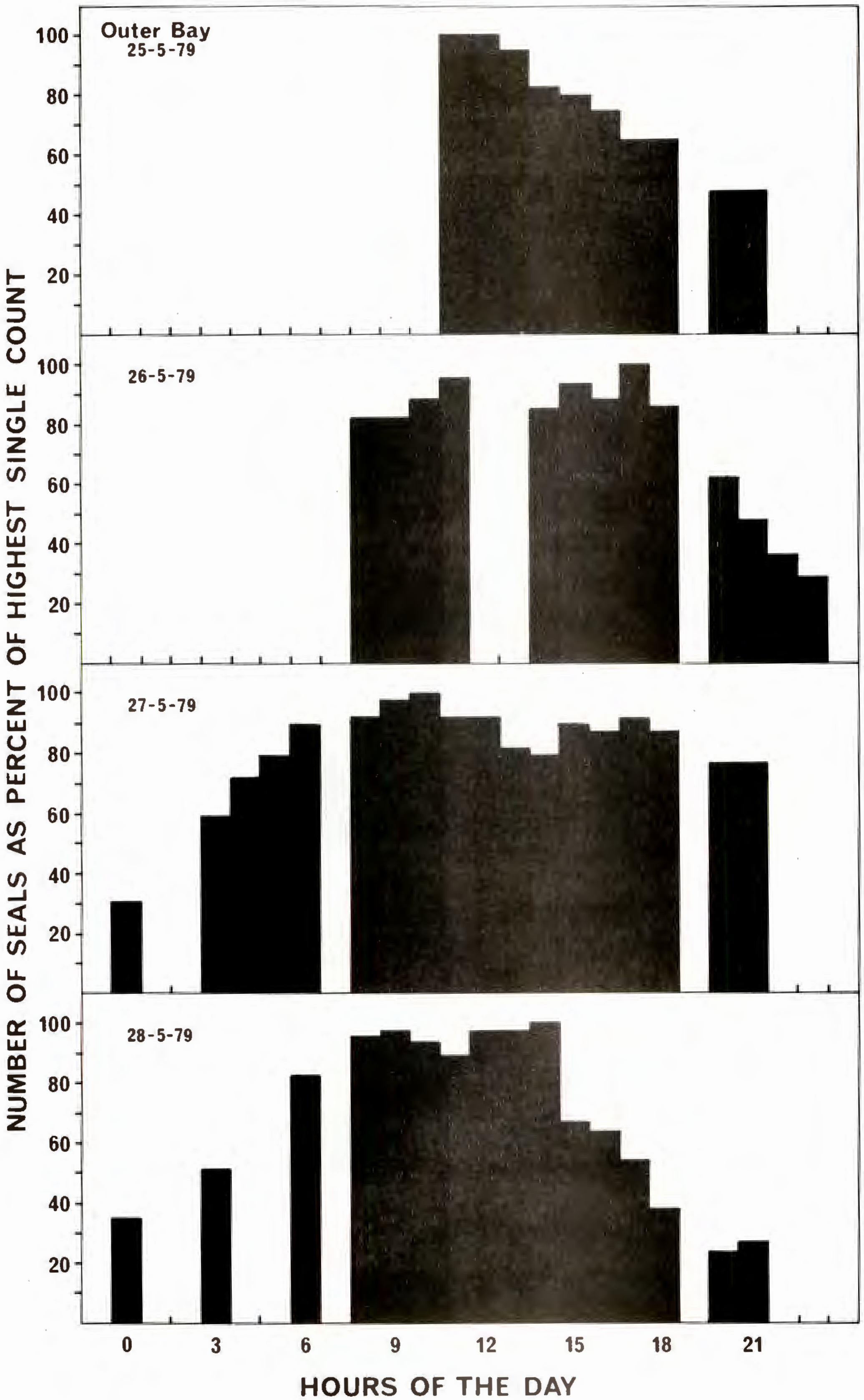

Fig. 8. Daily variation in numbers of seals observed in Outer Bay, expressed as a percentage of the highest single daily count.

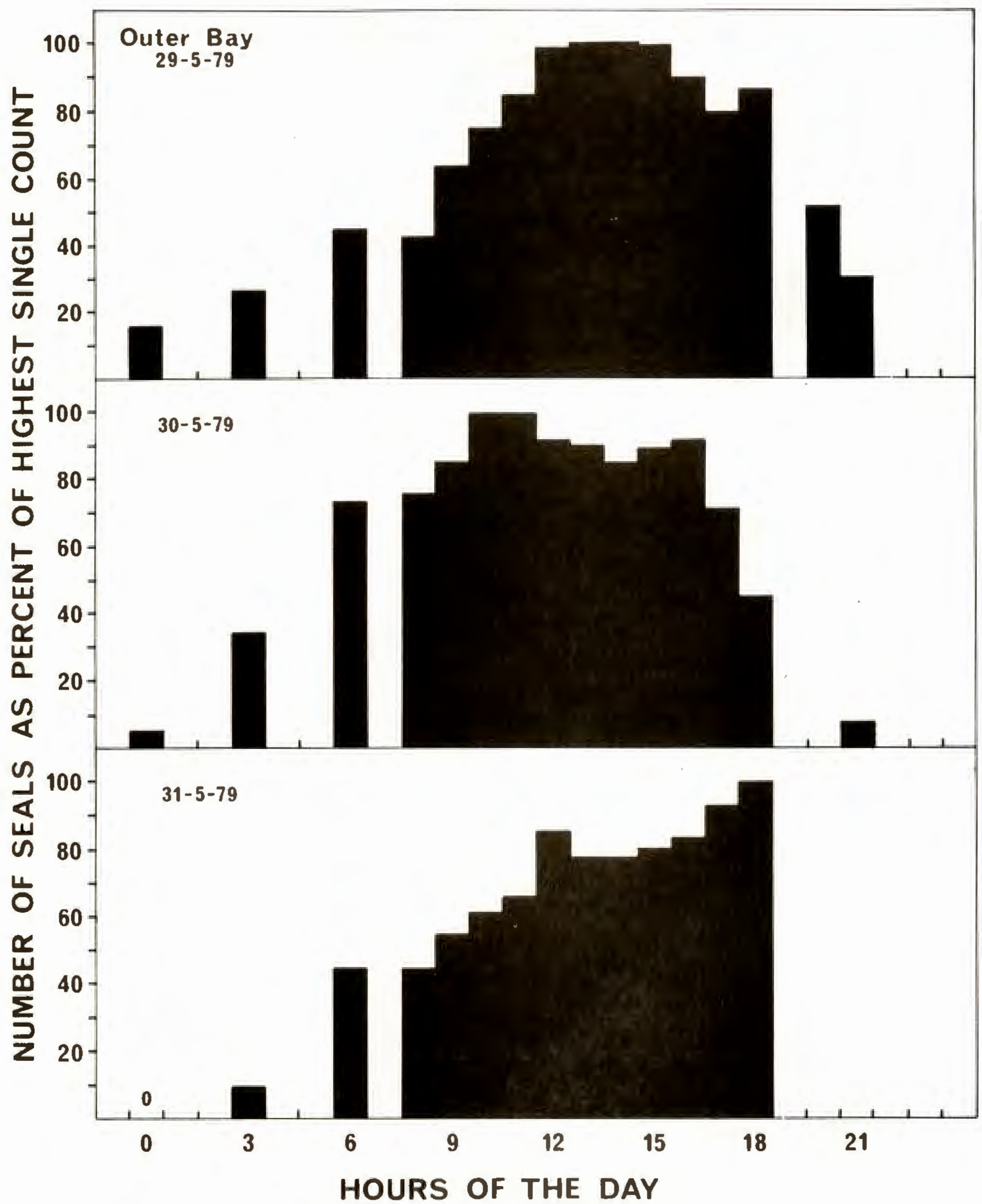

Fig. 8 continued
Daily variation in numbers of seals observed in Outer Bay, expressed as a percentage of the highest single daily count.

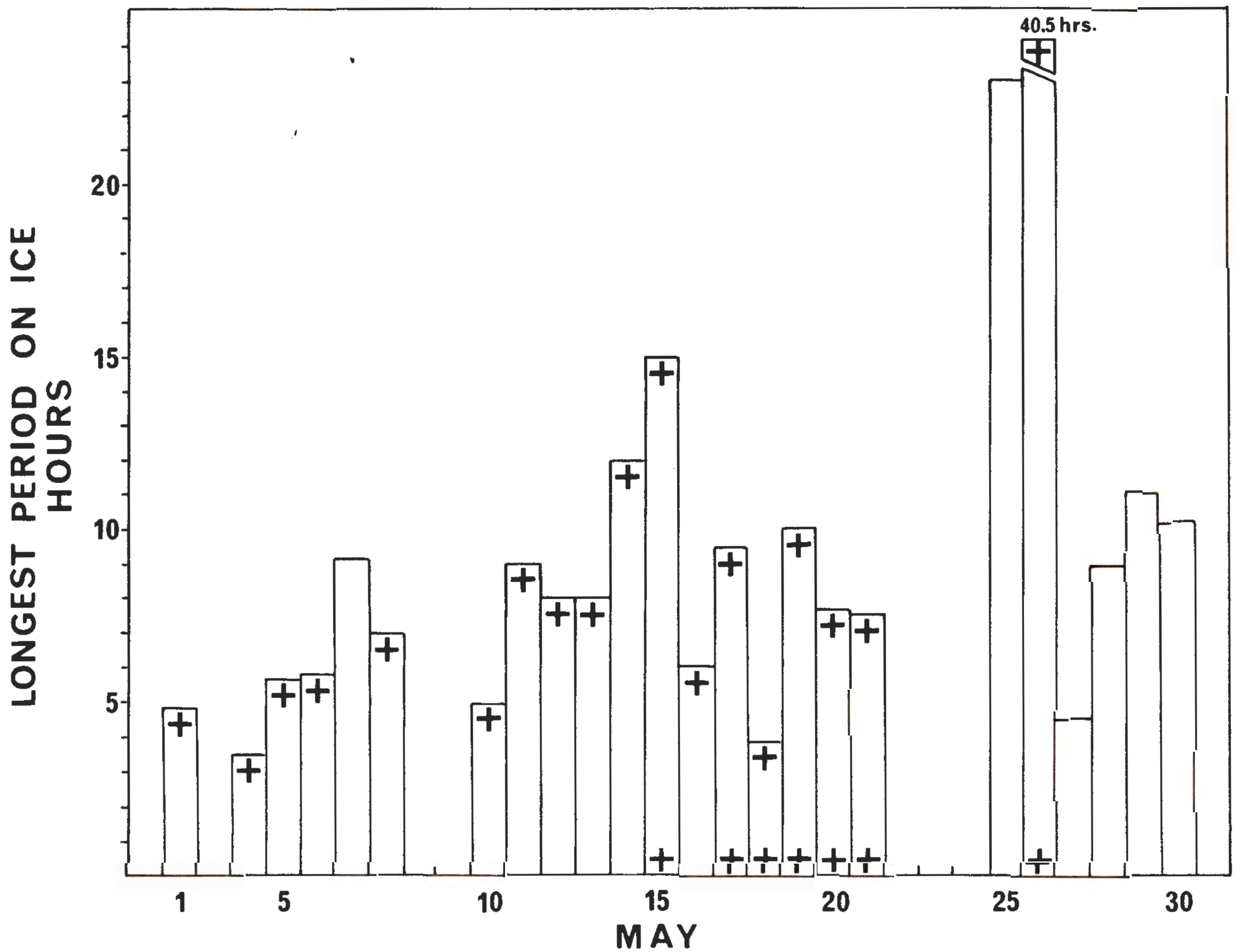

Fig. 9. Daily variation in the longest period of time spent hauled out by a seal in South Bay and Outer Bay.

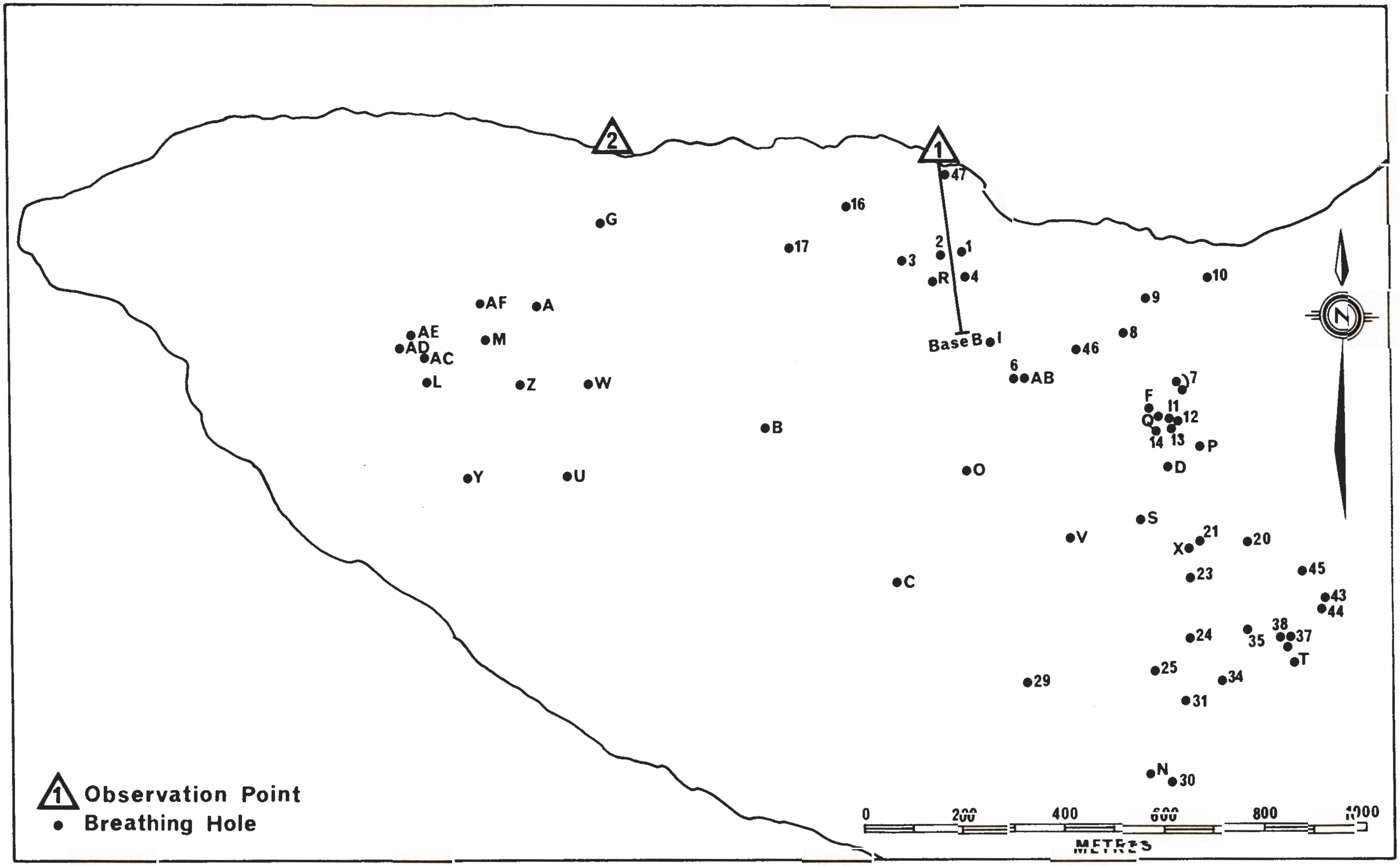

Fig. 10. Positions of all breathing holes located in South Bay.

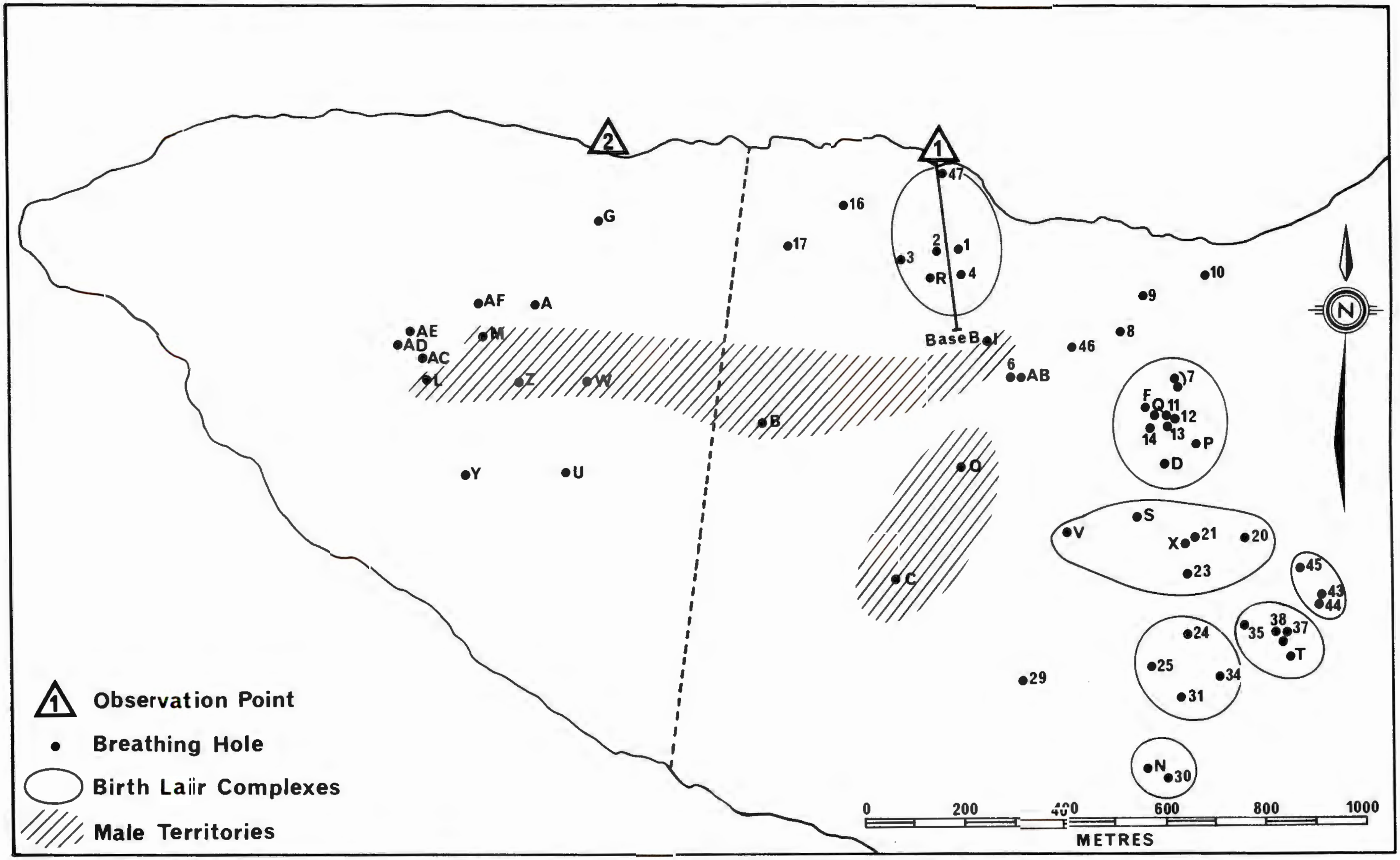

Fig. 11. Positions of breathing holes, and their relation to birth lair complexes and male territories in South Bay.

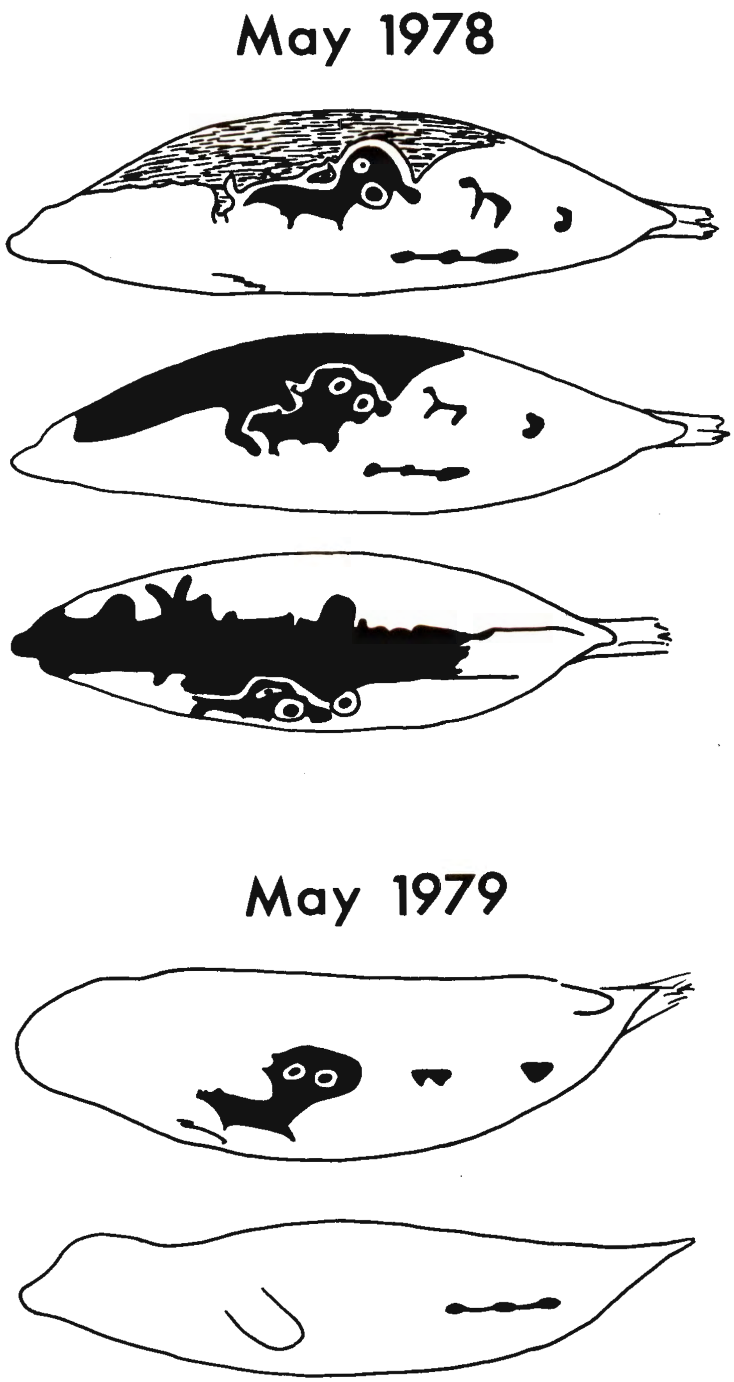

Fig. 12. Drawings made in 1978 and 1979 of what is believed to be the same male ringed seal.