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ENVIRONMENTAL ATLAS GIPSDALEN, SVALBARD

Vol. III

Reports on the Fauna of Gipsdalen.

Prepared for Northern Resources Ltd.
by the Norwegian Polar Research Institute
Editors: Torbjørn Severinsen and Rasmus Hansson



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With contribution from:

Karl Frafjord:

A Study of the Pink-footed Goose in Gipsdalen, Svalbard, during the Pre-breeding and Early Breeding Periods.

Frithjof Mehlum:

Supplementary Ornithological Survey 1990 in Connection with the Gipsdalen Coal Mining Project.

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Effects of Disturbance on Marine Mammals.



Bünsow Land with Gipsdalen, Central Spitsbergen, Svalbard.

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Preface

This is the third volume of the Environmental Atlas Gipsdalen, Svalbard, which is a part of the Environmental Impact Assessment for the proposed coal mining project in Gipsdalen.

The Atlas consist of:

- Volume I: "*Sensitivity of the Gipsdalen Environment*", including a preliminary impact assessment of the proposed coal mining project, and (in separate cover) a vegetation map (two sheets), a conservation value map for vegetation, and a quaternary geology and geomorphology map. As volume I contains confidential information its distribution is restricted until further notice.

- Volume II: "*Reports on the Quaternary Geology, Vegetation, Flora and Fauna of*

Gipsdalen, and the Marine Ecology of Gipsvika"; full reports from the work carried out in 1989, also includes the above mentioned maps. The fauna report is in Norwegian, with an exhaustive English summary.

- Volume III (this Volume): "*Reports on the Fauna of Gipsdalen*"; full reports from the work carried out in 1990.

Based on the complete series of environmental studies and the plans for coal mining in Gipsdalen, an Environmental Impact Assessment of coal mining in Gipsdalen is planned to be prepared by the end of 1990.

Torbjørn Severinsen

Rasmus Hansson

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A STUDY OF THE PINK-FOOTED GOOSE IN GIPSDALEN, SVALBARD, DURING THE PRE-BREEDING AND EARLY BREEDING PERIODS



Pink-footed geese *Anser brachyrhynchus* (photo: Frithjof Mehlum).

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SUMMARY AND CONCLUSIONS

The Pink-footed goose *Anser brachyrhynchus* was studied in the period 23 May to 19 June, 1990 in Gipsdalen, Svalbard (Fig. 1). The geese had already arrived in the region upon our arrival. Spring was late this year, and little snow melted until about 5 June (Fig. 2). The total number of geese was not very great compared to other regions of Svalbard. The highest number of geese registered was minimum 110 - 130 individuals (Table 4), of these min. 30 - 40 pairs bred in the valley. The numbers of geese decreased during late May, but increased to a maximum during June (Fig. 7, Table 4). The increase in June was associated with higher temperatures and a rapid progress in the snow melting (Fig. 2, Fig 3).

During early spring the areas available for foraging were very small, and mainly positioned in the lower part of the valley slopes (Fig. 5, Fig. 6). At this time the geese seemed mostly to be feeding on roots. As larger areas became available probably more of the vegetative parts of plants were consumed. The most important foraging areas were Usherfjellet, Usherflata, Tverrådalen, Gips-hukodden and Dalkallen (Fig. 1). A few geese were also found in the uppermost part of the valley (Table 4). The important foraging areas were mostly classified as wet moss tundra, with vegetation considered to be of high conservation value.

Some geese probably commenced breeding in late May, shortly following their arrival (Fig. 13). A range in the start of egg laying of 3 weeks seemed likely, with most eggs laid in early June. The most important breeding regions were Tverrådalen, Dalkallen and Usherflata (Fig. 1, Table 3). Syvertsen (1990) was apparently not aware of the Tverrådalen area, but a difference between years in the localization of nests is also possible. Most nests were found in the lowermost part of the valley slopes, in the bottom of the valley, and along edges on the river banks (Fig. 5, Fig. 6). Males defended a territory surrounding the nest shortly prior to and during the egg-laying phase, which may function as a reserve of food for the female.

"Breeders" were defined as geese that could be identified to a nest, "non-breeders" could not be identified to a nest. Non-breeders foraged 41 % of the day and rested 44 % (Table 5), with an increase in foraging and a decrease in resting during June (Fig. 8). Foraging in non-breeders was not influenced by the climate, but more resting was found in low temperatures. Breeders rested 90 % of the day with the female mainly sitting on the nest and the male sitting nearby (Table 6). Males were probably responsible for most foraging in breeders, more than 7 % of the day.

In the first half of the study period, foraging in non-breeders occurred mostly during the day. In the second half, the time devoted to foraging had increased, but most of the increase took place during night (Fig. 9, Fig. 10, Table 8). Breeders showed no preference of time of day for foraging (Fig. 11).

During a grazing bout, feeding intensity was higher in females than in males, about 80 and 65 % respectively (Fig. 12). Males were more alert than females and frequently involved in aggressive behaviour against other males.

The Arctic fox *Alopex lagopus* was the main predator upon goose eggs, and about 19 % of the nests recorded were predated by foxes (some of these nests were only seen after being found by foxes). Pink-footed geese were able to defend their nests against foxes, but if the fox found the nest while the pair was off foraging they seemed unable to drive him away. The egg-laying period may be the most sensitive, since the female is still foraging a large part of the day. No predation on adult geese were found.

Experimental provocations by a person on foot or on snow-scooter probably resulted in less time devoted to foraging for several hours after the provocation. However, due to a small sample size on "disturbed" geese, reliable conclusions cannot be drawn. But the decrease was in the order of 1 - 19 % (Table 7). A 15 % decrease in feeding intensity during a feeding bout was found in males (Fig. 12). No such decrease was found in females. Most likely males were more alert after a disturbance, while females grazed most efficiently because they were in need of an optimal fat storage for egg-laying and incubating.

Geese fled at somewhat greater distances when approached by a person on foot than by a person on snow-scooter. Perhaps the geese were more habituated to snow-scooters or vehicles. Usually, non-breeders fled when the human disturbance was 200 - 500 m away, but they were scared off from a greater distance by a small helicopter (AS 350 B1). The individual differences in flight distance were probably mostly related to the motivational state of the geese, which was changing during the pre-breeding, egg-laying and incubating periods. Incubating pairs had to be approached closely before they left the nest, both male and female would be sitting with their heads lowered toward the ground. They would not leave the nest even when overflown by the small helicopter only about 50 m above ground. Most of the geese that were scared off returned within 2 hours, and no permanent reduction in the numbers was noted.

The proposed coal mining project in Gipsdalen (Brekke & Hansson 1990) most likely will have a severe negative impact on the population of Pink-footed geese. The effects will be both direct and indirect. Direct effects will physically reduce the areas available for foraging and reproducing, and frighten the geese away from an even larger area. A high level of activity at the coal mine entrance in the uppermost part of the valley, at the harbour in Gipsvika, and along the road through the valley will probably not be tolerated by Pink-footed geese. It is assumed that they will leave these areas. If the road and conveyor are to be situated as proposed by Brekke & Hansson (1990), they will affect the most important spring feeding areas, as well as some of the most important breeding areas. This will certainly reduce the population of geese in the valley dramatically.

The geese will also be indirectly affected by human activities in Gipsdalen. Disturbances and stress will probably result in increased energy expenditure, less time devoted to foraging and less feeding efficiency. A reduced storage of fat will follow. This will influence on the reproductive success through smaller clutch size, increased predation and reduced survival of goslings.

Gipsdalen is probably not important for foraging of migrating geese during the spring migration. However, during the summer time the numbers increased (Syvertsen 1990), e.g. geese are immigrating from other regions to feed in Gipsdalen. Many of these probably came from Gåsøyane, and a number of Barnacle geese were also immigrating. During the summer moult, the flightless geese are very sensitive to any disturbance. Thus, human activities in Gipsdalen will also influence geese breeding elsewhere.

A decrease in the number of Pink-footed geese in Gipsdalen most likely will also affect other parts of the ecosystem, such as vegetation and the populations of predators like the Arctic fox.

It is difficult to see how the negative effects on the population of geese can be reduced. Wherever the road and conveyor are built, they will influence on some areas important to geese. The harbour will add to this negative influence. Locating these constructions to the south-eastern slope of Gipsdalen may reduce the negative impact to the breeding population, compared to a location on the opposite side.

INTRODUCTION

The Pink-footed goose *Anser brachyrhynchus* breeds in large numbers on Svalbard (Norderhaug 1971, Mehlum 1989), but little knowledge exists on factors contributing to the breeding success of the species. When the geese arrive on the breeding grounds in spring, the melting of snow has hardly begun. According to Løvenskiold (1964) most geese arrive during the last ten days of May with the earliest record on 16 May. In years with late snow melt, the geese may delay their arrival until early June (Løvenskiold 1964). On Brøggerhalvøya, Svalbard (78° 55' N) the first recordings of Pinkfooted geese over three years were 20 May, 1987 and 1988, and 16 May, 1989 (Frafjord unpublished data).

According to Løvenskiold (1964) the geese "cannot breed until the snow melts on their breeding grounds" or the first half of June, and "most of the egg-laying takes place in the last half of June". However, the snow cover in Svalbard is far from uniform as the top of moraines, steep hills etc. may be swept totally free of snow by the winds. The nests may be placed in steep hills or on level ground, and the species nest either as single pairs or in small colonies. Most often the nests are situated so that the birds have a good view of the surroundings, and are able to spot a predator from a long distance (Løvenskiold 1964, Mehlum 1989).

When the Pink-footed geese arrive in spring they are fat and able to survive despite the fact that little food is available (Løvenskiold 1964). The clutch size is commonly 3 - 5, and the female incubates while the male is on guard nearby (Mehlum 1989). The cost of reproduction is very high, and may be apparent for at least two months after the nesting phase (Black & Owen 1989). The female may lose a large proportion of her body weight during the 26 - 27 days of incubation, as her food intake is small during this period (Inglis 1977). If her storage of fat is not sufficient, the female may desert her nest, which results in a complete breeding failure. The period prior to clutch completion is assumed to be the best time for additional feeding (Inglis 1977). The male defends a territory, which may safeguard an area around the nest in which his mate can feed (Inglis 1977).

Few predators prey on adult Pink-footed geese on Svalbard. The Arctic fox *Alopex lagopus* is capable of killing them, but the geese are in most cases thought to win such a fight (Løvenskiold 1964). The eggs and young are however, more

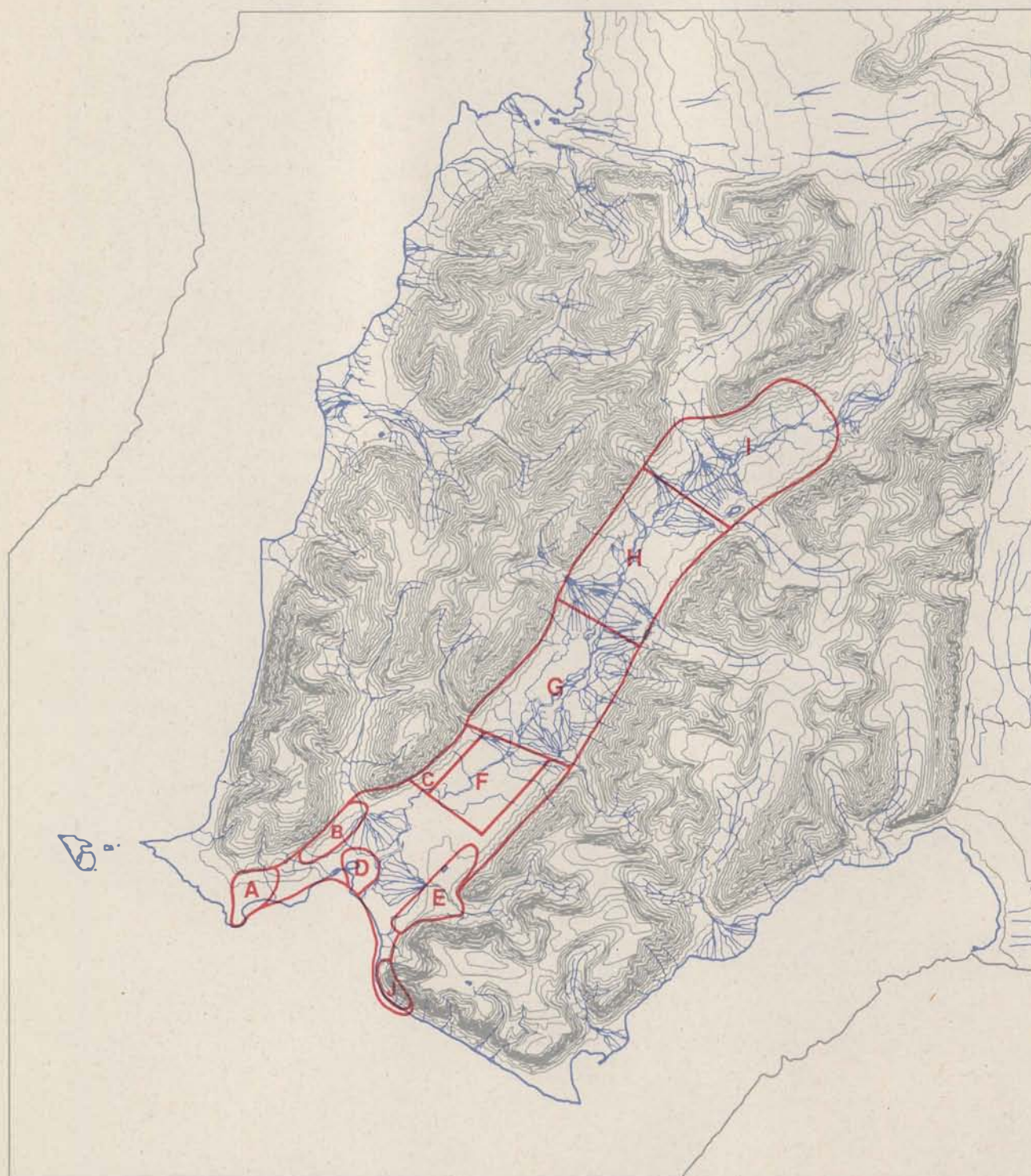


Figure 1 The study area and the most important feeding and breeding regions in Gipsdalen (A - J).

- | | |
|------------------|----------------------|
| A - Gipshukodden | F - Usherflata |
| B - Tverrådalen | G - Leirflata |
| C - Usherfjell | H - Pyefjellet |
| D - Haugen | I - Nordstrømfjellet |
| E - Dalkallen | J - Skiltvaktten |

susceptible to predation by both foxes, Glaucous gulls *Larus hyperboreus* and skuas *Stercorarius* spp. In Iceland, Inglis (1977) found the Arctic skua *Stercorarius paraciticus* to be the most important predator, as they were relatively inconspicuous and did not elicit strong responses from the geese. In Greenland, the Arctic fox is known to prey on adult White-fronted geese *Anser albifrons flavirostris* and their eggs, but this species is also capable of defence against foxes (Birks & Penford 1990). One reason for the female goose to remain on the eggs as long as possible is probably to prevent predation (Inglis 1977).

The Pink-footed goose is very sensitive to human disturbances (Mehlum 1989), possibly because of heavy persecution in earlier times. During the moulting phase, both the flightless adults and the young are very shy at any disturbance and will flee to the nearest water (Madsen 1984a). The geese reacted to helicopters at distances up to 20 km in Greenland (Madsen 1984a), with an average reaction distance of 10 km (Mosbech et al. 1989). Much less is known on the effect of disturbances in the pre-breeding and incubating periods. The effects of human impact at this time are probably several. The geese may use shorter time for feeding or feed less efficiently, they may be more exposed to predators or they may be excluded from suitable or optimal habitats altogether. This may apply to both migrating, non-reproducing and breeding birds.

This study was part of an Environmental Impact Assessment for Gipsdalen, Svalbard, on behalf of the Northern Exploration Ltd. The aim was to study the numbers, habitat utilization, behaviour and sensibility to disturbances during the pre-breeding and early breeding periods in Gipsdalen. In 1989, Syvertsen (1990) estimated the breeding population of Pink-footed geese in Gipsdalen and Templet to 34 - 65 pairs.

MATERIAL AND METHODS

Weather and snow melt

The study was conducted during 23 May to 19 June, 1990 in the Gipsdalen valley, Svalbard (Fig. 1). Upon our arrival in the valley the snow cover was nearly 100 %, not including the areas exposed to winds. By the beginning of June, the snow still covered about 90 % of the valley bottom (Fig. 2). This was due to low temperatures in May (Fig. 3). Thus, spring was late this year with serious snow melting commencing from about 5 June, and from then on water was running everywhere. After 9 June the snow disappeared very rapidly, and by our departure most snow had disappeared

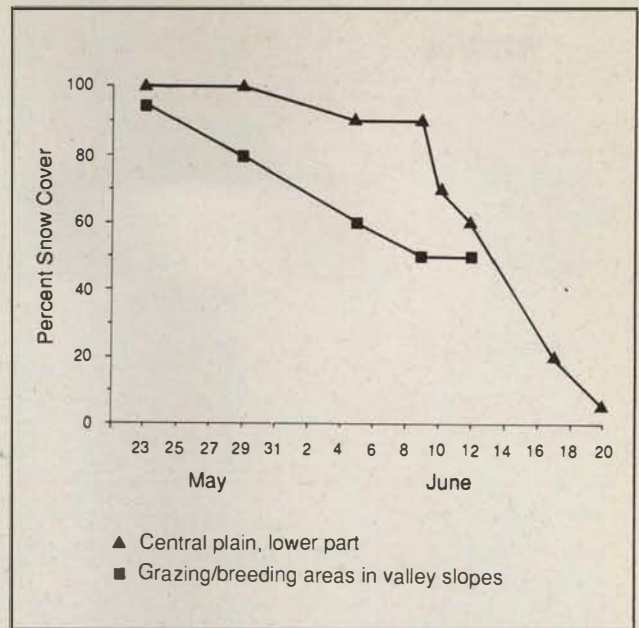


Figure 2 Approximate percent of snow cover in Gipsdalen during the study period as evaluated from photos.

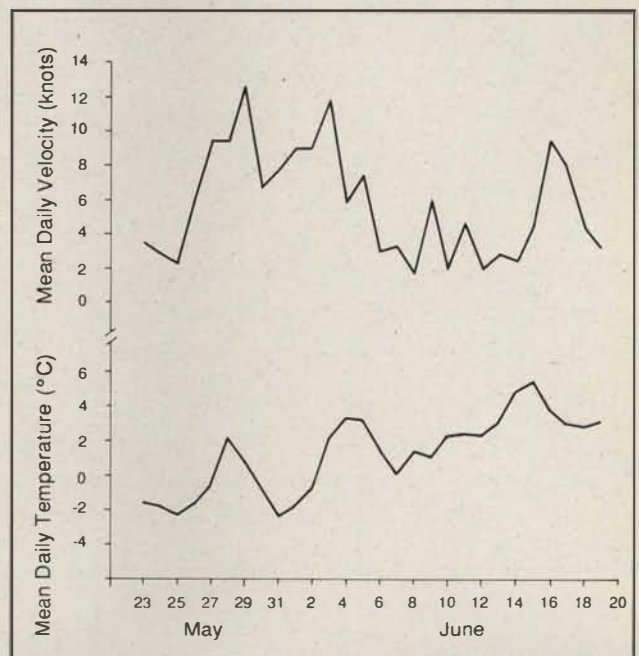


Figure 3 Mean daily temperature and wind velocity during the study period for Longyearbyen. Data from the Norwegian Meteorological Institute.

in the lower part of the valley (Fig. 2). The snow in the lower parts of the valley slopes disappeared more rapidly initially than on the bottom of the valley (Fig. 2). The ice on Gipsdalselva broke up on 6 - 8 June.

The sun was above the horizon during the whole study period. On 7 June the weather was so foggy that no work at all could be done.

Table 1 Periods of activity recordings in different regions of Gipsdalen.

Date	Region
24-27 May *	E - Dalkallen
27 May-2 June	C - Usherfjell
4-6 June	B - Tverrådalen
9-16 June	F - Usherflata
12-19 June	D - Haugen

* plus recordings on single days during the whole period

Table 2 Descriptions of the behaviour of Pink-footed geese recorded during activity studies in Gipsdalen.

Behaviour	Description
Resting	Sitting + Standing, including situations where it could not be decided whether the geese were sitting or standing.
Sitting	Body on surface, incl. incubating.
Standing	Standing quiet.
Foraging	Feeding, head below horizontal, incl. grazing and probing into the ground for roots.
Preening	Preening of feathers.
Walking	Movement on ground.
Swimming	Positioned in water.
Flying	Incl. geese passing over.
Drinking	Incl. eating snow.
Social interaction	All social behaviours, incl. mating.
Antipredator behaviour	Defense or escape behaviour, incl. to some extent head up and warning.

Daily mean temperature was calculated according to the formulae:

$$T = \frac{(T(07) + T(19) + T(\text{Max}) + T(\text{Min}))}{4}$$

T(07) = temperature at 0700 hour,

T(Max) = Maximum daily temperature, etc.

A wind chill index (WCI) was also calculated:

$$\text{WCI} = (10.45 + 10 \sqrt{W} - W) (33 - T)$$

W = wind velocity (m/sec),

T = temperature (Rosenberg et al. 1983).

Gipsdalen has a more inland climate than Longyearbyen with lower winter temperatures (Elven et al. 1990), and the temperatures in May and June most likely were somewhat lower than in Longyearbyen.

Numbers and habitat exploitation

The Pink-footed geese had already arrived in Gipsdalen on 23 May. The whole valley was examined four times during the study period. All geese observed were counted from selected stands by the use of spotting scopes (20 - 45x) and binoculars (10 x 40), and their positions plotted on a map (1:100 000). During the first period it was quite easy to spot the geese due to the small areas free of snow, but as snow melting progressed and as the birds commenced breeding it became increasingly difficult to spot them. During the late period it was impossible to search the whole valley, because of water flooding everywhere. Furthermore, a search through the valley at that time would inevitably scare many breeding pairs off the nest. A fifth census through the whole valley was performed from a helicopter. The purpose of this helicopter flight was to count reindeer calves, searching through the valley at slow speed and low altitude (50 - 100 m). From the back seat the view was not very good, but probably most of the geese scared off were seen. A possible bias in the censuses was geese flying back and forth, and in some cases both a minimum and maximum estimate of the numbers observed had to be given.

In May and early June censuses were performed almost daily in the lower part of the valley from a slightly elevated stand near the sea north of Gipsdalselva (Haugen, Fig. 1). Even though many geese could be observed at quite a distance (about 5 km at Usherfjellet), we probably did not spot all the geese in the region from this stand. These counts terminated when the ice on Gipsdalselva broke up.

Behavioural observations

Observations on the activity of Pink-footed geese were performed in five localities (Fig. 1, Table 1). Recordings were made from a tent and the behaviour of all geese observed was noted at five minute intervals. Exceptions to this routine were observations of two breeding pairs on Haugen (Fig. 1), which were done from the hut in Gipsvika each 10 minute. Most observations were made at distances from 300 - 800 m, maximum near 2 km. A total of 10 different behaviours were recorded (Table 2), and 1 - 22 geese were observed in each scan. Each data entry was termed a fix.

All percentages of behaviours were weighted against the number of observations.

When possible, breeding or territory-holding pairs were differentiated from other geese. "Non-breeders" were defined as geese that could not be identified to a nest, i.e. including both real non-breeders, the pre-breeding period and to some extent the egg-laying period. "Breeders" were geese that could be identified to a nest, including the incubating and to some extent the egg-laying periods. Egg-laying pairs were classified as breeders as soon as they could be identified to a nest territory.

A Pearson's correlation coefficient between the most frequent behaviours and climate (temperature, wind velocity and WCI) was calculated for days with more than 100 observations ($n = 14$). On none of these days were the observations spread evenly throughout all 24 hours.

The intensity of foraging was studied in selected periods, when active, foraging individuals were followed for 10 minutes and their total time used in foraging summed. In some cases 5 minutes were used as an observation period. A foraging period was said to be interrupted if the focal individual shifted to some other behaviour different from feeding, walking or standing more than about 30 sec. The clock was then stopped and the time elapsed used as an observation period. The intensity of feeding was calculated as percent of the observation period. A Mann-Whitney test was used to examine differences between medians of groups (z-score).

Members of a pair were sexed according to the abdominal profile, as the females in spring are fatter than the males (Fig. 4, see Owen 1981). Males also for the most part appeared somewhat larger (see Haftorn 1971, Inglis 1977) and paler than females, and were frequently chasing other males. Attempts were also made to sex juveniles according to the amount of fat, but it is not known if this is reliable. Juveniles were distinguished from adults by a darker appearance (Haftorn 1971).

Responses to predators and disturbances

The responses to potential predators were recorded opportunistically, along with the approximate distance and behaviour of the predator. However, vigilant behaviours such as "head up" and "extreme head up" (Inglis 1977) were not recorded. Likewise, potential human disturbances were recorded whenever possible. Three slow approaches by one person were done deliberately to study the reactions of the geese. These were

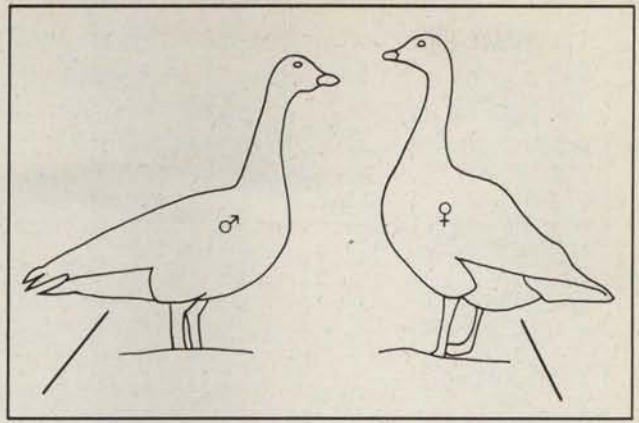


Figure 4 Sexual dimorphism in the amount of body fat in Pink-footed geese (abdominal profile). Drawn from a photo by F. Mehlum.

respectively on snow-scooter and on ski at Tverrådalen 6 June, and on foot at Usherflata 16 June (Fig. 1). The duration of each of these provocations was about 20 minutes. Activity recordings and recordings of feeding intensity were made up to 3.5 hours after the provocations.

The reactions to helicopters and noise from helicopters were noted carefully whenever possible. Some helicopters were heard passing by out in the fjord, and during the last days of the study period a helicopter was often visiting Gipsvika and landed at the hut. On 10 June, a helicopter search for reindeer calves through the whole valley was performed. One observer joined this flight and noted the numbers and approximate distances of geese that were flushed. The other observer was sitting in the hide at Usherflata and noted the reactions of a number of geese there.

All helicopter traffic in Gipsvika and Gipsdalen was by the small "Ecureuil" (AS 350 B1). The sound propagation from a helicopter is dependent upon many factors: weather, atmospheric conditions and topography, and speed, load, altitude and direction of movement of the helicopter (Fjeld et al. 1988, Mosbech et al. 1989). Helicopters also generate infrasound, i.e. very low frequency noise, which may propagate up to 1000 km (Fjeld et al. 1988).

RESULTS

Breeding biology

Although the aim of this project was not to evaluate breeding biology and reproductive success, some interesting observations were made but not quantified. In the pre-breeding period the geese mostly foraged in small flocks, but single pairs were also observed. A lot of chasing between

Table 3 Numbers of Pink-footed goose nests found in the lower part of Gipsdalen. I = minimum numbers observed, II = I + some likely nests or nests observed to be found by foxes.

Region	I	II
B - Tverrådalen	11	15
D - Haugen	2	2
E - Dalkallen	6	6
F - Usherflata	4	6
J - Skiltvaktan	1	3
Total	23	32

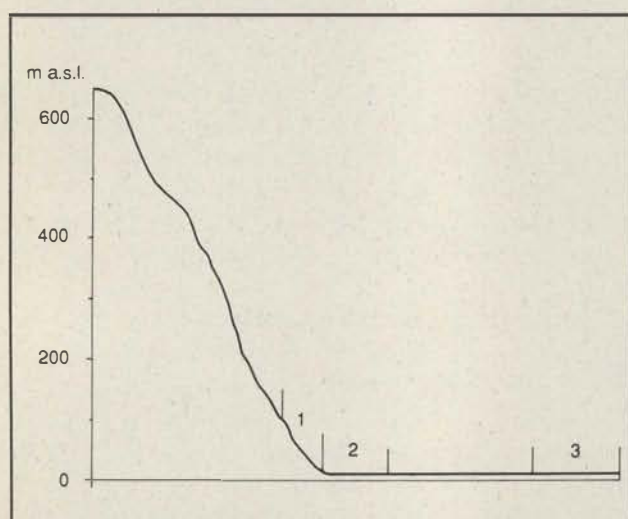


Figure 5 Cross section from a part of Gipsdalen, showing the main levels of feeding and breeding at Tverrådalen and Usherfjell-Usherflata. 1 - Low part of valley slope, 2 and 3 - central plain.

males was observed, but the males rarely chased females. Many of the pairs were followed by one or two juveniles, toward which the male behaved less aggressive than toward others. Matings were observed on only two days, 28 May and 16 June, but indicate a range in the onset of breeding of more than two weeks. One goose was flying in circles around us and constantly warning on 31 May (Skiltvaktan, Fig. 1). This was thought to be the male and his mate was probably sitting on the nest. Since the female did not fly off, she was probably incubating or close to starting incubation. Eggs are normally laid at intervals of 1 - 1.5 day, so the clutch will be completed after 4 - 8 days (Haftorn 1971). At Tverrådalen incubating geese were first observed on 5 June. This observation also supports the view that breeding commenced the last days of May. On 5 June a fox was first seen eating a goose egg.

We passed incidentally close by a nest containing two eggs on 11 June. This pair was probably still

in the egg-laying phase. On 16 June one pair established a nest territory, and the next day one egg was found in their nest. By 19 June a large number of non-breeding geese were still observed, but it remains unknown whether these were really non-breeders (e.g. young geese), unsuccessful breeders or geese that had not yet started breeding. It is possible that some of these individuals may have intended to start breeding even this late. Thus, a range in the onset of breeding of three weeks or more seemed likely in 1990, with the majority of eggs laid in early June.

A pair could not be identified to a nest before egg-laying had started. During the first days the male behaved aggressive toward others, and chased them away from his territory surrounding the nest. After the onset of incubation, the male was rarely aggressive, and he sometimes tolerated other geese close to the nest both on snow and on exposed land. Nest building probably started shortly prior to egg-laying, but was rarely observed. In the two nests examined on 11 and 17 June no down was found. In one of these the single egg was covered by mosses. During the egg-laying period the female was most often located close to or upon the nest, but sometimes foraged quite a distance from the nest. During incubation, the female rarely left the nest.

Breeding pairs and nests were not deliberately searched for, but during the behavioural observations many of the breeding pairs in the lower part of the valley were found. A few more were recorded when found by foxes. Tverrådalen, Dalkallen and Usherflata seemed to be the most important breeding areas (Fig. 1, Table 3). At Tverrådalen all except one of the nests were found in the lowermost part of the hill, and the single one was found in the bottom of the valley (Fig. 5). At Usherflata, the nests were built on small tussocks in the bottom of the valley (Fig. 5), while in Dalkallen and Haugen they were mostly located at the edges of the river banks (Fig. 6). At Skiltvaktan, at least one pair seemed to be breeding beneath a cliff. Breeding on top of a moraine was indicated by a pair at Pyefjellet (Fig. 1), but they were only seen when flying away. Nesting mostly took place in small colonies, with the distance between nests greater than 10 m.

Numbers and habitat exploitation

The numbers of Pink-footed geese in Gipsdalen were highest during the last part of the study period (medio June), intermediate in the first part (medio May) and lowest during the last days of May and first days of June (Table 4). The same trend was found when searching the lower part of the valley daily (Fig. 7a). By 8 June the total

Table 4 Numbers of Pink-footed geese in different regions of Gipsdalen (the names of different region codes are given in Fig. 1). The number for 10 June was flying geese recorded during a helicopter flight through the valley.

Date	Region										Total
	A	B	C	D	E	F	G	H	I	J	
24 May	17	4-6	15-22	0	0	2	5	10	0	0	26-31
29 May	8-11	3	11	0	1	0	1	2	4	0	30-33
3 June	6	5	16	0	2	0	0	2	0	0	31
8 June	6	43	2	3	3-22	26-28	12	12	4	1	112-133
10 June	4	4	17	2	2	2*	8-24	16	17	0	75-98

* Probably plus 10 geese noted by the observer at Usherflata.

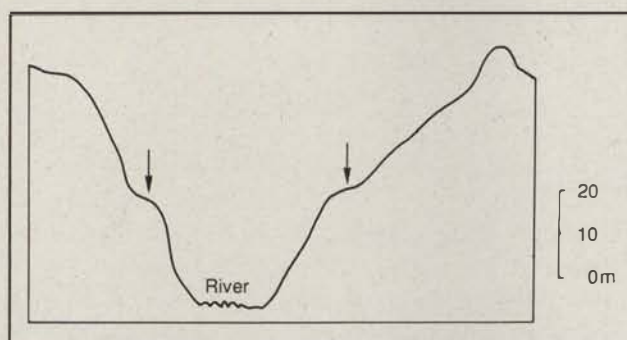


Figure 6 Cross section of the side valley at Dalkallen, showing the main feeding and breeding sites.

number had increased much (Table 4), probably because the temperature had risen and the snow was melting rapidly. Some of these birds probably came from Templet.

In May, the main foraging areas were Gipshuk-odden and Usherfjellet, with only a few individuals found at Dalkallen, Tverrådalen and Usherflata. In this early period a lot of flying was observed, notably to and from Templet. The flying geese were probably searching for suitable foraging areas. At this time most geese foraged in small areas in the lowermost part of the valley slopes.

As wider areas became free of snow in June, Usherflata, Tverrådalen and Dalkallen were the most important foraging areas (Table 4). In Usherfjell and Usherflata combined, the numbers were rather constant throughout the study period, with a small increase in early June (Fig. 7b). At Tverrådalen only a few geese were observed prior to June, but from 4 June the numbers increased rapidly (Fig. 7c). The area called Dalkallen was regularly visited by a few foraging geese, but sometimes the number was greater (e.g. on 8 June when 22 geese were found, Table 4).

The rest of the valley seemed less important for foraging, but geese were observed even in the

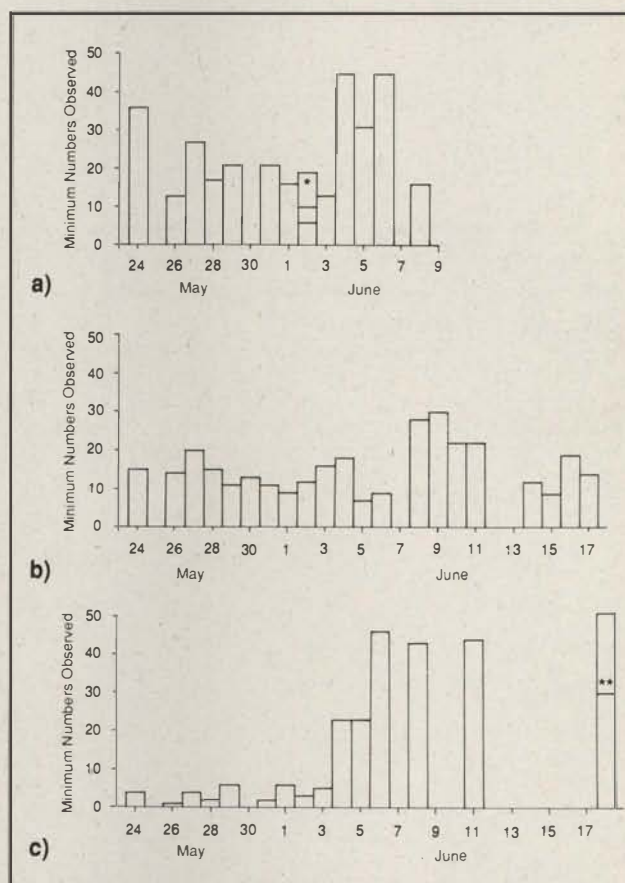


Figure 7 Numbers of Pink-footed geese recorded daily from:

- a) Haugen: All geese that were observed in the regions A - E and J were counted.

* - three censuses this day, showing some variation in numbers (12⁰⁰, 15⁰⁰ and 21⁰⁰ hours).

- b) Usherfjell and Usherflata, and

- c) Tverrådalen: Includes recordings made both during censuses and behavioural observations.

** - Both a minimum and maximum figure had to be given this day due to many geese flying around.

Table 5 Percent of time devoted to different behaviours of non-breeding Pink-footed geese during different 5-days periods in Gipsdalen.

Behaviour	Date					Total
	24-28.5	29.5-2.6	3-9.6	10-14.6	15-19.6	
Resting	49.1	61.6	40.1	32.7	29.9	43.9
Sitting	18.5	39.3	14.2	14.5	15.1	20.2
Standing	27.2	21.2	25.5	18.0	14.8	22.1
Grazing	6.6	26.4	45.9	51.5	48.8	41.1
Preening	1.7	2.5	1.6	7.2	9.3	4.1
Walking	9.5	5.2	6.4	5.4	6.2	6.9
Swimming	0.0	0.0	1.4	0.4	0.9	0.4
Flying	2.1	2.8	4.0	1.9	3.6	2.6
Drinking	0.0	0.1	0.0	0.0	0.2	0.0
Social interaction	0.8	1.3	0.4	0.8	1.1	0.9
Antipredator behaviour	0.2	0.0	0.0	0.1	0.1	0.1
No. of fixes	2357	1267	915	1709	894	7142

Table 6 Percent of time devoted to different behaviours of breeding Pink-footed geese in two periods in Gipsdalen.

Behaviour	Date		Total
	9-13.6	14-19.6	
Resting	91.0	88.5	89.7
Sitting	76.9	75.5	76.2
Standing	14.1	13.0	13.5
Grazing	6.7	8.1	7.4
Preening	0.7	1.1	0.9
Walking	1.0	1.8	1.4
Swimming	0.0	0.1	0.0
Flying	0.2	0.2	0.2
Social interaction	0.4	0.1	0.3
No. of fixes	1364	1404	2768

uppermost part of the valley where snow melting was later than in the lower parts. During the helicopter flight on 10 June, 17 geese were flushed in this region (Table 4). Many of these were found along Nordströmfjellet towards Florabreen.

Templet as a whole was only examined on a single day, 24 May, when 26 - 31 Pink-footed geese were observed. Only the northern part of Templet was examined regularly, where few geese were found (Fig. 1, Table 4).

Time budgets

Among non-breeders resting and foraging occupied 44 and 41 % of the day respectively for

the total study period (Table 5). After an initial increase in resting during late May and early June, the amount of resting decreased (Fig. 8). Foraging evolved contrary to resting and showed an increase in June. Other behaviours were infrequent, with walking and preening most common (Fig. 8, Table 5). Non-breeding geese were involved in social interactions only about 1 % of the day (Table 5). Most of these were aggressive interactions among males and of short duration.

Most observations on breeders were from pairs with incubating females. Breeders were resting 90 % of the day (Table 6), with females mainly sitting on the nest and males sitting nearby. Foraging occupied only 7.4 % of the day (Table 6), with a small increase from the first to the second period studied (Fig. 8). Males were responsible for most of this foraging. Incubating pairs were rarely involved in social interactions (Table 6).

Since only three provocations were made, the numbers of activity recordings were few. Compared to undisturbed non-breeders, foraging decreased about 19 %, sitting increased 10 % and standing increased 6 % after the human provocations (Table 7). But these calculations are probably not strictly correct. When the first provocations were made on 6 June, we were only able to identify some pairs to their nests. Both the "disturbed" and the "undisturbed" observations include some egg-laying and incubating geese, but the error is likely to be greater for the "disturbed" due to the small sample size. When combining undisturbed non-breeders and breeders, foraging amounted to 31 % for the same period. This is only 1 % more than the disturbed geese (Table 7). The correct answer is probably somewhere in between these figures,

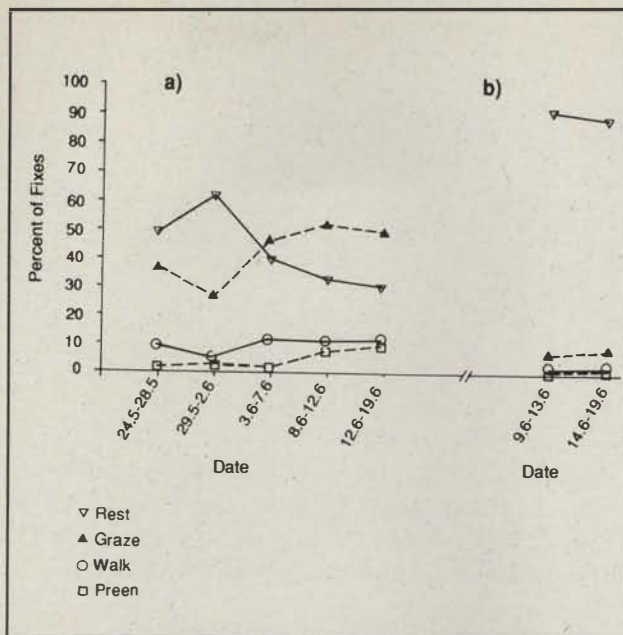


Figure 8 Percent of time devoted to the most frequent behaviours of a) non-breeders and b) breeders in Gipsdalen (5 days periods).

i.e. foraging was reduced by 1-19% in recently disturbed geese.

No significant correlations between foraging and temperature, wind or WCI were found for non-breeders. The geese did however, rest more in low temperatures than in higher ($r = -0.63$, $p < 0.01$), and a correlation was also found between resting and WCI ($r = 0.74$, $p < 0.01$) and sitting and WCI ($r = 0.68$, $p < 0.01$). Thus the temperature did influence on the geese to some extent, but wind had a minor effect. No significant correlations between these behaviours and the minimum temperature were found, but resting and preening were correlated with the maximum temperature of the day ($r = -0.63$ and $r = 0.69$ respectively, $p < 0.05$).

Daily activity patterns

The diel activity pattern for non-breeders showed little variation during the total study period, but an increase in sitting during the night (from 02⁰⁰ to 05⁰⁰ hours) and during the evening (21⁰⁰ - 22⁰⁰ hours) was found. When splitting the study period in two, the same variation in sitting was found during the first half of the study period, from 24 May to 4 June (Fig. 9). In this period most foraging occurred during the day (Fig. 9). In the second half of the study period, 15 - 19 June, the non-breeders did not rest as much during the night but were mostly foraging (Fig. 10). The amount of nightly foraging doubled from the first to the second period (Table 8). In the second period the geese were foraging even more during the night than during the day (Table 8). Thus, an increase in total time devoted to foraging in this

Table 7 Percent of time devoted to different behaviours of Pink-footed geese following human provocations ($n=3$) at Tverrådalen and Usherflata, 6 and 16 June (disturbed). Percent of behaviours in undisturbed non-breeders for the same periods of day as disturbed (01⁰⁰ - 03⁰⁰ and 16⁰⁰ - 19⁰⁰ hours) for the period 5 - 19 June are also shown. Most antipredator behaviour was directed toward an Arctic fox.

Behaviour	Disturbed	Undisturbed
Resting	51.7	35.4
Sitting	23.1	13.0
Standing	28.1	22.1
Grazing	29.9	48.6
Preening	1.3	3.6
Walking	6.8	6.9
Swimming	0.0	0.7
Flying	1.6	3.3
Social interactions	0.0	1.4
Antipredator behaviour	8.7	0.1
No. of fixes	381	840

Table 8 Mean percentage of time devoted to grazing in non-breeding and breeding (incubating) Pink-footed geese during day (08⁰⁰ - 19⁰⁰ hours) and night (20⁰⁰ - 07⁰⁰ hours) in Gipsdalen. Mann-Whitney test between day and night.

	Period	Day		Night		z	p<
		\bar{X}	SE	\bar{X}	SE		
Non-breeders	24.5-2.6	40.7	2.8	24.1	4.4	2.69	0.01
Non-breeders	5-19.6	43.4	2.6	54.0	4.1	1.99	0.05
Breeders	9-19.6	6.6	0.9	8.3	1.4	0.54	n.s.

period was not accomplished by more foraging during the day, but by more foraging during the night compared to the first period.

As breeders were mostly sitting, only minor variation in the behaviour during the day was expected (Fig. 11). Breeding geese foraged infrequently during most of the day, with no clear preference for time of day (Fig. 11, Table 8).

Feeding intensity

Females fed 15% more than males in undisturbed conditions (Fig. 12, $z = 4.01$, $p < 0.01$). This meant that the females fed more intensively while males were more alert. The difference was even greater after a disturbance or provocation (Fig. 12). The females did not reduce their feeding

intensity following a disturbance ($z = 0.45$, $p > 0.05$), while males reduced feeding intensity by more than 15 % ($z = 2.22$, $p < 0.05$). With both sexes combined, no significant difference was found in the intensity of foraging prior to and after a disturbance ($z = 1.64$, $p > 0.05$, Fig. 12).

During June, a significant increase in the intensity of feeding was found (simple regression, $r^2 = 0.14$, $F = 17.48$, $p < 0.001$). Males contributed most to this increase ($r^2 = 0.19$, $F = 10.97$, $p < 0.01$), and females less ($r^2 = 0.11$, $F = 5.70$, $p < 0.05$). A similar relationship was found between feeding intensity and numbers of geese near the focal individual (range 1 - 9 in numbers). The increase in feeding intensity was greater in males in larger flocks, than in females (males: $r^2 = 0.10$, $F = 4.99$, $p < 0.05$; females: $r^2 = 0.01$, $F = 0.59$, $p > 0.05$). However, in all the tests concerned a great range in the distributions was found, which explains the low r^2 -values.

Responses to human disturbances

Upon being approached by humans, the non-breeders reacted by vigilance with head up and if approached too close they would fly off. They rarely ran off on ground and never fled to water. During the first period, the geese would simply leave the area upon a disturbance by humans. Later, as breeding commenced, they mostly flew around in circles and returned to the same area soon after the person had left. Non-breeders usually fled when the human disturbance was 200 - 500 m away, but sometimes when the humans were as far away as more than 1 km.

Incubating geese would hardly leave their nest. One pair was passed as close as 10 m on several occasions, both on ski and on snow-scooter. The female was incubating and the male sitting nearby. Upon our approach, both lowered their head and neck toward the ground, but they did not fly off. Another pair was passed on snow-scooter as close as 30 m without the female flying off, while the male did fly away when the distance to the approaching scooter was about 50 m.

During the provocation at Usherflata on 16 June, the pair which had just started breeding and laid one egg was the first to leave. They reacted when the person was about 500 m away and flew to the southern slope of Gipsdalen. Another 13 non-breeders left at about the same distance and 5 left at about 400 m. After 1.5 hours 8 non-breeders returned, and after 1.8 hours the breeding pair returned to their nest.

The two provocations at Tverrådalen on 6 June, were performed on ski (start 00³⁰ hour) and on

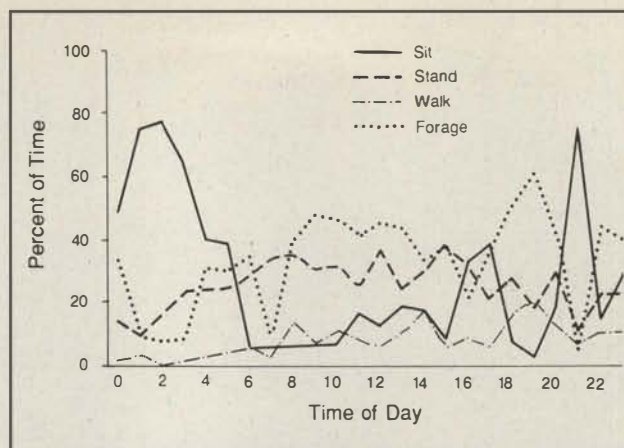


Figure 9 The percentage of day spent in the four most frequent behaviours by non-breeding Pink-footed geese in Gipsdalen in the period 24 May to 2 June. Total number of fixes - 3624.

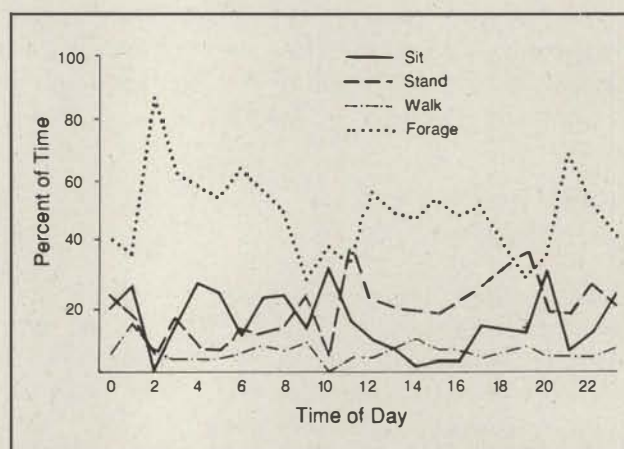


Figure 10 The percentage of day spent in the four most frequent behaviours by non-breeding Pink-footed geese in Gipsdalen in the period 5 to 19 June. Total number of fixes - 3518.

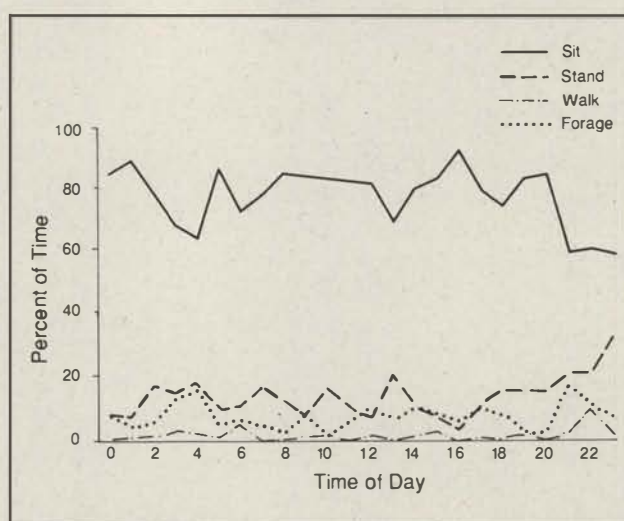


Figure 11 The percentage of day spent in the four most frequent behaviours by breeding Pink-footed geese (incubating pairs) in Gipsdalen in the period 9 to 19 June. Total number of fixes - 2768.

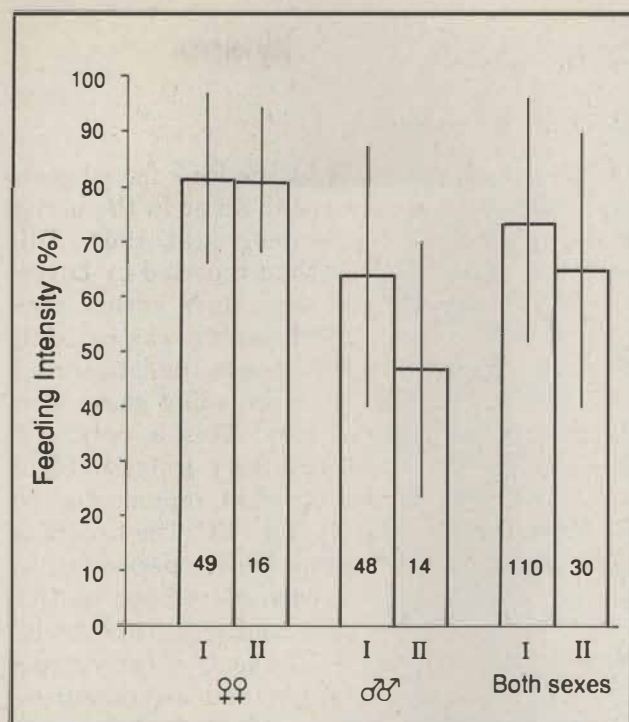


Figure 12 Feeding intensity of male and female Pink-footed geese in undisturbed (I) and disturbed conditions (II). Numbers of observations are given in each column. Bar length - SD.

snow-scooter (start 17⁰⁰ hour). The person on ski scared 16 geese so they took to their wings; 12 at distances of 300 - 500 m, 2 at distances less than 100 m, and 2 at distances less than 50 m. Of these, 6 flew only about 400 m before settling down. Twelve geese did not fly off at this provocation, but 4 of these stopped grazing and walked higher up on the hill (distance to the person was more than 200 m). The others were mostly breeding pairs and showed no or only minor responses.

The reactions were notably different to the provocation by a person on snow-scooter. This time 38 geese did not take to the wings and only 8 did, even though the same route was driven. The geese that did fly off fled when the snow-scooter was 50 - 200 m away, and four of these immediately landed about 100 m from the snow-scooter.

Non-breeders usually fled from the helicopter when it was 500 - 1500 m away, and the maximum distance observed when geese took to the wings was about 2 km. In some cases geese reacted to the noise of a helicopter at longer distances, by stopping grazing and stretching their neck. In one instance, 9 of 10 geese showed this reaction for 2 min. when the helicopter was more than 4 km away. Incubating pairs did not leave the nest even when the helicopter passed only about 50 m above their heads, but they did lower their heads toward the ground. On 19 June, the helicopter flew over the two breeding pairs on

Haugen or close nearby over the sea more than 6 times, but they did not leave their nests.

During the helicopter flight through the whole valley on 10 June, 10 non-breeding and a pair of incubating geese were observed at Usherflata. As the helicopter flew up the valley along Usherfjellet at a distance of about 1.5 km, the 10 non-breeding geese stopped grazing for some minutes. The breeding pair remained inactive. On the return of the helicopter down the valley, it swept down from Aitkendalen in a manner similar to "autorotation" thereby producing a much stronger noise. Now the 10 non-breeders fled when the helicopter was about 2 km away, but the breeding pair did not leave their nest. About 1 hour after this incident the first flying geese were heard, but no geese landed and started grazing until 2 hours afterwards.

Reactions to predators

Predation by Glaucous gulls or Arctic skuas was not observed. Glaucous gulls flew over colonies of geese infrequently, and as far as could be seen elicited no reaction from the geese. Arctic skuas were more frequent visitors to the geese colonies, but did likewise not elicit any response from the geese. One exception was observed, however. In one instance a skua landed close to a nest when both parents were off feeding. The gander rapidly returned and chased the skua off, and afterwards he stayed at the nest.

The Arctic fox was the most important predator in Gipsdalen. Foxes were observed robbing 5 - 6 nests (19 %) and stealing 8 eggs. However, three of these nests were only seen after being found by foxes. The reactions to foxes were different among incubating, egg-laying and non-breeding geese. Incubating pairs, with the female sitting on the nest and the male sitting close nearby, most often remained motionless without raising their head even when a fox ran close nearby. The fox paid no attention to their nests. Egg-laying pairs which were close to or on their nests mostly seemed to be able to withstand a fox. This was achieved by standing against the fox with their wings spread out. However, if the fox found the nest when the parents were off feeding, they seemed to be unable to drive the fox away.

Two examples may illustrate the relationship between geese and foxes. In one case an egg-laying female was scared off the nest when surprised by a fox, but the male immediately defended the nest. For 12 minutes the fox was running around trying to reach the nest, but the gander managed to defend it with the aid of another goose. Both fox and geese were exhausted after the fight. Then the fox seemed to depart, walking away.

The gander left the nest mostly chasing other geese, as several had been attracted by the fight. However, the fox suddenly returned and was able to steal first one egg which he cached, and then another egg, without being interrupted by any goose. The pair was first seen at the nest 34 min. after the fox had left.

Another pair was visited by a fox when the female was sitting on the nest and the male stood nearby. The fox was very persevering, but only when he almost sniffed the nest did the female raise her wings and the fox jumped away. The fox also sniffed nearly between the legs of the male, but only once did he raise his wings. After more than 8 min., the fox rested 5 m from the nest. Later the same day the pair was visited by another fox. Unfortunately, they were away from the nest this time. As the fox found the nest, the geese flew around, but later landed some 20 m away. The geese made no attempts to drive the fox away, and he ate two eggs.

One male fox was responsible for most egg predation observed in this study, and he seemed to be well experienced with geese. In three nests the foxes dug carefully into the cover of mosses and vegetation to reach the eggs.

Non-breeders were not observed reacting when a fox was at distances more than 20 m, but a fox closer than 10 m would elicit reactions such as standing up, walking away, a defence posture or flying off. On several occasions were non-breeders attracted by the fight between a fox and a pair of breeders defending their nest. This resulted in a great chaos with the fox running in and out among the geese. Only once were a number of geese (9) observed leaving a grazing area after the arrival of a fox, most often the Pink-footed geese seemed quite capable of standing against the fox.

Observations on Barnacle geese

A few Barnacle geese *Branta leucopsis* were from time to time observed in the lower parts of Gipsdalen and in Templet. On 8 June and 29 May, 9 and 5 Barnacle geese were observed respectively, otherwise only a few were observed. The Barnacle geese were observed feeding in the same regions as the Pink-footed geese; Gipshukodden, Tverrådalen, Usherfjell, Usherflata, and Haugen (Fig. 1). No aggressive encounters between the two species were observed.

No Barnacle geese were found breeding in Gipsdalen in 1990, which confirms the observations in 1989 (Syvertsen 1990). However, Syvertsen found a large number, more than 100, grazing in Gipsdalen during the summer.

DISCUSSION

Breeding biology

In 1964, most egg-laying by the Pink-footed geese on Svalbard was estimated to occur in the period 25 May to 2 June (Norderhaug et al. 1965). This was considerably earlier than reported by Løvenskiold (1964), and also some days earlier than found in this study. The breeding was probably delayed some days in 1990 due to the late spring, and the first indications of breeding geese were found the last days of May. This is only 1-2 weeks later than reported from Iceland (Inglis 1977). A range in the onset of reproduction of 2-3 weeks seemed likely (Fig. 13). The benefit of early reproduction is a long growth period for the young, which should be even more important on Svalbard than in the more southern Iceland with a longer summer season. The costs of early reproduction are less available food and lower temperatures. The females are more dependent upon the body reserves, and probably exposed to a higher rate of predation due to less food available for the predators (Inglis 1977).

Sensitivity to predation seemed to be greatest during the egg-laying phase, as the female at this time was off the nest feeding a large part of the day. When incubating, the female rarely left the nest and the eggs were well protected. Arctic foxes are able to kill adult Pink-footed geese (Inglis 1977, Frafjord unpubl. data). The outcome of a contest between an Arctic fox and a pair of geese is probably dependent upon the experience of both fox and geese. The habit of a number of pairs of placing their nests along the edges of cliffs, most likely served to limit the access of the fox so that the nest was more easily defended. The habit of covering the eggs with mosses and vegetation instead of down during the egg-laying period, probably had a camouflage advantage in addition to halting the development of the earlier eggs (e.g. Inglis 1977).

Numbers and habitat exploitation

None of the Pink-footed geese in Gipsdalen were marked, and it is not known whether all the geese observed in the first period were the ones that later bred in the area. Compared to the total of 25 000 individuals on Svalbard (Madsen 1984b, Mehlum 1989), the number in Gipsdalen was relatively low. Even though the geese arrived some days before we did, the low number indicated that Gipsdalen was not an important feeding area during the spring migration. The variability in the numbers observed probably resulted from many geese flying around, and leaving the area for shorter periods due to the late spring. The accuracy of the censuses was not

known, but they may have underestimated the population by 10 - 20 %. The late inventories were more inaccurate than the first, because the geese were distributed over larger areas. The total number at the onset of breeding was probably in the order of 130 - 150 individuals. The proportion of non-breeders was not known, but a minimum of 30 - 40 pairs did breed in Gipsdalen.

During May and early days of June, only small regions were free of snow and available to foraging geese. These tiny areas were mainly at the foot of hills and probably of high importance to the geese, even though it is likely that some feeding was done outside Gipsdalen, e.g. in Templet. As snow melting progressed a greater part of the valley became available for foraging, but some areas were most preferred. These were areas of wet moss tundra (Elven et al. 1990): Thermophilic *Carex parallela*-*C. saxatilis* type, *Homalothecium nitens*-*Carex subspathacea* type, and *Dupontia pelligera*-*Eriophorum scheuchzeri* type including *Eriophorum triste*-*Deschampsia brevifolia* type. These vegetation types have restricted distributions in Gipsdalen, and are most widespread at Usherfjellet/Usherflata (Elven et al. 1990). Geese mostly foraged in areas of very high and high value, as classified by the vulnerability and concentrations of rare plant species (Elven et al. 1990: Fig. 7). During May roots were probably important food, but later the geese probably consumed more vegetative parts of the plants.

Activity patterns and foraging

The amount of foraging and resting among non-breeders in Gipsdalen was similar to that of moulting geese in Greenland (Madsen 1984b: 41 % of the day), but Mosbech et al. (1989) found much less foraging in a more disturbed region on Greenland (10 - 15 %). Under the same disturbed conditions on Greenland moulting Barnacle geese grazed about 40 % of the day (Mosbech et al. 1989), while undisturbed non-breeding Brent goose *Branta bernicla h.* on Svalbard foraged 53 % of the day (Madsen et al. 1989). The increase in foraging of the nonbreeding geese in Gipsdalen in early June probably resulted from larger areas available as the snow melting progressed, although as food became more easily accessible less time would be needed for feeding. Furthermore, the most intensive foraging probably occurred shortly prior to and during the egg-laying period, most of which seemed to take place in early June. Several egg-laying pairs were probably included in the "non-breeder" data.

Non-breeders may have saved energy by more resting in cold weather, but the temperature did not influence foraging behaviour. Since the data

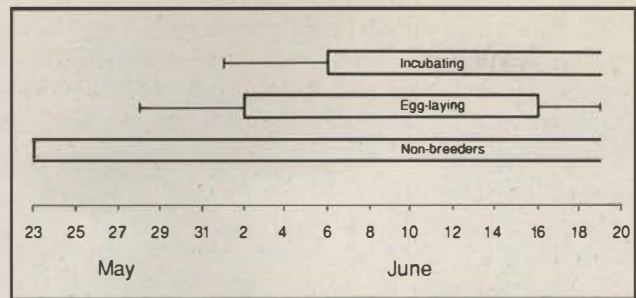


Figure 13 Breeding status of Pink-footed geese observed in Gipsdalen during the study period.

on climate came from Longyearbyen, it was not surprising that the correlation with geese activity in Gipsdalen was not very strong. Data on wind velocity were probably less representative than those on temperature. Furthermore, the climate at this time of year is not very extreme, but we did experience temperatures as low as -10°C .

Breeding pairs spent 90 % of the day resting, which meant that an incubating female probably was sitting on the nest even more of the day. In Iceland, females were incubating about 95 % of the day, while males were grazing 10 - 20 % of the day (Inglis 1977). Brent goose males on Svalbard were grazing somewhat more than Pink-footed males, about 31 % (Madsen et al. 1989). Males were probably responsible for most of the 7.4 % of foraging by breeders in Gipsdalen.

Resting was likely to be somewhat underestimated in non-breeders, since active individuals were more easily spotted than passive ones. But this error was thought to be small. Breeders, on the other hand, were often out of view when active, which implied some underestimation of the active behaviours. "Out of view" amounted to 8.7 % in breeders, but not all of this was foraging. Thus, foraging by breeders in Gipsdalen was probably in the same order as found in Iceland (Inglis 1977).

Females grazed more efficiently than males, most likely because they were in need of building up a layer of fat before egg-laying and incubating. Males on the other hand, were chasing off other geese that appeared too close to his mate. He also defended a territory around the nest. This behaviour may reduce competition in the female's foraging area and secure peaceful grazing for her (Inglis 1977). Alert males would probably also warn the female against the approach of predators. In addition, and perhaps most important, by guarding his mate the male would ensure that he was the only one to mate with the female (Alcock 1979). According to the last explanation, mate-guarding and aggressive behaviour should become less frequent after the clutch has been

completed. To some extent this seemed to be the rule, although the male more often was closer to his mate when she was grazing than to the nest (compare Inglis 1977). The increase in feeding intensity of males during June may also suggest a reduced aggressiveness in males.

The larger increase in feeding intensity in males than in females during June and in larger flocks, probably resulted from the fact that females were originally feeding more intensively. As breeding commenced, breeders settled in territories and became more isolated from each other and from non-breeders. By the middle of June the flocks of geese probably mostly contained non-breeders or unsuccessful breeders. A reduced aggressiveness and a more relaxed guarding motivation in males in such flocks would allow them to forage more peacefully.

Reactions to disturbances

The "non-breeding" Pink-footed geese in Gipsdalen fled from humans and helicopters at shorter distances than reported for moulting geese in Greenland (Madsen 1984a, Madsen et al. 1985, Mosbech et al. 1989). Maximum flight distance was about 2 km, while in Greenland it was 10 - 20 km, but then larger helicopters caused the disturbance. These generate more noise than smaller helicopters (Mosbech et al. 1989). In Gipsdalen, moulting flocks of geese with young fled when humans were 1 - 2 km away (Syvertsen 1990). This is a longer distance than the one found in this study during the pre-breeding and early breeding periods. Incubating pairs had to be approached very close before they left the nest. Clearly, the flightless geese react much stronger to human disturbances than pre-breeding and incubating geese. This means that the flight distance and behavioural response are dependent upon the reproductive status of the geese, and notably upon how long they have incubated. However, it is not known whether the non-breeders that were disturbed or scared off left the region for the rest of the summer, but this does not seem very likely since the number increased rather than decreased.

The responses to helicopters of Pink-footed geese were similar to the responses of Brünnich's guillemots *Uria lomvia* breeding on cliffs. Upon being approached by a helicopter, a part of the non-breeding guillemots left the cliffs while the breeders did not (Fjeld et al. 1988, Olsson & Gabrielsen 1990). A minimum distance of 2 - 3 km by helicopters to guillemot colonies was recommended by these authors.

A stronger reaction to the provocations on foot than to the one on snow-scooter was probably due

to some habituation. The provocation by snow-scooter was performed after the one on ski, which could have resulted in a more relaxed response. Furthermore, the geese were probably used to some traffic by scooters, and probably also to vehicles on their wintering grounds. (Many animals react more intense to an approach by humans on foot than by vehicles.) Despite this, during our regular travels through the valley geese could usually not be approached closer by a person on snow-scooter than by a person on foot. No habituation to helicopters by guillemots was found by Fjeld et al. (1988) or Olsson & Gabrielsen (1990). It is not likely that the Pink-footed goose will become habituated to more extensive human activities.

Foraging seemed to be reduced after a provocation, but the small sample size on disturbed geese did not warrant any reliable conclusions. It should also be noted that during the recordings after the first provocation on ski, a fox turned up among the geese and managed to steal several eggs. The fox extended the period of stress for many of the geese. However, it may be concluded that the reduction in foraging was much less than what was found in Greenland (Mosbech et al. 1989).

The feeding intensity or efficiency of males was reduced following a provocation. If the disturbance is small, some of this loss of foraging may be compensated by more grazing later. Males were probably responsible for most of the decrease in foraging, since females were able to feed intensively even after a disturbance. As female foraging probably benefits reproductive success more than male foraging, the effects of these small disturbances were probably not critical. But males do also lose some weight during the period of incubation. Males are responsible for most guarding of the young after hatching, and are in need of some energy reserves (Inglis 1977).

Long-term effects of disturbances may be more important than short term effects. As the female is consuming her fat storage during incubation, she may have to leave the nest more often to graze toward the end of this period (Prop et al. 1984, Madsen et al. 1989). Less time devoted to pre-breeding grazing inevitably implies less fat storage, and the female will have to leave her nest more often during the incubating period. Increased risk of predation follows, and the female will also have to use more energy in the warming of eggs (Inglis 1977). If the geese are exposed to repeated disturbances such as mining activities, the negative effects on reproductive success most likely will be severe.

Consequences of the proposed mining project

The proposed location of conveyor and road in Gipsdalen (Brekke & Hansson 1990) will greatly influence the foraging and breeding areas of the Pink-footed geese. The road will intercept some of the most important spring feeding areas, notably at Usherfjellet/Usherflata and Tverrådalen. Likewise, a high level of human activity in the mining area in the uppermost part of the valley and at the harbour area in Gipsvika, will probably not be tolerated. As a consequence, the areas available for foraging and breeding of Pink-footed geese in Gipsdalen will become very much reduced. It is difficult to see any solution to this negative effect. Wherever the road and conveyor are built it will influence on some areas important for geese. The results from this study may suggest that it would be better to place them along the south-eastern slope of the valley. If the harbour is also built in this part, it is possible that the Tverrådalen and Usherfjellet areas will not be entirely abandoned by the geese. However, we do not know if the species breeds at the same localities each year, and Syvertsen (1990) found most Pink-footed goose nests at Dalkallen in 1989.

In 1989, the population of Pink-footed goose increased during the summer (Syvertsen 1990). This means that geese from outside Gipsdalen immigrated to feed there, which also included some Barnacle geese. In this flightless period all geese are very sensitive and vulnerable to disturbances, and Syvertsen (1990) concluded that the assumed activity in Gipsdalen following mining would not be tolerated. Thus, human activity will influence not only the geese breeding in the valley, but also geese breeding elsewhere (e.g. on Gåsøyane). The effects remain unknown, but the number of geese on Bünsow land is not very great (Syvertsen 1990).

A great reduction in the population of Pink-footed geese may also affect other parts of the ecosystem. Foraging geese possibly influence the vegetation, both by removing plants or parts of plants, and by a fertilizer effect of the droppings. Furthermore, populations of predators like the Arctic fox may also be reduced.

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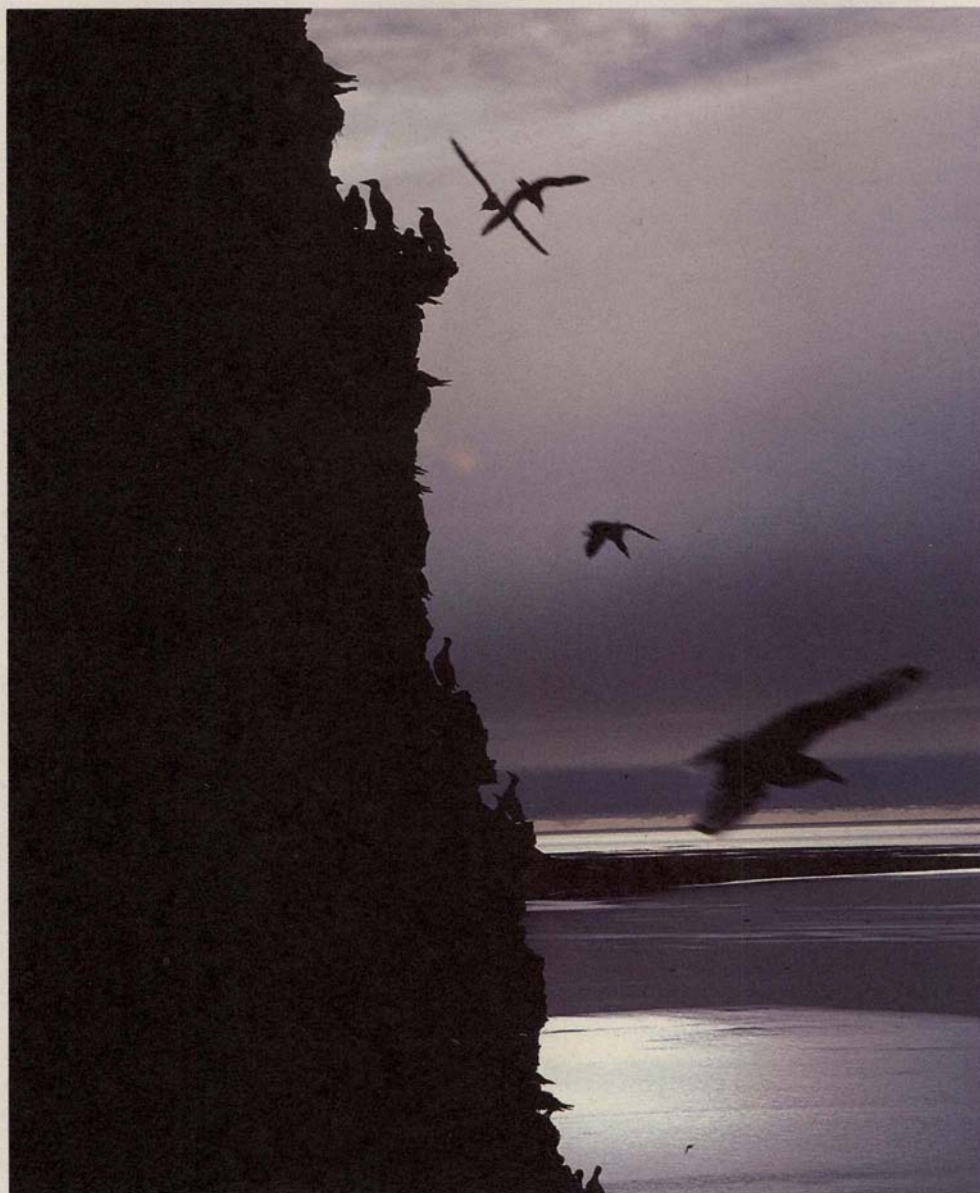
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SUPPLEMENTARY ORNITHOLOGICAL SURVEY 1990, GÅSØYANE AND GIPSDALEN



Bird cliff with Brünnich's Guillemots *Uria lomvia* and Kittiwakes *Rissa tridactyla*
(photo: Per Espen Fjeld).

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SUMMARY AND CONCLUSIONS

In July 1990 a census of birds were made at Gåsøyane bird sanctuary, Gipsvika, lower parts of Gipsdalen, and Tempelet mountain. The aim of the census was to supplement ornithological investigations in the area made for Northern Resources Ltd. during the summer of 1989 and May - June 1990.

Gåsøyane is a major breeding locality for Eiders, and also important for Barnacle and Pink-footed Geese. A unique breeding colony of Puffins is also located in the sanctuary. Eiders and geese move to the shallow waters of Gipsvika after breeding for feeding and moulting. Barnacle Geese also move to ponds and swamps in lower Gipsdalen during moulting.

Gipsdalen is a breeding locality for Pink-footed Geese, and the lush vegetation in wet moss tundra areas and swamps are extensively used as foraging areas for geese during the whole summer season. Several hundreds of moulting, flightless Pink-footed Geese are found in these areas after the breeding season. The birds are very shy and escape to the mountain slopes when disturbed by humans. Escape reactions were documented at a distance of about 2 km between the geese and the observers. Arctic geese are very vulnerable to human disturbance, and habitats may be abandoned by the geese in areas with human interference. Industrial activities in the Gipsdalen area will undoubtedly influence the goose populations in the valley.

The material collected during this investigation supports the previous statements of the importance of Gipsdalen and Gipsvika as bird habitats. Gåsøyane, with its status as a bird sanctuary, have high conservation value. The breeding bird populations at these islands are very vulnerable to oil pollution in the Gåsøyane - Gipsvika area. Eiders and geese breeding at Gåsøyane leave the islands after breeding, and most probably move to the Gipsvika area. Gipsvika is certainly an important feeding area for post-breeding Eiders, as well as for Long-tailed Ducks. Gipsvika and the waters outside Tempelet are also important resting and feeding areas during the whole summer season for several species of seabirds, including Puffins, Fulmars, and Black Guillemots.

A census of breeding Brünnich's Guillemots and Kittiwakes was conducted at Tempelet mountain. Based on this year's data and previous censuses in 1988 and 1989 it is estimated that the number of breeding Brünnich's Guillemots is 1200 - 1600 pairs. The number of breeding Kittiwakes was about 1300 pairs. These numbers of seabirds are

small compared to the total populations in Isfjorden. It is unlikely that disturbance from human activities in Gipsvika will cause any negative effects on their breeding performance. Oil pollution in the area will be an potential threat to these birds.

INTRODUCTION

Birds are important elements in arctic ecosystems. They also constitute prominent features of animal life in arctic areas being very numerous and conspicuous creatures.

The major groups of birds in the Svalbard area are selected within the framework of the assessment system (MUPS) as Valued Ecosystem Components (VEC's). These are: a) seabirds, b) eiders and geese, and c) svalbard ptarmigan. In connection with preparing the Environmental Atlas of the Gipsdalen area an inventory of the occurrence of birds were made during the summer of 1989 (Syvertsen 1990). Furthermore, a study of the pre-nesting ecology of geese in this area, and the potential effects of disturbance on geese was performed in May-June 1990 (Frafjord 1990). The present report summarize additional data collected in July 1990 on the occurrence of seabirds, eiders and geese in the Gipsdalen area and the neighbouring islands, Gåsøyane. The July 1990 data were collected by Fridtjof Mehlum and John Frikke. These three papers will constitute the field results to be used in the assessment of the potential effects on birds by the planned activities connected to the coal mining project.

GÅSØYANE

Present status of protection

Gåsøyane were protected as a bird sanctuary in 1973 because they comprise a scarce biotope in Isfjorden area and still inhabited by a rich bird fauna. The area was regarded as having potentials to be a major breeding habitat of several bird species in the Isfjorden area. In 1985 the sanctuary was recognized as an international important bird habitat, given a special status and included in the list of wetland areas under the Ramsar-convention. Four other sanctuaries in Svalbard were also given such status. This international convention is dealing with the conservation of wetlands of international significance for birds.

Habitat description

Gåsøyane (Fig. 1) consists of a group of three small islands situated west of Gipshuken. They

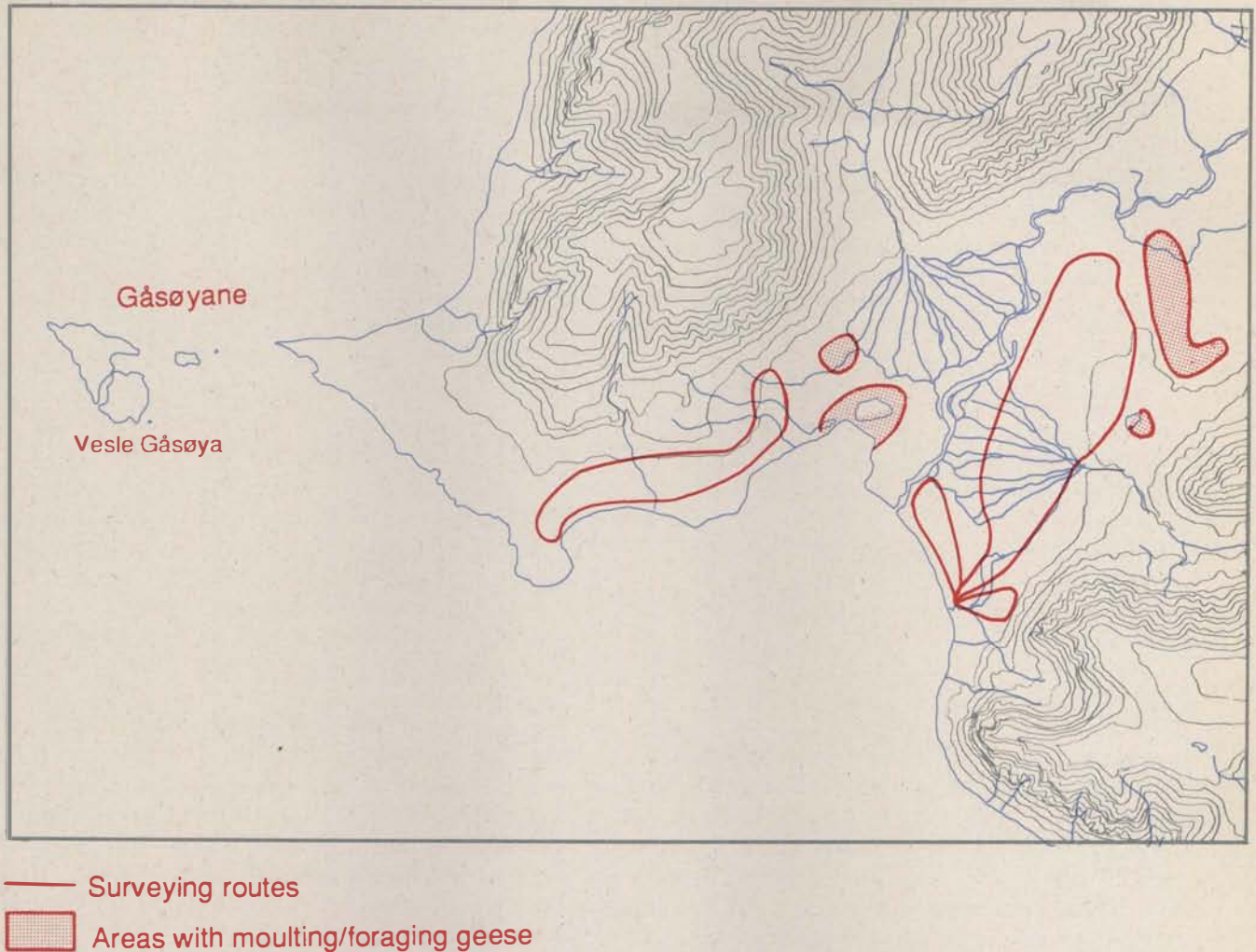


Figure 1 The surveyed area in Gipsvika and Gipsdalen.

cover a total area of 2 km². The islands are relatively flat, the highest point reaching 20 m above sea level. On the northern and eastern sides of the islands are dolorite rocks with steep cliffs facing towards the sea. These are occupied by nesting seabirds such as Puffins and Black Guillemots. The elevated parts of the islands are undulated block-field, suitable as nesting places for geese. Most of the islands are covered with relatively flat ground where Eiders and Arctic Terns are nesting. A small pond is surrounded by lush vegetation.

Observations in 1990

The islands were visited on 14 July. Vesle Gåsøya was visited by foot while the other two islands were observed from a Zodiac. The following bird observations were made:

Barnacle Goose

A total of 43 full grown and 6 clutches of goslings were seen on the two largest islands. Additionally

3 females were still incubating their eggs. The total number of goslings could not be determined because of long observation distance and the shyness of the flocks.

On the small easternmost island one incubating pair and two pairs with goslings were recorded. The total number of adults and clutches present on the islands on this day were 51 and 12, respectively. On Vesle Gåsøya about 20 deserted goose nests were found. It is not known whether these were nests of Pink-footed or Barnacle Geese.

Pink-footed Goose

No Pink-footed Geese were seen on the islands during the visit. However, as mentioned for the Barnacle Goose 20 deserted goose nests were recorded on Vesle Gåsøya, some of which were probably Pink-footed Geese. The date of our visit was probably too late for locating incubating birds of this species. Usually they also leave their breeding areas soon after hatching.

Brent Goose

Only one family was recorded. In addition to the parents, 5 goslings 1-2 weeks old were seen.

Common Eider

The visit to the islands was too late to get a reliable figure of the total number of nesting Eiders in the area. Most of the nests found were already deserted. On the western half of Vesle Gåsøya 18 nests with still incubating females were found. In the small freshwater pond 20 females and 4 males were present. Eiders were scattered on the sea around the islands. 15 flying males were seen in one flock and 8 in another. In addition 24 females with chicks, and 23 females without chicks were seen. From these informations it is concluded that the number of Eiders present at the time of our visit were far less than the total breeding population on the islands.

Puffin

The islands are known to be a breeding habitat for a small number of Puffins. We found the Puffin breeding on all three islands in the cliff and boulder areas on the northern and eastern parts of the islands. A total of 250 individuals were counted either sitting on the cliffs or resting on the sea adjacent to the colonies.

Other bird species

Of other bird species we recorded 13 Black Guillemots, about 300 pairs of Arctic Terns (not censused thoroughly), about 20 Glaucous Gulls, 1 Arctic Skua, 1 Purple Sandpiper, 1 pair of Great Black-Backed Gull, and at least 3 pairs of Snow Bunting. The tern eggs were about to hatch.

Discussion

Gåsøyane have been known for many years as a breeding place for eiders and may also be for geese. The name of the islands indicates that geese have been abundant in the past. However, there is little evidence for that in the literature. Gordon (1922) visited the area in 1921 but saw no geese at all. Dalgety et al. (1931) reported that the Brent Goose nested in the area. As indicated by Mache (1970) there might be a confusion with regards to the name because eiders earlier were named geese.

The literature contains little information of population sizes of different birds species on the islands. The most detailed informations are given by German ornithologists (Mache 1970) who

visited the area in 1970. The actual dates of their visits were 27 - 28 June and 9 - 10 July.

Geese

In 1957 Blurton Jones & Gillmor (1959) observed 6 adult and 15 goslings of Pink-footed Geese at Gåsøyane, but they found no proof for breeding. Mache (1970) counted 18 Pink-footed Geese and recorded 6 nests of this species but found no Barnacle Geese on the islands. In 1982 the islands were censused by the nature conservation officer (A. Børset) at the Governors office (on 6 July) (Prestrud & Børset 1984). He estimated the breeding populations of Pink-footed Geese at 10 pairs, and Brent Geese at 1 pair. No information of breeding Barnacle Geese is given for 1982 by Børset (unpubl. report), but 3 pairs is given in the paper by Prestrud & Børset (1984). The Governors office also censused the area in 1983, and estimated the number of breeding geese at 6-8 pairs of Barnacles and 30 - 50 pairs of Pink-footed geese. (Prestrud & Børset 1984).

The most recent published information on breeding Barnacle Geese on Gåsøyane is presented by Prestrud et al. (1989). They claim that 10-30 nests were found in 1983 (and/or?) 1985. In addition to that they also reported 5-10 nests on the near by Gipshuken in 1983. These data indicate that Barnacle Geese colonized the islands between 1970 and 1982, and have established as yearly breeding birds in the area.

Eiders

The number of breeding Eiders was in 1970 estimated at 650 pairs (Mache 1970). The two smallest of the islands were censused by Børset (unpubl.) in 1982. He estimated the number of breeding pairs at 370-450. His rough estimate for all islands combined was 650-800 pairs. On this basis it seems that the Eider population has been in the same order of magnitude since at least about 1970. The King Eiders was reported by Løvenskiold (1964) as a breeding species on Gåsøyane. Mache (1970) also reported 6 males and 2 incubating females of King Eiders on the islands.

Puffin

Gåsøyane have been known as breeding locality of Puffins for a long time (Løvenskiold 1964). As an example, Gordon (1922) found "some half a dozen" on a flat-topped rock. Mache (1970) reported at least 24 individuals at the islands in 1970 and found one nest. The difference between the 1970 and 1990 data indicate a significant increase in numbers in recent years of Puffins inhabiting these islands. Few Puffin colonies in

Svalbard are so easily observed from sea level as these. The location of the nesting places close to the sea level makes these colonies ideal for scientific studies of the species and for educational purposes, and for pure experience of this beautiful bird.

Other species

For other bird species Gåsøyane seem less important as breeding habitat. One pair of Red-throated Diver was reported breeding on the islands in 1922 (Congreve 1953) and in 1948 (Løvenskiold 1954). The species is not to my knowledge documented as breeder in later years. However, the freshwater pond of the islands is suitable as a nesting habitat for this bird. The area is probably not an important habitat for waders, because of limited areas of wetlands. The Grey Phalarope is documented as breeder in 1957 (Løvenskiold 1964) and in 1970 (Mache 1970), as well as the Turnstone (2 pairs 1970, Mache 1970), Purple Sandpiper (Løvenskiold 1964), and probably Ringed Plover (Mache 1970). A large colony of Arctic Terns is located on the islands. The colony was also present in 1921 (Gordon 1922) but no data on colony size is known. Mache (1970) estimated the number of breeding pairs at 400. No conclusions should be made from the difference between the 400 pairs in 1970 and the roughly estimated 300 pairs in 1990. The terns are important elements of the islands' bird life together with eiders, geese and puffins. The Black Guillemot is the other breeding alcid species on the islands in addition to the Puffin. However, only a few pairs of this widespread species in Svalbard are breeding in the area, and Gåsøyane can not be regarded as an important breeding habitat.

GIPSVIKA AND GIPSDALEN

Habitat description of Gipsvika and Gipsdalen has been given in the previous reports made for NRL and will not be repeated. The purpose of the present investigation was to obtain supplements to the ornithological data collected in 1989 (Syvertsen 1990) in order to evaluate the year to year variation in bird abundance in the areas concerned. We visited the area during the period 25-27 July. The area covered was the whole Gipsvika area from Gipshuken to Tempelet. Only the lower parts of Gipsdalen were visited (Fig. 1).

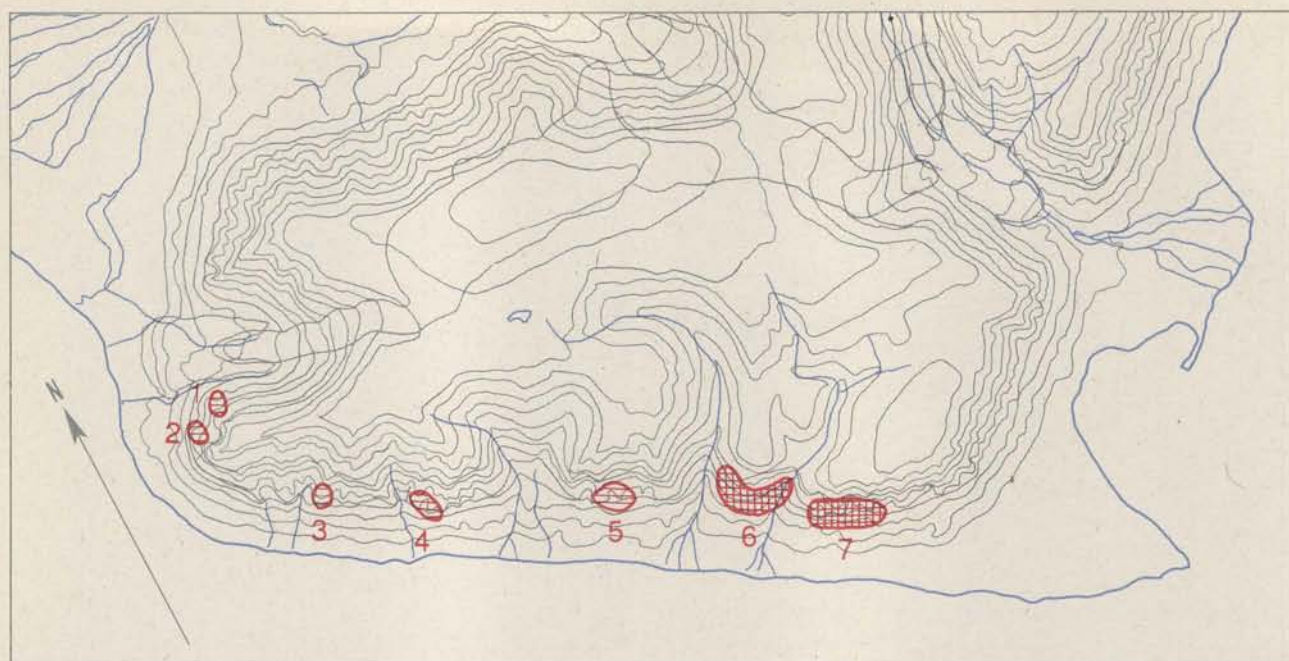
Geese

Observations of geese were made on the beach in the inner part of Gipsvika north of the outlet of the river Gipselva, in freshwater ponds, and in

areas with humid and lush vegetation. The geese occurred only in vegetation types classified by Elven et al. (1990) as wet moss tundra and swamps. The observations of geese made in three areas. At the pond or small lake NW of Dalkallen we recorded 8 adult Barnacle Geese and 4 adults of Pink-footed Geese, including 1 pair with 2 goslings. They were all foraging in the swampy tundra vegetation alongside the lake. The other concentration of geese was located on the flat tundra areas between Usherfjellet and Dalkallen (called Usherflata by Frafjord 1990). A total of 124 adult Pink-footed Geese were observed in that area. Several clutches of goslings were accompanying the adults. But because of the great observation distance the number could not be determined. When the observers were visible to the geese they were at 1 km distance. They immediately ran away towards the mountain slope of Dalkallen. The third area where geese were observed at the outer part of Tverrådalen towards Gipsvika. On 26 July we observed a flock of about 50 geese. These were a mixed flock of Barnacle and Pink-footed Geese, but the ratio of the different species could not be determined. The flock was spotted from about 3 km distance and reacted to our presence when we were 2 km away. They ran away from us towards the slopes of SE Gipshuken. On 27 July we approached the innermost part of Gipsvika from Gipshukodden. All geese observed was associated with the tarn and wet moss tundra N of the outlet of Gipselva. A total of 56 adult Barnacle Geese with 3 clutches of goslings, and 8 adults of Pink-footed Geese with 2 clutches of goslings were observed. Most of the birds discovered us as we appeared free in sight at about 1.5 km from them. Some escaped into the bay, while others moved some hundred meters further away from us. We did not go any closer, and the geese remained in the area.

Eiders and other seaducks

During our visit the shallow waters of Gipsvika were permanently occupied by Common Eiders. On 26 July observations were made from the area south of Gipselva. A total of about 150 females and a few clutches were seen along the shore from Skiltvakten to Gipselva. A group of 9 Long-tailed Ducks were also present. On 27 July we recorded 26 females and 49 young Eiders in shallow water along Tempelet mountain. On the same date we censused the northern side of Gipsvika. From Gåsodden to Gipshukodden we recorded about 100 female Eiders. Between Gipshukodden and the bottom of Gipsvika 58 females, 46 males and 42 juvenile Common Eiders were counted. Most birds were seen close to the beach, while the males were swimming in flocks further out in Gipsvika. In the inner part of Gipsvika we



Kittiwake and Brännich's guillemot, breeding area.



Brännich's guillemot, breeding area.

Figure 2 Observed breeding areas of Kittiwake *Rissa tridactyla* and Brännich's Guillemot *Uria lomvia* in Tempelet area.

also recorded a flock of 33 Long-tailed Ducks. Two females of King Eider, both with two chicks, were present in a small tarn close to the sea in the innermost part of Gipsvika.

Discussion

Geese

The Gipsvika - Gipsdalen area is important as habitat for both Barnacle and Pink-footed Geese during the summer season. The geese are present in the area from their spring arrival in May - June and probably to their autumn migration in September. The area is utilized by geese both as foraging area prior to nesting, nesting area, and moulting and foraging area after the breeding. The number of Barnacle and Pink-footed Geese seen by us was similar to the number given by Syvertsen (1990) for the middle of July 1989. This indicates that the this order of magnitude is representative for the present population sizes of the two goose species in the area. The geese were observed in the same localities in both years, and these observations identifies the most important geese habitats during the moulting period as the pond below Dalkallen, Leirflata between Aitkenfjellet and Usherfjellet, and the ponds near the outlet of Gipsvika. Additionally Syvertsen (1990) identified the wet tundra parts of Leirflata

further east in the valley as important for Pink-footed Geese. The shyness of moulting individuals of both goose species that we experienced fits well with the information available in the literature. The Pink-footed geese reacted by leaving the area when we appeared on the scene 1 - 2 km away similar to Syvertsen's (1990) observations.

Human activity in this area will certainly have significant impact on the behaviour of these geese, and probably the Pink-footed Goose will disappear from the area both as foraging, nesting and moulting area.

We also confirmed the assumption that the Gipsvika area is an important post-breeding habitat for marine ducks such as Eiders and Long-tailed Ducks.

TEMPELFJELLET

Tempelfjellet is inhabited by breeding seabirds of several species. The Fulmar is the most abundant species, but exact population estimates is difficult to obtain because of insufficient existing methodology. Syvertsen (1990) has given an estimate of minimum 6 000 breeding pairs. The Kittiwake and Brännich's Guillemot are the two species in Tempelet which can be censused with reasonable

accuracy because they breed in dense colonies on cliff ledges. Puffins also breed at Tempelet, and also for this species methodological problems prevent us from making exact estimates of population size. Based on Syvertsen's (1990) data and our own impression, the number of breeding puffins must be more than 1 000 pairs. Additionally Black Guillemots probably breed at Tempelet in low numbers.

In Tempelet seven colonies of Kittiwakes and/or Brünnich's Guillemots have been identified (Fig. 2). The census data from 1989 is presented by Syvertsen (1990). We made new counts in 5 of these colonies in 1990 (27 July). Additionally unpublished data exist from the area in 1988, when the colonies were censused on 13 July by P.E. Fjeld. Data from all three years are presented in Table 1 and 2.

The data collected during the three different years of Brünnich's Guillemots shows that 2100-3000 adults were present in the colonies. Applying the breeding factor given by Bakken & Mehlum (1988) for Brünnich's Guillemots on Bjørnøya (0.55 breeding pairs per number of individuals present on the ledges), we estimate the breeding population at 1200-1600 pairs. According to the Norwegian Polar Research Institute seabird colony database the total number of individuals in colonies within the Isfjorden area is about 52 000. Thus the Population in Tempelet is of minor regional importance. The data on Kittiwakes indicate an increase of the breeding population from about 750 pairs in 1988 to 1250-1300 in 1989 and 1990. This might reflect the general trend in northern parts of Svalbard where colonies of this species are increasing in size. According to the previous mentioned seabird database a total of 22 000 pairs of Kittiwakes breed in the Isfjorden area.

Gipsvika and the sea surface adjacent to Tempelet was used as resting place and may be also feeding ground for Fulmars and Puffins. On the average about 100 Fulmars and 20-30 Puffins were seen on the sea surface. Thus the coastal waters in this area may be considered as important not only for Eiders and Geese but also seabirds.

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Table 1 Census of Brünnich's Guillemots at Tempelfjellet 1988-1990

Colony no.	1988	1989	1990
1	315	322-358	no data
2	180	164-200	no data
3	80	60-90	75
4	50	69	35
5	180	198-199	30
6	350	366-379	370
7	1335	1506-1657	1075

Table 2 Census of Kittiwakes at Tempelet 1988-1990

Colony no.	1988	1989	1990
6	145	339	350
7	603	917	942

Blurton Jones, N.G. & Gillmor, R. 1959: Some observations on wild geese in Spitsbergen. *The Wildfowl Trust. 10. Ann. report. 1957 - 1958.*

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SVALBARD REINDEER IN GIPSDALEN, BÜNSOW LAND



Svalbard reindeer *Rangifer tarandus platyrhyncus* (photo: Torbjørn Severinsen).

by

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SUMMARY AND CONCLUSIONS

Population surveys of Bünsow Land, the first ever carried out, resulted in observations of up to 60 individuals. The observed calf percentages ranged from 25 to 32 in the March - April 1990 survey period, and two newborn calves were seen June 10th. The calf births are taken as indirect evidence that a population, estimated to 60 to 100 reindeer, inhabit Bünsow Land. Classification of Landsat MSS data indicate a quite low population density. The population might thus be increasing and is considered important for the reoccupation of grazing areas westwards on the northern shores of Isfjorden.

Industrial activities should refrain from constructions that might bar the local reindeer from moving across the southern part of Gipsdalen. New calf surveys should be carried out during the two first weeks of June in order to ascertain the significance of Gipsdalen and Bünsow Land as a "staging area" for reoccupation of grazing range.

INTRODUCTION

The Svalbard reindeer *Rangifer tarandus platyrhincus* is indigenous to the Svalbard archipelago. It is a genetically distinct subspecies of the genus *Rangifer* (reindeer and caribou) that may have been isolated for up to 40 000 years (Hakala et al. 1985). Although originally abundant when man started exploiting the area the populations were considered decimated by the beginning of the century (Vollebæk 1926). Since protection by law in 1925 the Svalbard reindeers have increased in numbers from the order of 1000 to perhaps 10000 individuals in 1985 (Lønø 1959, Norderhaug 1969, Øritsland & Alendal 1986).

Although it has been demonstrated that Svalbard reindeer populations might grow at rates comparable with that of any deer population (Øritsland unpublished) considerable areas on the archipelago have not yet been reoccupied. For example, five animals were observed on Bünsow Land on the northern side of Isfjorden already in 1970 (Norderhaug 1972), but very few individuals have yet been observed in an adjacent area such as Dickson Land. Although the Svalbard reindeer has an unusually sedentary life style, significant numbers might emigrate to new ranges when facing starvation (Tyler & Øritsland 1989). Such a 'food depletion leads to emigration' mechanism might be part of the reason for the slow dispersion of reindeer from areas with high population densities to what now is virtually virgin grazing range and known as good hunting grounds by the end of 19th century.

The present work was precipitated by plans for opening mining activities in Gipsdalen on Bünsow Land and concerns a winter and spring census of this valley and adjacent areas. This is the first attempt at a systematic population survey of this area.

MATERIAL AND METHODS

Three winter counts were carried out in March and April by use of snow-scooters and followed by a helicopter survey in June. The areas covered by the observers did not overlap and the progression of observations had sufficient speed to prevent that moving animals were counted twice.

Since area values for vegetation coverage of Bünsow Land not yet have been made available the Landsat 1 image 2543-11162 obtained July 18, 1976 were classified with respect to vegetation. A supervised classification procedure based on the data from MSS channel 4 (0.5-0.6 μm) and 7 (0.8-1.1 μm) and the EBBA image processing system was used. The values of uniform areas with dry vegetation typical for winter grazing range, 'wet green summer' range and 'bird cliff vegetation' were used in a classification and the resulting image evaluated subjectively on the CRT for correspondence with on the ground knowledge about the vegetation (Ødegaard et al. 1980). The feature space of the same values were plotted and adjusted subjectively towards vegetation (high MSS4 and MSS7 values for green vegetation) to new classes and the whole area reclassified for visual evaluation till 'best' correspondence with 'on ground knowledge' was obtained.

RESULTS

The classification of Landsat data yielded 227 km² of vegetated area of which 27 km² might be considered moss tundra or the rich bird cliff vegetation type (Eurola & Hakala 1977).

The three snow-scooter surveys on Bünsow Land were carried out at March 30th, April 8th and April 25th (Table 1, 2 and 3). Snow conditions did not allow access to the mountain plateaus. On March 30th the Kapp Napier area was covered adequately while the weather allowed only a quick coast and valley bottom survey of the other areas excluding the coast NE of Bjonahavna. The number of animals observed in the various areas are given in Table 1 also indicating the most important winter grazing areas according to presence of reindeer. The last census (April 25th) is considered the best, covered the entire Bünsow Land and yielded 60 individuals (32% calves).

Absence of tracks up the mountain sides indicated that no or few animals were located on the top plateaus and thus missed during the censusing in April.

The helicopter survey covered the areas south of a line from the von Post glacier to Kapp Ekholm and below altitude 500 m and was carried out on June 10th in order to ascertain whether calving is taking place on Bünsow Land. Two newborn calves (Fig. 1) and 42 adults and subadults were observed.

DISCUSSION

Due to the high costs of helicopter operations, use of snow-scooters is the preferred method for winter censusing of Svalbard reindeer. Fixed wing aircraft is considered a poor observation platform (Øritsland & Alendal 1986). Steep mountains, narrow valleys and the consistently clumped distribution of the small population renders transect or other stratigraphic methods for population estimates impractical. The limitations in use of snow-scooters were demonstrated by the fact that we were not able to reach the mountain plateaus where some animals might have been located in the present case. Snow-scooters do allow accurate observations when the conditions are good, however, particularly because the observer may take the time necessary to search each area in detail. At the same time the speed of the counts made from snow-scooters and the control offered by tracks in the snow makes it reasonable to assume that animals were not counted twice.

Never the less, with the present method observations of number of animals must necessarily be considered minimum values i.e. the 60 individuals seen on April 25th represents a minimum for Bünsow Land. The 19 calves found the same day represent an unusual high calf percentage (31.7%) and might indicate that some older individuals were missed. Calf percentages for Svalbard reindeer is reported to range from 5.6 to 27.3 (Reimers 1977, Tyler 1987) although 34.5% calves (i.e. 29 of 89 individuals) were found on a comparatively small area, the NW part of Barentsøya (Alendal et al. 1979). Assuming that some subadult and adult animals were missed in the present census, the population size of Bünsow Land should at least be adjusted to 'a reasonable calf percentage': Maintaining that there were 19 calves in the area percentages 27, 20, 19 and 15 correspond to population sizes 70, 95, 100 and 126 individuals respectively.

Realistically it can not be assumed that there is a separate population on Bünsow Land on the basis

Table 1 Svalbard reindeer observations on Bünsow Land, 30 March.
- : Areas not covered.

	adults	calves	total
von Post- Kapp Murdoch	-	-	-
Bjonapynten area	4	2	6
Gipsdalen S.	0	0	0
Gipsdalen N.	2	0	2
Gipsvika area	0	0	0
SW of Gipshuken	10	4	14
Phantomodden	0	0	0
Kapp Ekholm area	0	0	0
Kapp Napier area	5	1	6
Total	19	7	28
Calf %		25.0	

Table 2 Svalbard reindeer observations on Bünsow Land, 8 April.
- : Areas not covered.

	adults	calves	total
von Post- Kapp Murdoch	-	-	-
Bjonapynten area	16	6	22
Gipsdalen S.	1	1	2
Gipsdalen N.	7	1	8
Gipsvika area	0	0	0
SW of Gipshuken	7	2	9
Phantomodden	-	-	-
Kapp Ekholm area	-	-	-
Kapp Napier area	-	-	-
Total	31	10	41
Calf %		24.4	

Table 3 Svalbard reindeer observations on Bünsow Land, 25 April.
- : Areas not covered.

	adults	calves	total
von Post- Kapp Murdoch	0	0	0
Bjonapynten area	18	4	22
Gipsdalen S.	2	0	2
Gipsdalen N.	4	3	7
Gipsvika area	0	0	0
SW of Gipshuken	11	8	19
Phantomodden	1	1	2
Kapp Ekholm area	4	2	6
Kapp Napier area	1	1	2
Total	41	19	60
Calf %		31.7	

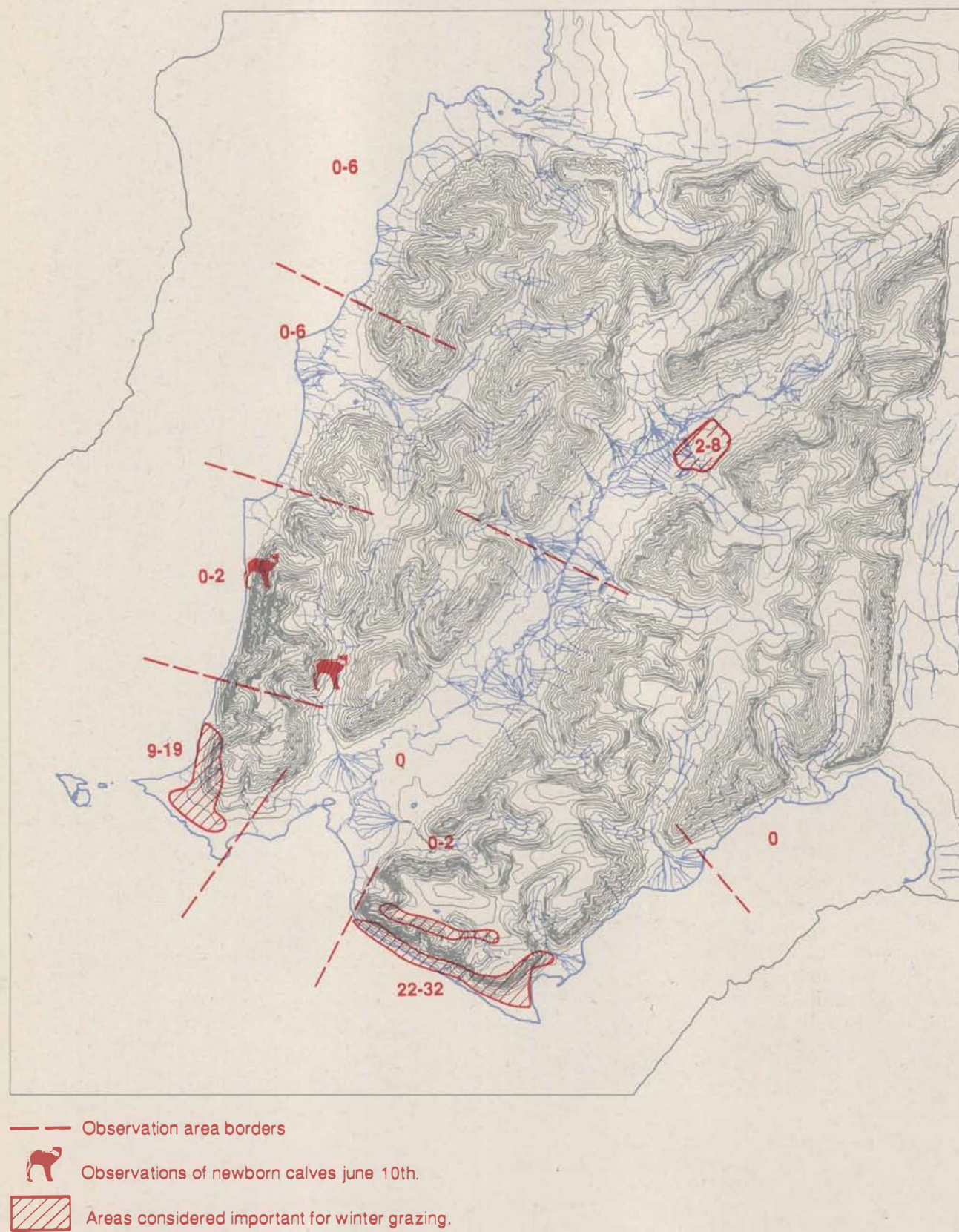


Figure 1 Ranges of census values from April 1990 observations of Svalbard reindeer.

of the present data alone. Observations of tagged animals have not been carried out, and local people have observed reindeer tracks crossing Billefjorden. However, the sedentary life style of the Svalbard reindeer (Tyler & Øritsland 1989) together with the topography, a peninsula bordered by glaciers, may be taken as circumstantial evidence.

The helicopter survey provided the first observation of calving on Bünsow Land and suggest that it is permanently populated by Svalbard reindeer. Normally most of the calving of Svalbard reindeer takes place the first week of June (Tyler 1987, Øritsland unpublished) and the females with calves will stay in the general area of birth for some days. It might be speculated that the late spring of 1990 caused a late calving. On the other hand newborn calves tend to lay still when scared and are difficult to spot from the air. It is thus reasonable to assume that there were born far more than two calves in the area. On ground observations are needed in order to properly delineate the extent of the calving grounds on Bünsow Land.

A population density of about 0.44 individuals per km² (100 individuals, 227 km² vegetated area) for Bünsow Land is considerably lower than that of Adventdalen which was estimated to range from 4 to 7.4 individuals per km² (Øritsland et al. 1980), but can not reasonably be attributed to a poor population census. Even if the mountain plateaus were not properly covered during the winter counts it is highly unlikely that from several hundred to nearly one thousand animals were missed. An error of this magnitude would also be detected by the helicopter survey. Verification of the vegetation classification is needed. The estimate of 227 km² vegetated area appear high, but even half this area would correspond to a very low reindeer density when compared to Adventdalen. Thus it seems reasonable to assume that there is presently about 100 reindeer on Bünsow Land and that this local stock is in a growth phase.

Most of the reindeer were observed in the Bjonahavna - Tempelet and SW Gipshuken beach areas (Fig.1) which thus should be considered important winter grazing areas. The nearly identical census values of 41 and 40 individuals for the Bjonapynten to SW Gipshuken area for April 8th and 25th respectively may indicate that it is a well established group of reindeer exhibiting the same fidelity to relatively small areas as observed for Adventdalen (Tyler & Øritsland 1989). Summer surveys of vegetation and feces concentrations have indicated that particularly the top of Tempelet and Sindballefjellet might be

of importance as winter grazing area (Spjelkavik & Elvebakk 1989) and it is interesting to note the persistent observations of a few animals between Norstrom and Finlayfjellet in the inner part of Gipsdalen. It is conceivable that prevailing winds down the glacier Florabreen provide more exposure of the vegetation in this area than in the outer parts of Gipsdalen.

EVALUATION - VULNERABILITY-RECOMMENDATIONS

The local reindeer 'population' is too small to have any significance in terms of survival of Svalbard reindeer as a subspecies. Bünsow Land with its small population might be important for the reoccupation of potential living habitat such as Dickson Land on the north side of Isfjorden, however. The planned mining operations should be carried out with this in mind: The reindeer need probably to cross Gipsvika and Gipsdalen, and constructions physically obstructing such movements should be avoided. Svalbard reindeer, with exception for the calving period from the last week of May to mid June, appear to be tolerant to noise and vehicles (Tyler 1988).

Dispersal of reindeer from Bünsow towards Dickson Land depends on a good calf production. Hiking along Gipsdalen and the SW beaches of Bünsow Land should be avoided in the calving period. It would be valuable to carry out on ground calving surveys during the first two weeks of June for the coming three years, followed by a pause and another series of surveys in perhaps ten years if the mining operation is to continue.

Obviously the 'calving base line' for the area is too weak at the present and should be strengthened, preferably before operations started.

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AN EVALUATION OF TEMPELFJORDEN AND SASSENFJORDEN AS BREEDING HABITAT FOR RINGED SEALS *PHOCA HISPIDA*



Ringed seal *Phoca hispida* mother and pup at the breathing hole (photo: Christian Lydersen).

by
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SUMMARY AND CONCLUSIONS

This study was conducted in Tempelfjorden and Sassenfjorden, Svalbard, March 12 to April 4 1990. A Siberian husky dog was used to detect Ringed seal breathing holes in the ice, using random stratified sampling to sample 20 % (40 km²) of the total area. The area was estimated to contain 997 Ringed seal breathing holes, corresponding to 293 Ringed seals. A maximum of 185 pups were born in the area. A breeding condition factor was constructed to enable comparisons of yearly and areal variation in ice cover and precipitation within Ringed seal breeding habitats. Tempelfjorden (Stratum III) was found to be an excellent breeding area for Ringed seals. The inner parts of Sassenfjorden (Stratum II) was evaluated to be a medium good breeding habitat, and the outer parts of Sassenfjorden (Stratum I) was found to be a poor Ringed seal breeding habitat.

INTRODUCTION

The Ringed seal *Phoca hispida* is the most abundant marine mammal in the Svalbard area. It inhabits the fjords and open water areas in the whole archipelago. It constitutes one of the top predators in the strictly marine food chain (Lydersen et al. 1989), and is itself the main prey for the polar bears *Ursus maritimus* in the area (Lønø 1970).

The Ringed seals are assumed to be territorial during the breeding season in spring (Stirling 1977). When ice freezes in the fjords in early winter, adult Ringed seals of both sexes establish themselves in these ice-covered areas. Each seal maintains a number of breathing holes in its territory by scratching the ice with the claws on its foreflippers. When sufficient snow accumulates the seals may dig out lairs in the snow covering the breathing holes (Smith & Stirling 1975). In Svalbard it is mostly on lee and windward sides of ice pieces calved from the glaciers and frozen into the fjord-ice, where enough snow accumulates to enable the seals to construct lairs. Basically two types of lairs are found; haul-out lairs and birth lairs. The haul-out lairs are used for resting by Ringed seals of both sexes. During the rut Ringed seal males have a very strong odour emanating from the facial region (Hardy et al. in press), and male haul-out lairs are easily distinguishable from other haul-out lairs. The peak of pupping in Svalbard is the first week of April. The females give birth to a single, white coated pup in a haul-out lair, which then gets classified as a birth lair (Fig. 1). Birth lairs are normally larger than ordinary haul-out lairs (Gjertz & Lydersen 1986), and are identified by

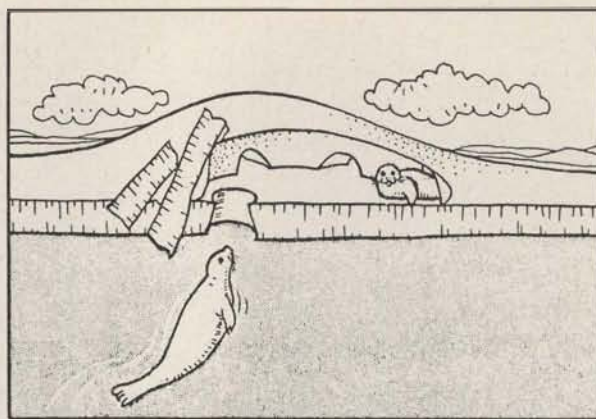


Figure 1 Cross section of a Ringed seal birth lair. From Gjertz and Lydersen 1983.

placental remains, lanugo (white hairs) from the pup, or by the small tunnels dug out by the pup inside the lair (Smith & Stirling 1975). The main function of the birth lair is to protect the pup from predation by polar bears, arctic foxes *Alopex lagopus* and birds (Smith 1976, 1980, Lydersen & Smith 1989), and act as shelter against low temperatures and strong winds (Smith et al. in press).

An average of 3.4 breathing holes per adult seal has been found by recording freeze-up of breathing holes within a restricted area after killing a seal (Hammill & Smith 1990). The best way to detect Ringed seal breathing holes and lairs is to use trained dogs that detect the smell of these structures on long distance and attacks them in a similar way as polar bears and arctic foxes do. Trained dogs have been used for several studies of Ringed seal density both in Svalbard and other arctic areas (Smith & Stirling 1975, 1978, Lydersen & Gjertz 1986, Hammill & Smith 1989, 1990, Lydersen et al. 1990). The objective of the present study is to estimate the size of the Ringed seal population inhabiting Sassenfjorden and Tempelfjorden in Svalbard during the breeding period, and evaluate the importance of the area as breeding grounds for Ringed seals. We have used the dog search technique within a stratified random sampling regime for estimating the number of breathing holes in the area, and estimated the number of seals using literature data on breathing holes per seal (Hammill & Smith 1990).

MATERIAL AND METHODS

This study was conducted in Sassenfjorden and Tempelfjorden, Svalbard, (Fig. 2) March 12 to April 4 1990. The study area was totally covered with ice during the whole period. Sassenfjorden was covered with relatively new ice, and the outer parts of this fjord consisted of new ice

without any snow cover at all. Precipitation during the middle of March resulted in a thin snow cover also in this area. The snow cover in Tempelfjorden, which had a stable icecover the whole year, was maximum 20 cm on the flat fjord ice. Only in very few places had ice calvings from the glaciers frozen into the sea ice. In the outer parts of Sassenfjorden some small scale pressure ridges were formed, but they were too small and the snow cover in the area too poor, to contribute anything to improve the possibilities for lair constructions.

The study area was divided into 3 strata (Fig. 2). Stratum III consisted of Tempelfjorden, stratum I of the outer unstable area of Sassenfjorden including Gipsvika, and stratum II of the intermediary zone between the stable Tempelfjorden and the unstable outer parts of Sassenfjorden. The total area investigated consisted of 200 km² and was too big for total sampling. A random stratified sampling was thus used to survey the area. The fjord was stratified in plots consisting of 1 km² squares in the open water areas, and along the shoreline neighbouring plots were added to give areas of 1 km². The plots were numbered consecutively from one to 200. A sampling grid covering 20 % of the total area was made (Fig. 3) by picking 40 numbers between 1 and 200 with the random number generator of a HP 11C calculator. The plots were located on the fjord using a compass and the meter counter on the snow-scooters. In order to test for the

accuracy of the metercounter, a distance of 1 km was driven by the scooter and then measured with a Simrad laser rangefinder. This procedure was repeated 10 times giving a result of 993 m \pm (SD) 21m.

Snow and ice cover conditions are important for the breeding success of Ringed seals. To evaluate the year-to-year variations in these parameters, we have constructed snow and ice indexes from satellite imageries and metrological data from 1980 to 1990 (except 1987). Information on yearly ice conditions is gathered from January 1st to May 31. Good ice conditions in the three first months of the year are important for the Ringed seals to establish themselves in their territories with appurtenant breathing holes, and ice cover in April and May is important as a platform for suckling the pups. Satellite imageries (Advanced Very High Resolution Radiometer) from a National Oceanic and Atmospheric Administration (NOAA) satellite received at Tromsø Telemetry Station (Norway) were studied for the periods in question. An ice cover index (ICI) was calculated for each strata for the different years (Fig. 4);

$$ICI = \frac{\sum (n_i A_i)}{n_t A_t}$$

where n_i is number of days with ice cover A_i in km², and n_t is the total number of days (=150) and A_t total area in km².

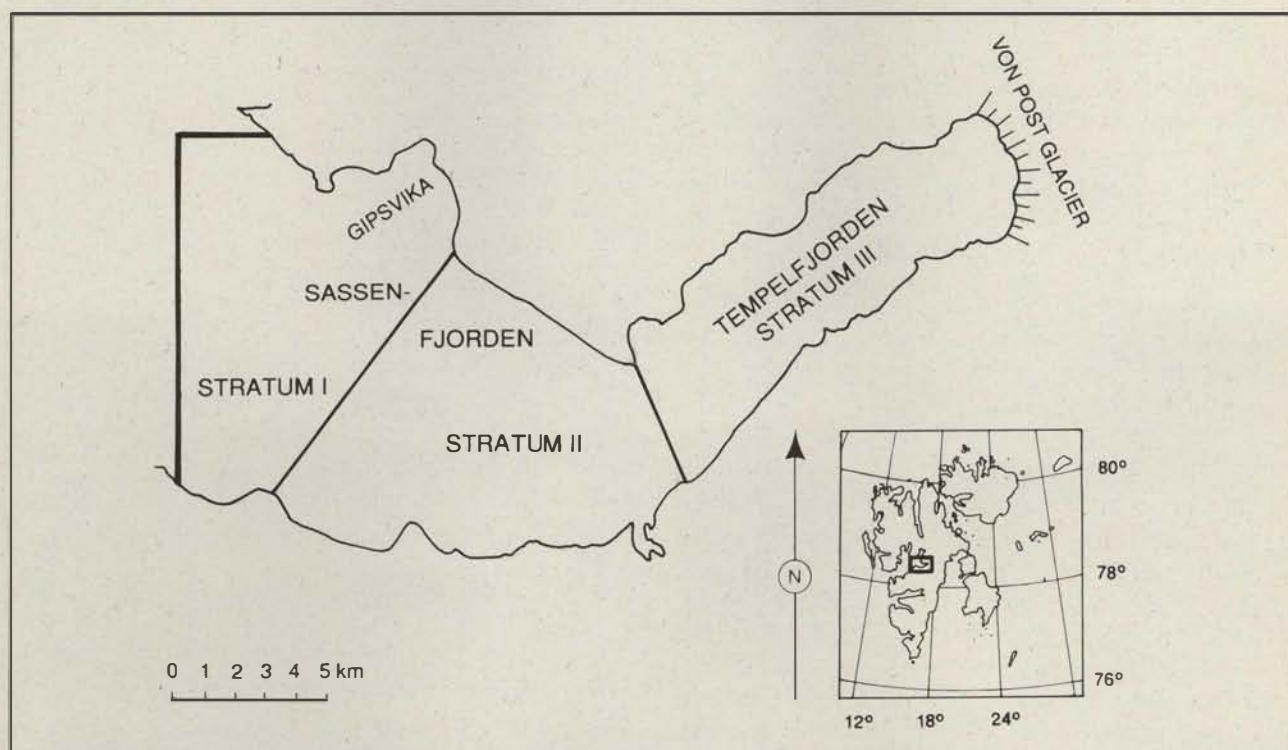


Figure 2 Map of the study area. Stratification used during the survey for Ringed seal breathing holes spring 1990 is shown.

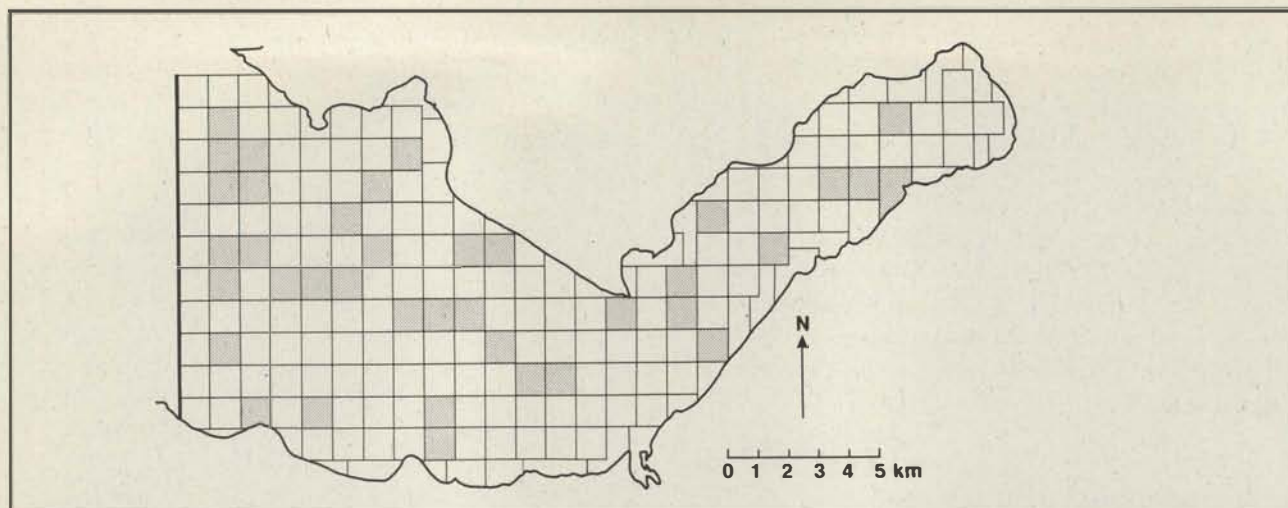


Figure 3 Sample grid for the random stratified sampling of Tempelfjorden and Sassenfjorden spring 1990. Hatched plots were surveyed for Ringed seal breathing holes.

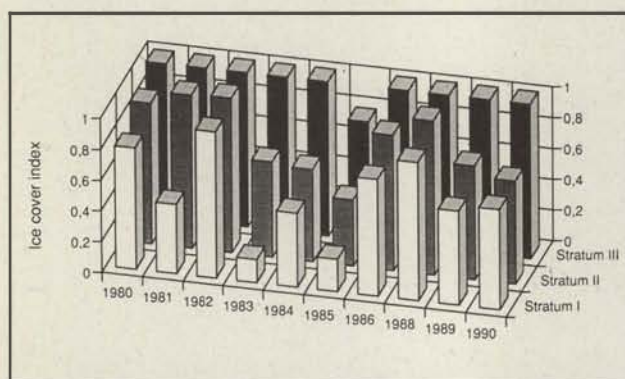


Figure 4 Yearly and areal variation in ice cover index in the different strata of the study area from 1980 to 1990.

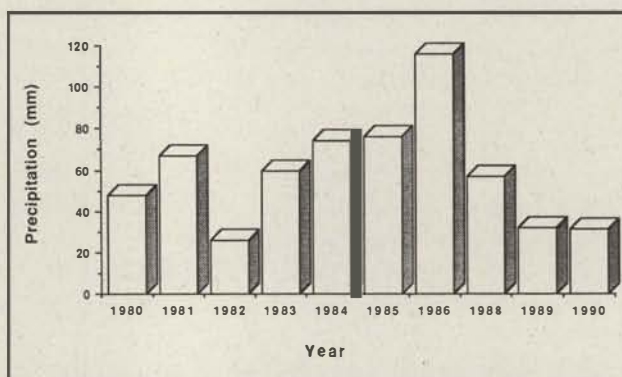


Figure 5 Yearly variation in precipitation (from Jan. 1 to March 31) in the study area from 1980 to 1990.

Snow cover is important for survival of the pups since it enables the females to dig out birthlairs. Peak of pupping was considered to be first week of April. Consequently, only precipitation data from January 1st to March 31 was collected. Maximum precipitation of 116 mm for this period was registered in 1986. A snow cover index (SCI) was calculated for all years by dividing the registered number of mm precipitation for each year by 116 (Fig. 5). Eventually, a breeding condition factor (BCF) was calculated as $BCF = ICI \times SCI$.

When searching the area for seal structures (breathing holes and lairs), two snow-scooters were driven at low speed (ca. 5 km per hr) with a Siberian husky dog running between the scooters and wind coming in from the side (Fig. 6). When the dog caught the scent of a seal structure it searched until it found the structure, and waited there for us to arrive. We thereafter drove back to the transect line where the dog first got the scent, and continued the sampling. It was crossed back and forth within the plot on distances varying from 75 to 200 m depending on wind conditions.

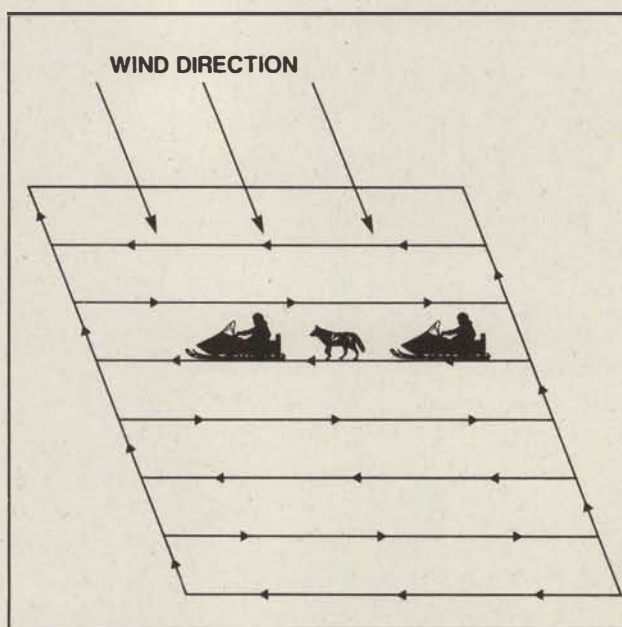


Figure 6 Showing the dog search technique, using two snow-scooters crossing within the plot against the wind and the dog running between the scooters. Sides of the square are 1 km.

Table 1 Densities of Ringed seal breathing holes in Tempelfjorden and Sassenfjorden, Svalbard, spring 1990.

Stratum	Area (km ²)	No of plots sampled	Density of breathing holes	Standard deviation	Range
I	68	17	1.77	1.82	0 - 6
II	84	12	4.42	3.40	0 - 10
III	48	11	10.55	6.79	4 - 24
Total	200	40			

Table 2 Estimation of number of Ringed seals inhabiting Tempelfjorden and Sassenfjorden, Svalbard, spring 1990.

Stratum	Estimated number of breathing holes	Estimated number of Ringed seals	Density of Ringed seals km ⁻²
I	120.4	35	0.51
II	371.3	109	1.30
III	506.4	149	3.10
Total		293	

Table 3 Estimated number of rutting Ringed seal males compared to other types of Ringed seals, based on calculations of numbers of breathing holes (BH) from the two groups of seals found in Tempelfjorden and Sassenfjorden, spring 1990.

Stratum	No of BH found in plots	No of rutting male BH found in plots	No of other BH found in plots	Estimated no BH in stratum	Estimated no of males	Estimated no of other Ringed seals	% males	% other Ringed seals
I	30	2	28	120.4	2	33	6	94
II	53	13	40	371.3	27	82	25	75
III	116	36	80	506.4	46	103	31	69
Total	199	51	148		75	218		

Under favourable conditions the dog could detect Ringed seal structures at distances exceeding 1 km. All breathing holes and lairs found were noted. Male structures were identified by their special odour. It is assumed in the further calculations of seal densities that the dog detected all structures within the plots searched.

RESULTS

A total of 199 Ringed seal breathing holes (including the four in lairs) were found in the 40 plots surveyed. The density of breathing holes was highest in Stratum III (Table 1), and the lowest in Stratum I. All differences were significant (Mann-Whitney-U-test, $p < 0.03$). We found only four lairs in the 40 plots; they were all found in the same plot in the inner parts of Tempelfjorden and probably belonged to a single seal. As a consequence of the significant differences in Ringed seal breathing hole densities between the three strata, the total number of seals was calculated as the sum of the estimates in stratum I, II, and III. This gave a local population of 293 Ringed seals in the whole area investigated in the breeding season of 1990 (Table 2).

Of the 293 Ringed seals, 75 (26 %) were rutting males, and 218 (74 %) were classified as other types of Ringed seals (Table 3). The other types of

Ringed seals should ideally consist of adult breeding females only, which implicates a maximum of 218 pups being born in the area. The sex ratio in the whole area is 1 male per 2.9 females.

When comparing the breeding condition factors for the 10 last years, 1990 was found to be a year with relatively poor breeding conditions (Fig. 7). The mean values for the BCF for this period, excluding 1990, were $0.14 \pm (\text{SD}) 0.11$, $0.21 \pm (\text{SD}) 0.11$, and $0.26 \pm (\text{SD}) 0.11$ for stratum I, II, and III respectively. The corresponding values for 1990 were 0.09, 0.09, and 0.14. The only year in the period with poorer breeding conditions was 1982. Tempelfjorden (stratum III) is the area with the best breeding conditions, and the outer parts of Sassenfjorden (stratum I) is the area with the worst breeding conditions. This trend is general for all the years considered.

When comparing the breeding condition factor with seal densities found in the three strata (Fig. 8), it clearly emerges that an increase in the seal density is associated with an increase in the breeding condition factor.

DISCUSSION

The assumption that the dog detects all the Ringed seal breathing holes within the plots

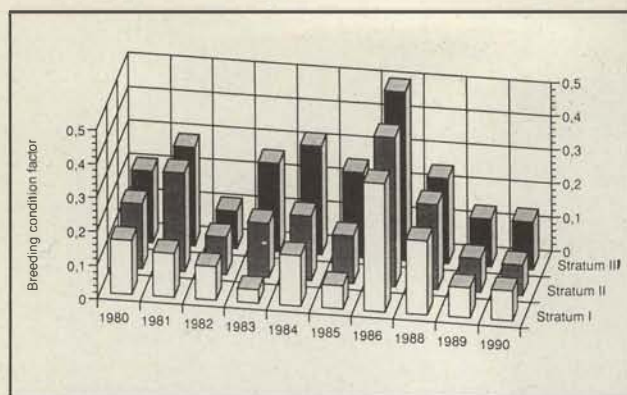


Figure 7 Yearly and areal variation in breeding condition factor in the different strata of the study area 1980 to 1990.

surveyed, might lead to an underestimation of the seal densities. This, because the dog might overlook some of these structures. The only approach to evaluate the dog search technique quantitatively is done by Hammill & Smith (1990). The way of sampling the plots in their study, however, was quite different from ours. When their dog detected a hole, the same transect was not reestablished. Instead the dog continued running across the wind from the most recently detected hole until the boundary of the plot was reached. We always reestablished the same transect after detecting a hole. The dog(s) in the Canadian study had a set time to use, while we used as much time as we needed. Hammill & Smith (1990) also found that using one dog only, and reduce the plot size, significantly improved the survey results; their plots varied in size from 2 - 4 km², while our plots were only 1 km². Thus, our ways of surveying the plots using one dog, unlimited time within the plot, and relatively small plots, probably results in a very high proportion of holes being detected sampling plots only once.

When comparing the densities of Ringed seal holes in the breeding period found in Tempelfjorden and Sassenfjorden (Table 1) with results from other areas in the Arctic (Smith et al. 1978, Finley 1979, Smith & Hammill 1981, Kingsley et al. 1985, Hammill & Smith 1990, Lydersen et al. 1990), Tempelfjorden has one of the highest densities ever found. Only some smaller investigated areas < 2 km² in eastern Canada has been proven to have higher densities of Ringed seal breathing holes (Smith et al. 1978, Smith & Hammill 1981). The inner parts of Sassenfjorden has a medium density of seal holes which are comparable with densities found in Ringed seal breeding areas in other arctic regions (Finley 1979, Kingsley et al. 1985, Hammill & Smith 1990). The outer parts of Sassenfjorden (Stratum I), however, is a poor breeding area comparable with Van Mijenfjorden in Svalbard (Lydersen et al. 1990).

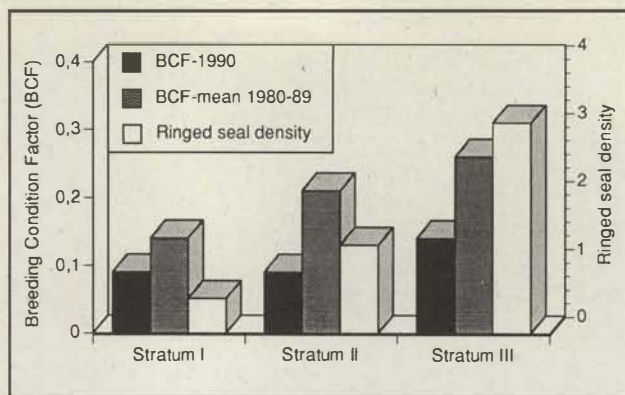


Figure 8 Density of Ringed seals in relation to breeding condition factors for the different strata in the study area.

The breeding condition factor gives a relative picture of two physical parameters important for Ringed seal breeding success in an area, and is as such useful for comparing these parameters between different areas or yearly variation within an area. Optimum conditions according to the breeding condition factor (BCF = 1) is complete ice-cover during the whole period and maximum snowcover. Precipitation data are included all the time up to the actual pupping, since the Ringed seal females are able to dig out a lair in less than 24h (Hammill & Smith 1989). When comparing the breeding condition factors for different years or areas, a higher value does not necessary imply more seals as shown in Fig. 8. It only indicates that the physical conditions are more favourable for breeding success, i.e. survival of the pups. Another physical factor highly affecting the breeding success, is the amount of ice pieces calved from the glaciers which are frozen into the sea ice, around which enough snow can accumulate to enable the construction of lairs. This factor is relatively constant when considering a single glacier, and will not be as important for comparing the yearly differences in breeding condition factor in a single area as for comparing different areas. Hammill & Smith (1989) found highest densities of Ringed seal breathing holes in areas with much snow and late ice consolidation. This might seem to be contrary to our results. However, late ice consolidation is a relative concept, and some of the investigated areas in Canada freeze up as early as September. In our study we consider ice cover from January 1st only, and the area with the earliest and most stable ice conditions (Stratum III) certainly had the highest density of Ringed seals. Not only physical parameters effects the breeding success in Ringed seals. Social factors and predation (Stirling & McEwan 1975, Smith 1987) and food availability (Lowry et al. 1980, Smith & Hammill 1981, Smith 1987) are also contributory.

As a consequence of the possibility that the dog might overlook some of the Ringed seal breathing holes, the 293 seals considered to be in the area in the breeding season of 1990 (Table 2) is a minimum estimate. On the other hand, classifying the 218 seals which were not rutting males as adult females, certainly leads to an overestimate of this group and thus of the pup production. From shot samples in Ringed seal breeding ground in Svalbard and other areas (Smith 1973, Lydersen & Gjertz 1987) we know that some immature seals also are found within these areas. Breathing holes and lairs from immature seals have no features which enables us to distinguish them from corresponding structures belonging to adult females. Subadults found within the stable breeding areas often are bitten and sometimes driven out of the water, which is taken as evidence for strong intraspecific territoriality (Stirling 1973). Even though immatures interfere with the ideal picture of breeding grounds consisting of breeding individuals only, it is reasonable to assume that the proportion of immatures decreases when moving from a relatively unstable breeding area (as stratum I) to a more stable (as Stratum III). This relationship is further reinforced by the increasing proportion of rutting males when comparing the same areas. The sex ratio for the whole area when considering all not rutting male structures belonging to adult females, was 1 male per 2.9 females. In the best breeding area (stratum III) the ratio was 1 male per 2.2 females. This is probably a more correct ratio, but still indicates a segregation between sexes in the breeding area in coordination with findings from Canadian arctic (Hammill & Smith 1989).

The overestimate of breeding females leads to an overestimate of number of pups produced. If excluding stratum I as breeding area since the only areas we registered pupping in 1990 was stratum II and III, we get a production of 185 pups for the 1990 season. The snow cover in the 1990 season was very poor, as indicated by low breeding condition factors and the fact that only 4 lairs were found in the 40 plots investigated. It is reasonable to assume that the proportion of pups surviving this season will be very low, because of predation. Pups killed by foxes were detected during the fieldwork, and polar bears and glaucous gulls *Larus hyperboreus* both known to predate these pups (Stirling & Archibald 1977, Lydersen & Smith 1989) were observed in the area. In addition a snowy owl *Nyctea scandiaca* was observed eating on a Ringed seal pup. The pup had been transported by the owl away from the place it had been killed, so it was impossible to say whether it was actually killed by the owl, or the owl only scavenged a kill from an other predator.

As a conclusion Tempelfjorden (Stratum III) was found to be an excellent breeding area for Ringed seals. The inner parts of Sassenfjorden (Stratum II) was evaluated to be a medium good breeding habitat, and the outer parts of Sassenfjorden (Stratum I) was found to be a poor Ringed seal breeding habitat. The number of seals occupying the study area during the breeding season 1990 was estimated to be 293, producing approximately 185 pups.

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EFFECTS OF DISTURBANCE ON MARINE MAMMALS



Bearded seal *Erignathus barbatus* relaxing on a small ice floe (photo: Per Espen Fjeld).

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SUMMARY AND CONCLUSIONS

The mammals of the sea have been disturbed increasingly during the last century. The level of ambient underwater noise has raised all over the world. Fishing, search for base metals and hydrocarbons have resulted in increased levels of ambient underwater noise even in the high arctic.

The reported effects of human disturbance to marine mammals are short term behaviour reactions. Most frequently the animals return to their normal activity short time after the disturbance has ceased. Sometimes however, the effect seems to last for several days. What makes one act a minor disturbance, while another, apparently of the same kind and magnitude, can disturb animals for days? Our knowledge about this problem is far too limited. We don't know much about what should be addressed as disturbance and what should not. Better knowledge of the normal behaviour of different species is important if we want to understand why they react differently to various stimuli. If a stimulus is imitating a predator in one way or another, or is cutting normal flight routes etc., the reaction might be hard to understand if the normal behaviour is unknown.

High levels of noise might give marine animals problems over time, even if they seem to habituate. It is unlikely that disturbance will cause seals or whales to abandon larger areas, though their local distribution may change if disturbance is particularly intense. The sound however, might interfere with communication and echolocation. This can give psychological effects like stress and be harmful over time. Failure of normal mating behaviour, abortion, or decreased ability of pregnant females to care for their young might be reactions. This will result in slow growth, and sexual maturity might be delayed. Such long term effects as indicated here, are hard to show in any investigation, and this has not been done till now.

Most of the man-made noise is low-frequency broadband noise which masks long distance communication in baleen whales. These whales have a scattered distribution, and reduced communication ranges might reduce their reproductive fitness and therefore be a threat to their existence over time.

In an archipelago like Svalbard with many fjords, noise will mainly be a local problem. Much noise in one area might disturb the local population of animals, but will not influence other areas. During summer the Harbour seals and the Walruses are the most vulnerable marine

mammals in the region. They have pupping grounds and important haul-out sites in Svalbard, and around these sites disturbance must be avoided.

The marine mammals can be affected directly in two ways. First through direct collisions between ships and swimming animals. This is mainly a problem for slow-swimming baleen whales. The scattered distribution of these animals makes this a minor problem. Better knowledge of migration routes and other places with higher densities at times of the year, can reduce the problem by restricting the access to these areas. The second direct effect is icebreakers killing seals on ice and destruction of seal lairs in the ice. At normal conditions adult seals will not be killed, but pups, especially in seal lairs, can be killed. After the icebreaker has left, the frozen track is a good place for making new birth lairs because of the cracked ice. The density of seal lairs in a track after an icebreaker is in one study found to be higher than in adjacent areas. However, no studies of reactions to repeated use of the same track has been done.

All of the documented consequences of disturbances are short term effects. Moving sources, boats and aircrafts, seem to be more disturbing than stationary sources, drillships and dredges. Some of these noisy activities, like flying over seal and Walrus haul-out sites, can cause mortality through abandonment or stampedes.

The Gipsvika and the outermost part of Sassensfjorden has not been found to be breeding habitats or important haul-out site to any marine mammals. The negative impact to the marine mammals from the Gipsdalen project will be the general increase in noise level in the marine environment, but no distinct reactions are expected.

INTRODUCTION

Sea has been the most prominent route for international and intercontinental traffic throughout the history of man. During the last century this traffic has been carried out not only by wind and water currents, but by all kinds of noise producing engines. The advanced technologies and the rapidly growing human population have resulted in increasing noise levels. The continuing search for non-renewable resources such as base metals and hydrocarbons have increased the traffic even in the arctic regions.

The political changes seen in USSR recently, might result in further increase in ship traffic in

the arctic region. Steps have been taken from the Russians to open a new ship route from Europe to the far east and the west coast of the USA. This route is to be held open by soviet icebreakers. High icebreaker activity and a lot of ships all year will result in increased noise pollution to the northern waters.

The aim of the present work is to identify the direct influence of man and manmade noise on the normal marine environment, and especially the marine mammals, based on a literature review. It has three sections. The first gives a general description of marine mammals, the second discusses the effects of different kinds of disturbance to marine mammals, while the third debates the effect of the planned activity in Gipsdalen on the marine mammals in the area.

Polar bears are considered not to be a part of this review. The effects of whaling and seal hunting is not discussed, and neither is any form of chemical or nuclear pollution. See Griffiths et al. (1987) for a review of the effects of oil pollution to marine mammals.

GENERAL DESCRIPTION OF MARINE MAMMALS

Introduction

Marine mammals is a diverse group, consisting of whales (baleen and toothed), Pinnipeds (eared seals, Walruses and true seals), Sirenians and Sea otters. These are ranging in size from 20 kg (Sea otter) to 150 000 kg (Blue whale). Operating in air temperatures from -60 °C (seals hauled out on ice in polar regions) to over 40 °C (seals hauled out on tropical sand beaches in the mid-Pacific), and in water from -2 °C to 30 °C. A wide variety of swimming speed is evident, depending on food preferences, predator-prey interactions, diving capacity and behaviour. Some species remain tied to land through a variety of biological activities, while others are fully aquatic. Some marine mammals have been reported to stay submerged for up to two hours. The metabolic rate varies a lot, depending on activity, starvation, temperature, etc. This diversity indicates the difficulties of treating marine mammals as a homogeneous group. In this first part of the report some of the principles and common features of marine mammals are discussed.

Anatomy

The anatomy of marine mammals mirror the problems they are confronted with during their time in water. The cooling effect of water exceeds

the cooling effect of air, but it depends upon factors of heat capacity as well as motion affecting conduction and convection. The cooling effect is increased with declining temperature of the water. In the Atlantic the mean annual surface temperature declines northward from 27 °C near the Equator to -1.7 °C at the North Pole (Defant 1961). Beneath the surface the temperature declines in all latitudes, even at equator the temperature of the Atlantic declines from 27 °C to 7 °C in 600 m. Compared to other animals the marine mammals have small appendages and a low surface to weight ratio. This results in low heat loss. Together with a thick boundary layer of blubber, this gives marine mammals a common appearance.

In terrestrial locomotion the surrounding air generally makes an insignificant resistance on locomotion. Most aquatic animals have developed streamlined shapes that result in minimalization of the water resistance and thus in locomotion costs. This results in high speed and the possibility of continuous swimming.

Physiology

Marine mammals have a deep body temperature of 36.5 - 37.5 °C at normal conditions, but it can fluctuate to a certain amount (King 1983). Frightened animals can have their body temperature raised with 1 - 2 °C, while sleeping adults might slightly lower it. Usually the temperature is kept at a constant level in spite of changing external temperatures. Beside a low heat loss, due to good insulation, they have the possibility to vary metabolic rate during changing conditions.

Marine mammals have eyes adapted to a life under water. For a long time all seals were considered to have pure rod-dominated visual functioning (Nagy & Ronald 1970). Later studies have shown both rod- and cone-like receptors in some species (Jamieson & Fisher 1971, Lavigne 1973, Lavigne & Ronald 1972). The maximum sensitivity of the eyes reflects in some degree how deep the different species dive for food. Deep diving seals like the Southern Elephant seal *Mirounga leonina* have maximum sensitivity shifted to longer wavelengths.

In air seals can see clearly in bright light, but with decreasing illumination the acuity decreases more in air than under water (Lavigne & Ronald 1975). At dark places in air they respond mainly to large objects appearing on the skyline, or to rapid movements (King 1983). In water their visual acuity is said to be as great as that of a cat on land (Schusterman 1972, Schusterman & Balliet 1970, 1971).

Marine mammals have small or non external ear pinna, but even so seals can hear at least as well as humans in air. In water they can hear better than the carnivores on land, and they have a very good directional hearing. Because the sound reception is so important with respect to the effects of noise, this is further discussed in a separate chapter.

Seals also have a well developed and densely innervated vibrissa (Dykes 1975). Harbour seals are capable of detecting vibrations ranging from 50 and 1000 Hz with the vibrissa, giving them the ability to determine various properties of objects moving under water without having to touch them (Renouf 1979). The vibrissa may provide the seal with information about speed of diving, changing in swimming direction, and spatial orientation (Hyvärinen 1989).

Sound production

Vocalization is used for communication during cooperative feeding and other social interactions (Sjare & Smith 1986b, Steiner et al. 1979). The vocalization of marine mammals also plays a reproductive role, similar to the bird song (Tyack 1981). This is also reflected in the annual and diurnal variation in activity shown in some species (Green & Burton 1988).

The sounds produced by marine mammals appear to be of three basic functions: Long distance communication, short distance communication, and echolocation. Sounds produced vary a lot from species to species. Sounds up to 170 kHz have been demonstrated, probably used for echolocation. Sounds of lower frequencies, down to 1 Hz, have a much longer range and are used for long distance communication.

Odontocet (or toothed whales) sounds include three classes: clicked signals, bursted signals, and pure tone signals. The whistle tones from the Belugas have a frequency of 3.45 - 9.1 kHz and are a little lower than other toothed whales (Fish & Mowbray 1962, Sjare & Smith 1986a). Belugas also produces clic series, pulsed tones and some noisy vocalization (Sjare & Smith 1987). Pure tone signals or whistles have not been shown to take part in any echolocating behaviour.

The clicked signals of odontocetes are composed of discrete clicks of sounds, usually very broad-band in character. This can be heard as individual burst of sound, or as trains of clicks. When the repetition rate is very high it may be heard as a single signal which frequency reflects this rate. Many of these appear to be social signals even though often thought to be related to

echolocation. The clicks are usually very brief, ranging in duration from a fraction of a millisecond (Evans 1966) to unique narrower band clicks of as much as 25 milliseconds duration in Killer whale *Orcinus orca* and Narwhal *Monodon monoceros* (Ford & Fisher 1978, Schevill & Watkins 1966). The clicks of odontocetes have often been described as white noise, implying uniform representation of frequencies over an extremely broad band. This is not strictly true and it is generally better to refer to most dolphin clicks as simply broad-band emissions (Ford & Fisher 1978).

Sperm whales *Physeter catodon* is only known to produce clicks, but at a variety of repetition rates and different lengths. These pulses have sharp onset, and are broadbanded with frequencies as high as 30 kHz, lasting between 2 to 30 msec or even longer. The clicks are put together in patterns starting with special sequences called codas. Sometimes the end sequence is the same as the starting one. Lone Sperm whales out of acoustic range of other whales seldom produce any audible sounds. But if sounds of other distant whales can be heard, the whale starts producing sound. The sound production increases as it approaches the other group, and it will stop making sounds when they separate again (Watkins 1980, Watkins & Schevill 1977). With increased distances the higher frequencies are attenuated by the environment, at 2 km most of the audible energy is found in frequencies below 5 or 6 kHz. The lower frequency content of Sperm whale clicks is variable but usually well below 100 Hz (Watkins 1980). The level of the sounds seems to be varied by the whales at will.

The underwater sound emissions of baleen whales are typically low frequency cries or moans, usually much longer in duration than the average odontocete click, and usually of a much narrower band character. Most frequencies are under 800 Hz and the duration is longer than 1 second (Ljungblad et al. 1982). Minke whales *Balaenoptera acutorostrata* produce in addition to the low frequency grunts some thumps and ratchets of higher frequencies (Winn & Perkins 1976). The variety of signals are considerable, though it does not seem to approach the complexity and variety known from odontocetes. The Humpback whale *Megaptera novaeangliae*, and to some degree the Gray whale *Eschrichtius robustus*, might be exceptions. They produce moans, grunts, pulse trains, blowhole-associated sounds and surface impacts (Fish et al. 1974, Hafner et al. 1979, Thompson et al. 1986). Source levels ranged from 162 dB (low frequency pulse trains) to 192 dB (surface impacts). The song of the Humpback whale commonly heard on winter

breeding grounds is composed of frequency modulated moans and cries. Every animal has a song of its own and this song can be used for identifying individuals.

Bowheads *Balaena mysticetus* produce moans and songs with median intensities 159 and 177 dB (Clark & Johnson 1984, Cummings & Holliday 1987, Ljungblad et al. 1980).

Most peculiar are the 20 Hz pulses of Finback whales *Balaenoptera physalus* and Blue whales *Balaenoptera musculus*. These calls are sometimes emitted with monotonous regularity over many hours of listening. The calls are narrow band and are of very high intensity, 186 dB re 1 μ Pa at 1 m (Watkins et al. 1987). In Blue whales these sounds usually have a duration of more than 15 seconds (Edds 1982). The 20 Hz signal is specially well suited for long distance communication (Payne & Webb 1971).

The sound production of seals is as variable as those of the whales. They range from peculiar church bell-like sounds of Walrus *Odobenus rosmarus* through extremely intense clicks, also in Walrus, to very prolonged trains (42 sec.) of resonant pulses in the Weddell seal *Leptonychotes weddelli* (Schevill & Watkins 1965), to underwater growls, barks and clicks in Sea-lions (Schusterman & Balliet 1969). Even ultrasonic sounds of up to 164 kHz have been recorded from Leopard seals *Hydrurga leptonyx* (Thomas et al. 1982).

The most usual sound from seals appears to be faint clicks, which usually have strongly emphasized frequency bands and are sometimes frequency modulated, and usually composed of low frequencies, though analyses that allow statements about sound energy above 30 kHz are few.

The importance of vocalization is demonstrated by Harp seals having their whelp and mating grounds at different places every year, depending on the ice conditions. The underwater sound is important to the arriving animals when locating the herd. Harp seals sounds have been recorded up to a level of 140 dB re 1 μ Pa at a distance of 2 meter (Terhune & Ronald 1986). This is higher than the Harp seal vocalization sounds reported by Watkins & Schevill (1979), but the average level at high calling rate in the study of Terhune & Ronald (1986) was considerably lower, about 100 dB re 1 μ Pa. The low levels are easily masked by high ambient noise during strong wind or by noise from human activity, and thereby making it difficult to locate the heard.

In species like the Walrus and the Bearded seal *Erignathus barbatus* the sound produced by the

males has the function of advertising a bull in breeding condition, and the establishment of a territory (Ray et al. 1969, Ray & Watkins 1975). These sounds are in the frequency range 200 - 2000 Hz for the Bearded seal and 200 - 1200 for Walruses (Schevill et al. 1966, Stirling et al. 1987).

Harbour seals are supposed to be remarkably quiet, and this is true for the female. After the age of one year little or no vocalization occurs. The male vocalize more, and most of it is in connection with mating, with a peak at the age of 5, but remains high for several years (Ralls et al. 1985). The frequency range of these sounds was from 0 to 4000 Hz. These results are from vocalization in air. It has been shown that Weddell seals produce many of the same vocalizations under water as in air (Thomas 1979 cited in Ralls et al. 1985), but it is not known if the same is true for Harbour seals.

Ringed seals were previously thought to be totally silent, but four different vocalizations are now identified (Two types of barks, yelps, and chirps). These are probably used for communication and social organization (Stirling 1973).

Both whales and seals are known to produce both underwater and airborne sound signals simultaneously, thus suggesting two separate loci, at least. This is shown by simultaneous recordings above and below water, and is shown in several species.

Sound reception

Probably all marine mammals have good hearing. The many stories told by whalers and sealers of the extreme care taken to remain quiet during the chase give a good indication of good hearing ability. A small sound would send the seal or whale into flight.

The absolute hearing threshold is the intensity of sound that is barely audible in the absence of background noise. The threshold varies with the frequency of the sound being detected. The curve relating threshold intensity to frequency is called an audiogram.

Audiograms for some marine mammals have been determined, and give an indication of good hearing ability (Awbray et al. 1988, Møhl 1968a, Terhune & Ronald 1972, 1975b, Thompson & Herman 1975). For each species there is a range of frequencies where hearing thresholds are low. Below and above this range the hearing thresholds increase with decreasing or increasing frequency. The increase in thresholds are rather

gradual at low frequencies. Problems with echoes, standing waves, etc. in the small test tanks, may have resulted in too high estimates for the low frequencies (<1 kHz). The sensitivity at low frequencies is especially interesting, because it is in this frequency range most industrial noise is found.

Audiograms from dolphins and porpoises shows great sensitivity also above the human threshold. The sensitivity seems to decline rapidly first above 120 kHz (Thompson & Herman 1975). The sensitivity also declines for the lowest frequencies.

Belugas *Delphinapterus leucas*, also called White whales, have a threshold about 50 dB re 1 μ Pa in the range 10 - 100 kHz. (Definitions of sound intensities will be a subject of a later chapter). The threshold at 125 Hz is 120 dB and at 8 kHz it is decreased to 65 dB (Awbrey et al. 1988). Belugas also have an excellent frequency discrimination, especially from 2 to 53 kHz, but it is still very good up to 130 kHz. At higher frequencies the discrimination becomes rapidly worse (Thompson & Herman 1975).

Seals seem to have a higher threshold than dolphins and porpoises. Their ability to hear high frequencies is declining at lower frequencies too (Terhune & Ronald 1975b). California Sea-lions *Zalophus californianus* and Northern Fur seals *Callorhinus ursinus* have higher thresholds, and the ability to hear high frequencies is even poorer (Moore & Schusterman 1987, Schusterman 1981, Schusterman et al. 1972).

Humans have a hearing sensitivity in air that is superior to that under water (Wainwright 1958). In seals the sensitivity is best under water. The audiogram of Harp seals *Pagophilus groenlandicus* and Harbour seals *Phoca vitulina* in air and under water differs with 10 to 20 dB in favour of under water hearing (Terhune & Ronald 1971, 1972). The sensitivity is also shifted to higher frequencies under water.

The upper frequency of marine mammals varies a lot. Harbour seals can detect frequencies from 1 to 180 kHz (Møhl 1968a), while in Ringed seals *Phoca hispida* the upper frequency is 60 kHz under water (Terhune & Ronald 1976). In air the Harbour seal can only hear frequencies between 1 to 22.5 kHz with highest sensitivity at 12 kHz, while the highest sensitivity in water is at 32 kHz (Møhl 1968b).

Masking occurs when the absolute threshold is elevated because of background noise, although not all frequencies in such noise contribute

equally to masking. The effective masking power is concentrated within a range of frequencies that surround the test frequency (Fobes & Smock 1981).

The effect of masking noise to the audiogram of Harp seals is demonstrated by the fact that the noise from the surface at wind speed of about 15 m/sec will raise the threshold for hearing frequencies under 50 kHz with approximately 15 dB, while frequencies above 50 kHz remain unaffected (Terhune & Ronald 1972, Wenz 1962).

All available evidence tends to show that the sense of hearing plays a dominating role in the life of whales. Whales lack an external ear, and the auditory meatus extends through the blubber from a surface slit to the middle ear. The entire ear is loosely connected with the skull, which is essential for the directional hearing of whales. The mechanism of sound conduction to the inner ear of large whales and seals is directly transferred through the skull, whilst animals are in the water. The aerial sound transmission of seals is typically mammalian (Turl 1982). The directional hearing in porpoises, which is very good, is based on some fatty "acoustic windows" on the jaw. Transmission of sound from water to these fatty canals is highly directional in their sensitivity. They respond mainly to high frequencies (Norris 1969).

The ability of marine mammals to hear is greatly inflected by water depth. The deeper down, the less ability to hear. This is based on the fact that blood sinuses in the middle ear cavity of seals and whales are filled when they do deep dives. This is a way to prevent blood gases from entering the cavity when diving. There are many other air-filled cavities constructed in a similar way. This helps eliminating problems with divers disease.

There are no data on hearing ability of baleen whales and Walruses.

Echolocation

If an animal listens to the echo of its own sounds and then uses that echo to determine a bearing, range, or the characteristics of the echoing object, it is echolocating. A very wide variety of sounds may be useful in this way and there is no priori way of saying what sounds are or are not used for echolocation. Only experiments of a critical nature can tell. It is difficult to demonstrate echolocating in marine mammals, but it has been shown in some toothed whales. It is highly probable that echolocation in some form is widespread among the odontocete whales. Belugas have three distinct modes of echolocating

signals, with repetition intervals down to 1.7 ms (Au et al. 1987).

From baleen whales like Minke whale and Blue whale different ultrasonic and short pulse frequency sounds have been recorded, suspected to be used for echolocating (Au & Penner 1981, Beamich & Mitchell 1971, 1973).

The effect of masking noise to Belugas and Bottlenose dolphins *Tursiops truncatus* echo localization have been examined (Turl et al. 1988). The Belugas were shown to be superior to the dolphins in detecting a small diametered sphere in noisy surroundings. The noise spectrum was relatively flat from 40 to 160 kHz (about 90 dB re 1 μ Pa/Hz). At the 75 % correct response threshold, the echo-signal-to-noise ratio ((Ee/No)max) was approximately 1.0 dB for the Beluga and 10.0 for the Bottlenose dolphin. The Belugas 75 % correct response occurred at noise levels of 85, 72 and 63 dB re 1 μ Pa /Hz at target ranges of 16.5, 40 and 80 m. The corresponding values for the Bottlenose dolphin was 72, 59 and 55 dB. When a distinct noise source is present, Belugas can use reflections from the surface to avoid the source of noise (Penner et al. 1986). Belugas can also adapt to noisy surrounding by changing frequency range and signal intensity (Au et al. 1985).

The California Sea-lion *Zalophus californianus* was suspected to echolocate, due to production of sounds similar to those of dolphins. Test with a single captive Sea-lion indicates that the ability to echolocate is poor (Evans & Haugen 1963).

According to Renouf & Davis (1982) also Harbour seals are capable of echolocating. However, their work is debated by Wartzok et al. (1984). They claim that the work is not convincing, and that the conclusion might be wrong.

Diving

70 % of the world's surface is occupied by oceans and seas, with a mean depth of 3800 m. The upper layers of the oceans are the richest in fauna and flora. Nevertheless, there are abundant food supplies at moderate depths for those able to reach them. The deeper a whale or a seal can dive, the greater the dimensions of its habitat become. Sperm whale has been reported down to 1134 m (Gaskin 1964), entangled in deep-sea cable, and one Northern Elephant seal *Mirounga angustirostris* has been recorded down to 894 m in a dive lasting 48 minutes (Le Boeuf et al. 1988).

Deep diving seals and whales have the ability to avoid the divers disease or "bends". This is caused

by compressible chests and lungs. This makes the lungs contract as the pressure increases, so that the pressure in the lungs is in balance with the surrounding tissue. Simultaneously the alveolar wall becomes compressed and thickens, reducing the rate of diffusion of nitrogen from lungs to blood. At a depth of about 100 m the collapse of the lungs is complete.

During diving under ice, and possibly under other conditions, Elsner et al. (1989) found that seals rely on a sensory hierarchy to find their way from one place to another. The vision is the most important, followed by audition and the vibrissal sense.

Breeding

The majority of the seal species and the most numerous populations are found in the cold northern and southern waters, where they give birth on ice or in ice covers. The seals usually breed in the spring or summer of their respective hemispheres. Usually the mating takes place after the time of birth. There is a limited courtship followed by a copulation lasting up to 10 minutes. The site of mating plays an important part in the social organization of seals. There are several strategies for the mating. Some are monogamous and stay together with only one female, while other species are polygamous, and mate with several females. In some species males stay in an area used by the females when passing over to the site of pupping. In other species males select an area into which they try to drive females. In polygamous species the male is usually much bigger than the female, while in monogamous species there is very little difference in size, or the female is bigger.

Vocalization between the mother and pup is active already short time after birth. In some species the mother is calling, while in others the pup is the vocal one. Vocalization is also used for territory holding and for males when calling for females. Most of the vocalization seems to be airborne calls, but also underwater communication is used.

Lactation last from 4 - 5 days in Hooded seals *Cystophora cristata* to 16 months or more in Walruses. During lactation the pups have a weight gain of up to 7 kg a day in Hooded seals, while Walruses only gain up to 0.5 kg a day (Bowen et al. 1985). Some species give birth in large colonies, while others are less social and give birth alone in birth lairs.

The phenomenon of delayed implantation appears to be widespread among seals. The length of delay

is from 1 - 5 months. Some species however, like the Walrus, is shown not to have delayed implantation.

There is great variety in how often a seal can give birth. Some species give birth every year after sexual maturity, while others do it only every second or third year.

The mating in whales and dolphins is of short duration after some hours of courtship. Delayed implantation has not been shown in whales. They mate and give birth at different times of the year, depending on species and latitude. The Minke whale has a breeding season in the Atlantic from January to May, and the time of birth is November to March. After this they lactate for 4 - 5 months.

Migration

The baleen whales have annual migrations that appear to represent an evolved compromise between differing requirements for breeding and maximal feeding potential. Some species move along at a speed of 100 km a day, while others move along at much lower speed. The length of these migration trips differs a lot. The distributional ecology of these migrating animals becomes largely a study of the distributional ecology of their prey species, and an analysis of the factors which may limit their ability to reproduce or rear calves or pups to maturity.

The general migration trend is movement towards the north in the summer and south in the winter on the northern hemisphere, and the other way around on the southern. Some have a more east-west movement, but the trend is clear. This is to take advantage of the high productivity during the polar summer.

How they orientate and navigate is poorly understood. Some near shore migrants, like the Gray whale, seem to follow the bottom topography parallel to the coast during the migrations (Norris 1966). Norris also observed a strange hopping he thought to be a way of observing the shore for further orientation. It has also been suggested that olfaction might play a part in detecting the place they are seeking.

There are no definitive hypotheses how truly pelagic species such as Blue, Sei *Balaenoptera borealis*, Sperm, and Bottlenosed whales are able to orientate and navigate across thousands of kilometres of open sea. It can be the seasonal movements of water currents, average position of the sun and the moon, stellar navigation or something else we do not know yet. It seems to

involve a high degree of learned behaviour. The young whales almost certainly learn the route by accompanying experienced adults. Among both odontocetes and baleen whales, formation of schools are observed. The size and composition differs from 4 - 5 animals in some baleen whales species and up to 50 animals in some odontocetes species.

Most seals and odontocetes do not have long yearly migrations between separate feeding and breeding grounds in the same way as the baleen whales, but sometimes species like the Harp seal start out on long food searching trips. These are in connection to scarcity of food in the area they usually inhabit. Seals may also swim together in groups for efficient feeding. Cooperative feeding takes place in some species, Fink (1959 cited in Evans & Bastian 1969) observed herds of Harp seals and Sea-lions swimming in tightly organized groups feeding.

EFFECTS OF DISTURBANCE TO MARINE MAMMALS

Introduction

What kind of human activity should be addressed as disturbance, and how is wildlife going to react to a planned human activity? These are the general questions to be asked. How do the animals react at the first confrontation? Do they get habituated to it? Will they be attracted to it, and may behaviour change over time?

In this part of the report, different aspects of human activity influencing the normal life of marine mammals will be discussed. The studies available are mostly focused on short-term behavioural reactions.

The human activities taken into consideration are disturbance from different kinds of vessels (ship, icebreakers, Hovercrafts, small boats etc.), fixed-wing airplanes, helicopters, snow-scooters, industrial installations, etc. These activities will affect marine mammals in two ways, by physically impinging on individuals, both in open waters and when animals are on ice, and by noise, both airborne and underwater. The noise produced can be interfering with sound production and hearing, and it can have different psychological effects.

Direct physical effects

Ship traffic in open water can present a serious hazard for marine mammals, particularly the slower moving baleen whales. In a study

carried out in California during the period from 1975 to 1980 (Patten et al. 1980 cited in Mansfield 1983) there were recorded 14 collisions, resulting in 8 dead whales, mostly Gray whales (6). In the same period eleven strandings of Gray whales were recorded in the same area, two of which were caused by collisions. The animals involved in the collisions in the California study were normal, healthy animals.

Icebreakers could also exert detrimental effects on animals inhabiting heavy pack ice or fast ice. The most frequently encountered species would be the Ringed seal. During winter and spring, adults of both sexes are found on the fast ice, in which they maintain breathing holes. In snow drifts and along pressure ridges, lairs are excavated above breathing holes for resting and for protection from predators. In March or April the adult female gives birth to its white-coated pup and nurses it for 6 to 8 weeks (Smith & Hammill 1981, Smith & Stirling 1975). The quality of ice and snow cover is a primary determinant of Ringed seal distribution. The risk for Ringed seal pups of being killed by icebreaker activity will depend on how the routes are planned and how often the ships will frequent the route. The authors of the "Integrated Route Analysis" (Arctic Pilot Project 1981) have calculated that a maximum of about 1 % of the Ringed seal pups born in Perry Channel each year will risk being destroyed by two big tankers passing the channel 8 times during the nursing time (Mansfield 1983). They also assumed that the ships followed a new track each time, and that all pups less than 6 weeks occupying birth lair in the path of the ship and up to one ship's width to each side would be killed.

Ringed seal lairs are found more frequently in frozen tracks after icebreakers than in compared areas (Alliston 1980 cited in Mansfield 1983). The study states nothing about how Ringed seals would react to repeated use of the same track.

Around Svalbard most stable ice and birth lairs are found in the inner parts of the fjords, and therefore the vulnerability to ship traffic is normally small.

The Beluga and the Bowhead whale appear to prefer the loose ice, up to 75 % cover, while the Walrus and the narwhal are found in the closer pack, up to 99 % cover. Both species are usually widely scattered throughout their preferred area and it is assumed that few would occur in the path of ships (Mansfield 1983).

Amphibian vessels are of two different types. The oldest is a slow carlike vehicle. It will

contribute to the airborne noise of the area. The second kind is the Hovercraft. Its speed is greater, but it is not supposed to do any damage to birth lairs, and a seal hit by a Hovercraft is likely to survive. The noise is comparable to the noise from a snow-scooter.

Dynamite and chemical explosions are used by geologists to profile acoustically the ocean sediments, and also by the U.S. Navy to make holes in the arctic ice for different military purposes. Dynamite explosions have a high amplitude and a short rise-time, characteristics that implicate hearing damage or death to nearby animals (Wright 1982, Yelverton & Richmond 1981, Yelverton et al. 1973).

Effects of underwater noise

Noise can cause high levels of disturbances to marine mammals, which might result in detrimental changes in behaviour. It can also increase the ambient noise level to the point where vocalization will be masked, and communication and echolocation will be interfered.

The noise also has effects like physiological stress, with signs similar to those seen after exposure to extreme heat or cold. These responses include a variety of measurable physiological changes, such as increased blood pressure, increased corticosteroid level and increased adrenal gland weight. Prolonged stress of this type can exhaust an animal's resistance to infection and disease and can, in extreme cases, result in death (Turl 1982).

The effect of different kinds of noise shows great variance between species. Some species react powerfully, while others do not react at all. How little some species react to noise, is exemplified by the problem fishermen have with keeping seals away from their fishing nets. Many different kinds of acoustic methods have been used for keeping Cape Fur seals *Arctocephalus pusillus* from fishing nets, without too much success (Shaughnessy et al. 1981).

The importance and utilization of underwater sounds in the lives of marine mammals varies greatly. Some species are virtually silent and inhabit areas where sound transmission is possible only over short distances. Other species vocalize year round and inhabit areas where sounds can be detected at great distances.

The level of ambient noise that will mask a signal depends on the frequency of the signal and on which species it is. Bottlenose porpoise and Beluga can hear low frequency pure tones when

they are less than 20 dB higher than the noise. At higher frequencies the critical ratio is higher (Johnson 1968, Johnson et al. 1989).

In Ringed seals the ability to hear masked signals is similar to the Bottlenosed porpoise at low frequencies, but is poorer at higher frequencies. At noise levels 60 dB higher than the background noise, the signal must be 30 - 40 dB higher than the actual noise (Terhune & Ronald 1975a).

Measurement of underwater noise has to be described. The acoustic intensity of a sound wave underwater is related to the acoustic pressure (p), the velocity of sound (c), and the density of sea water (ρ) by

$$I = \frac{p^2}{(\rho c)}$$

Sound pressure level (SPL) is the ratio between the acoustic pressure measured at the hydrophone and a reference pressure (1 μ Pa). This is used since intensity is not a direct measurable quantity.

The general expression for the SPL in decibels is

$$\text{SPL} = 20 \log \left(\frac{p}{p_0} \right)$$

p - pressure measured at the hydrophone
 p_0 - reference pressure (re) of 1 μ Pa

To enable different measurements of sounds to be compared it is useful to have a theoretical value for the source strength. The value used is called the source level, and is the acoustic pressure that would be measured in an infinite body of water at a distance of one meter from the source of sound, considered as a point.

dB re 1 μ Pa at 1 metre (Ross 1976)

When dealing with broadband sources and not single-frequency tonal components of underwater sound the spectrum level does not refer to the total acoustic pressure of the received signal. It is the calculated value for a spectrum level equivalent to that produced by an ideal filter 1 Hz in width at the effective centre frequency of the band (Ross 1976).

dB re 1 μ Pa $\sqrt{\text{Hz}}$ (Ross 1976)

To compare underwater sound to airborne sounds it is useful to remember that a healthy human ear can detect a minimum intensity of 10 - 12 watt per m² in both air and water. The pressure required to produce the same intensity in water

as in air is about 60 times greater. The threshold for hearing for humans in water will be 61.5 dB re 1 μ Pa.

The ambient underwater noise is the general noise having no distinct source. The ambient noise is a composite of at least three overlapping components, turbulent - pressure fluctuations (1 - 100 Hz), wind-dependent noise from bubbles and spray (50 - 20 000 Hz) and the oceanic traffic (10 - 1000 Hz). The level is strongly affected by the presence of ice, the depth of the sea, the vessel traffic present and the different meteorological factors (Wenz 1962).

In areas with ice, the ambient noise is much reduced compared to areas without ice (Payne 1964, Thiele 1988). In high arctic were the ship traffic is low, the sound levels are even lower (Milne 1967, Milne & Ganton 1964). Even if areas with ice have low ambient noise, the ice will produce some sounds. This noise comes from ice cracking up due to thermal stress, being moved around by the wind, currents or waves, breaking and crushing owing to tension or compression, icebergs capsizing or breaking, release of entrapped air in melting ice, or because ice interacts with the sea bottom or the shore. In areas where there is much ice movement, noise can be surprisingly high. A rolling iceberg made noise measured to 115 dB re 1 μ Pa / Hz^{0.5} at a range of about 200 m (Leggat et al. 1981 cited in Mansfield 1983), and an actively forming pressure ridge was measured to 136 dB re 1 μ Pa / Hz^{0.5} at 1 m (Buck & Gr  en 1979).

Under the ice edge the general noise level is 12 dB higher than open water levels, and about 20 dB higher than levels for far in the ice field (Diachok & Winokur 1974).

In areas without ice the sea state and other meteorological factors as wind and rain will influence the noise level. The wind induced noise is wide-ranged (30 - 3 000 Hz), and the noise from rain is most significant at frequencies around 1 000 - 10 000 Hz. The turbulence found in shallow waters, the surface bubbles and spray caused by wind and precipitation and the sound from oceanic ship traffic are also sources of background noise in the sea. The ship traffic makes its most significant contribution at frequencies below 200 Hz.

The ambient noise levels of different places and at different times of the year may vary with up to 20 dB (Miles & Malme 1988, Milne & Ganton 1964, Leggat et al. 1981, Thiele 1982, Thiele 1988). At times there can be high level impulses (signal to noise ratios up to 40 dB) of underwater sound

occurring 3 - 4 times per minute were associated with the many active glaciers in the area (Miles & Malme 1988).

The ambient noise in one fjord on Svalbard, Van Mijen fjorden, has been measured to 101 - 110 dB (lin) in the spring (Enger et al. 1987).

Sound propagation varies owing to changing bottom conditions, different thermocline conditions, ice cover, wind, etc. This is an important problem when calculating the sound level of different disturbances. Underwater sound radiating from a vessel will be attenuated by spreading, absorption by sea water, absorption and reflection from the bottom, and reflection from undersurface of ice. The intensity of sound decrease initially proportional to the square of distance. This is called spherical radiation, and can be expressed as

$$L = 20 \log r \text{ dB} \quad (\text{Alberts 1960})$$

r is the distance in meters

This is equal to 6 dB per distance doubled

Under some conditions the radiating of sound will not follow the rules of spherical radiation, but cylindrical spreading. Under such conditions, which could be caused by very stable surface layers or special conditions in deep water, the loss is equal to 3 dB per doubling of distance.

The absorption of sound by sea-water is low, especially at lower frequencies. At 1 kHz it is 0.08 dB/km and at 5 kHz it is 0.035 dB/km (Thorp 1965).

Propagation losses increase when sound, particularly at the lower frequencies enters shallow water (about 200 m) and interacts with the bottom. An additional loss of 25 dB at 63 Hz is reported when sound from a source 150 nautical miles away in Baffin Bay moved into the coastal area of NW Greenland (Leggat et al. 1981 cited in Mansfield 1983).

The propagation loss in Van Mijen fjorden, Svalbard, was reported to be extremely low. Almost no loss at all in the range 1 to 10 km (Enger et al. 1987).

Ships in open water produce noise which increases with increasing speed. Thiele (1981) also showed that the noise from the icebreaker M/S "VOIMA" increased approximately 5 dB as the ship went from open water to icebreaking. The ice was 0.3 m thick, and the depth in the test area was 80 meters. Sailing ahead in ice at full

power the noise level was around 160 dB re 1 μPa /Hz^{0.5} at 1 meter at frequencies lower than about 100 Hz. This is about 10 dB lower than the measured sound from some Canadian icebreakers going ahead in open water (Mansfield 1983).

The sounds from smaller boats working around drilling sites in open water have been shown to produce sound pressure levels of the same magnitude as the icebreakers. Ford (1977 cited in Mansfield 1983) estimated peak sound pressure levels of two tugs, each pushing a full barge, to be 164 dB re 1 μPa /Hz^{0.5} at 1 m, while the estimated range of a supply ship 'Canmar Supplier VIII' were 144 - 167 dB re 1 μPa /Hz^{0.5} at 1 m.

Discrete tones produced by the frequency of rotation of the propeller blades are expected to reach higher levels in the full power mode, but they will be confined to narrow bands, and are therefore of lesser concern than the broad band spectrum of other sounds.

The big Liquefied Natural Gas tankers (LNG) designed for gas transport in the arctic regions will be cruising at 17 knots at 40 % power in open water. Under such conditions the peak sound level will be about 165 dB re 1 μPa /Hz^{0.5} at 1 meter.

The effect of this noise is not well understood. Potential effects of continuous industrial noise on communication among sea mammals is also of concern. Increased background noise at low frequencies will decrease signal-to-noise ratios, and reduce the range to which calls can be detected. Assuming spherical spreading, a 20 dB increase in noise level will reduce theoretical detection range by a factor of 10 (Terhune 1981 cited in Mansfield 1983). A such reduced detection range may result in problems with detecting other members of the same species, an essential factor of mating.

Reported effects of ships in open water to marine mammals are few. Sometimes dolphins go surfing on the front wave of ships, and whales approach the whalers ship. In other connections they might abandon an area when a ship is arriving. Baker et al. (1982 cited in Cowles & Imm 1988) found changes in respiration rates and diving behaviour of Humpback whales, when boats were within about 900 m. Close and erratic movements had the greatest effect.

Sorensen et al. (1984) reported that "squid-eating" toothed and beaked whales were less common near boats than elsewhere. "Fish-eating" cetaceans and some baleen whales did not show the same response. This might be caused by an

altered diving pattern, and not by a reduced amount of whales in the area (Fraker et al. 1982 in Sorensen et al. 1984).

Dolphin schools respond to approaching ships by swimming away from the projected track of the ship in most cases. The avoidance began at 6 or more miles away from the ship (Au & Perryman 1982, Hewitt 1985).

The way whales react to human activity have been reported to change over time. Minke whales, which originally had positive reactions to approaching ships are reported to show little or no effects at all any longer in an area of much traffic (Watkins 1986). Finback whales have changed from a negative to no response, while Humpback whales have changed from often negative to often strong positive reactions to ships in the same area.

Midsummer 1978 Glacier Bay, Alaska, was abruptly abandoned by Humpback whales. This was thought to be the effect of increased vessel traffic. After regulating the traffic the whales reoccupied the area again. This might be a direct result of the regulation, but studies of the whale distribution and prey abundance in these years show high correlation (Johnson 1983).

Decreased Harp seal vocalization in an area of high noise levels has been reported by Terhune et al. (1979). This decreased vocalization may reflect a change in the seals behaviour and/or movement of some seals away from the vessel.

Icebreakers produce much noise. This noise is dominated by the cavitation noise produced by the propellers. The noise from the machinery and by the impact of the ship with the ice cover contributes little to the total noise at some distance from the ship (Thiele 1988). The source strength is highest at the lowest frequencies, up to 180 dB at frequencies below 100 Hz during full astern. The highest levels at full speed ahead is 5 - 10 dB lower. These noises could be detected up to a distance of 55 km in open water and up to 33 km in fast ice (Thiele et al. 1990).

Cosens & Dueck (1988) reported that icebreakers produce reactions in both narwhals and Belugas. Both species had less time inactive, but their reactions differed in concern to directed movements. Narwhals had an increase in slow directed movements while Belugas had a decline in directed movements. Belugas also had an increase in non-directed movements while narwhals showed no such changed behaviour. Both species choose less ice-covered places during disturbances, 0 - 20 % ice-cover in controversy to

earlier, 80 - 100 % narwhal and 40 - 60 % Belugas. Both species avoid the ship at distances up to 50 km. This is consistent with the observations done by Barber & Hochheim (1986), but they found Belugas were less variable in their orientation away from the ship.

The effects of ships in the Beaufort Sea on Belugas has shown that the animals are habituated to industrial activity. The responses shown are of short duration and there have been no longer-term changes in the use of the Mackenzie estuary. The effects on whales in undisturbed areas is substantially different (Finley et al. 1983). Belugas started to react to a fast approaching icebreaker (27 km/t) going in open water at a distance of 35 - 40 km, and at the time of the arrival all the Belugas and narwhals were gone. They returned first 30 to 40 hours after the ship had arrived. The noise levels of the ship was 171 dB re 1 μ Pa at 1 m when the ship was moving forward. The most prominent tones were at 53 Hz and 205 Hz.

The Bowhead whale migrates in areas with much ice. It is capable of determining the ice conditions by sound alone (Ellison et al. 1987). High levels of noise could affect this ability, and result in problems with finding suitable breathing holes and migration routes.

Seismic survey is mostly done with airguns, not with explosives as previously. The intense pulses emitted (179 dB re 1 μ Pa were recorded at range 1.9 km (Green & Richardson 1988)) have a longer period of reaching peak and the peak value is lower than the corresponding value from a TNT explosion. This reduces the direct lethal effect on marine animals (Yelverton & Richmond 1981).

The sound emitted from airguns has frequencies between 50 and 200, which is in the audible area to both marine mammals and fishes. At a distance of 5 m there has not been reported any death or damage to any stadium of fish from airguns (Knudsen & Enger 1990). Only the highest peak values resulting from simultaneous firing of several airguns can result in some damage to eggs, larvae, or mature individuals of northern anchovy *Engraulis mordax* (Kostyuchenko 1971).

Seismic surveys may not kill much fish, but it may frighten them. Green (1985) reported that airgun shooting resulted in reduced amounts of fish captured in an area. It was a pilot study, and no sure conclusions were made.

Effect of seismic surveys on fish will influence the distribution of the marine mammals feeding on them.

Seismic exploration activity has been shown to result in displacement of Ringed seals from their normal habitat. Densities in control areas were found to be two to four times greater than in seismic areas (J. Scott Crundy, ADFG, pers. com. to Wright 1982).

The behaviour of Bowheads remained normal as a response to single airgun firing at 3 - 5 km distance (received levels 118 - 133 dB re $1\mu\text{Pa}$). They oriented away during tests at ranges of 2 - 4.5 km and 0.2 - 1.2 km (received levels 124 - 134 dB re $1\mu\text{Pa}$). During the experiments at the shortest distance the speed might have been an increase in speed of the whales (Richardson et al. 1986). Bowhead whales swimming away from airgun sounds, may swim into the surf zone or position themselves in the sound shadow of a rock or island. At distances of 6 km the general activity was not altered by noise from seismic vessels at full operation. There were some indications of subtle alterations in surfacing-respiration-dive cycles, and in turns and pre-dive flexes (Reeves et al. 1984, Richardson et al. 1985, 1986). Ljungblad et al. (1988) reports higher noise levels, 104 - 160 dB up to a distance of 10 km, and changed behaviour up to the same distance.

Gray whales stopped feeding and moved away from seismic activity in 50 % of the experiments when the average pulse level reached 173 dB re $1\mu\text{Pa}$. Most whales returned after the seismic vessel had moved on (Malme et al. 1988). They concluded however that the responses of feeding gray whales are too varying to make firm conclusions regarding responses to airguns. Further experiments are needed.

Artificial islands are permanent noise sources. The density of Ringed seals were 20 - 80 % lower within 2 nm of three artificial islands in the Beaufort Sea than it was 2 - 4 nm away. In the years after full activity at these islands, the density increased again (Frost et al. 1988).

Drilling and dredging seems to produce minor effects. Drillships produce noise measured in 20 - 1000 Hz to 125 - 137 dB depending on how deep the sea is (Green 1987). Dredging resulted in noise of 133 to 142 dB in the same bandwidth. Defect equipment like damaged propellers will result in higher noise levels.

Migratory Gray whales exposed to drillship noises of 110, 117 and 122 dB re $1\mu\text{Pa}$ in the 50 to 315 Hz band produced no clear evidence of disturbance or avoidance behaviour for noises below 110 dB, but at levels above 120 dB the noise affected feeding Gray whales at distances

below 300 m. (Malme et al. 1983, 1984 cited in Cowles & Imm 1988).

Beluga Whales continued to move in the same direction when play-backs of drilling noise began. Beluga whales within 2 km of the sound source appeared to feed during play-back experiments. Whales also approached and quickly passed closely by the underwater speaker while sounds were being projected (Stewart et al. 1983 cited in Cowles & Imm 1988).

Play-back of drillnoises below 110 dB produced no clear evidence of disturbance or avoidance behaviour in grey whales. Possible avoidance occurred for exposure levels around 119 dB (Malme et al. 1988). Richardson et al. (1985) found differences in the reactions of Bowheads to ongoing drilling and brief play-back experiments. They tended to react more to the play-backs. It did seem to be consistent with their observations of reactions to all rapidly changing situations like approaching boats or aircrafts, while they did not react much to circling aircrafts or fishing boats in the area.

Malme et al. (1988) reports that feeding Humpback whales showed no consistent responses to drillship play-backs at ranges to the source of >0.5 km with received sound levels of >116 dB.

Richardson et al. (1986) found no evidence of avoidance of non-migrating Bowhead whales to air-gun seismic blows at distances of 3 to 5 km with RSL 118 - 133 dB.

In the deeper off-shore waters of the Canadian Beaufort Sea the use of drillships has been going on since 1976, and in a report from Dome Petroleum Limited (Ward & Pessah 1988) they conclude that there are no trends to decreasing use of the exploration area by Bowheads in the years 1976 - 1985.

Small boats with outboard engines have been shown to attract Gray whales in areas where whales are repeatedly exposed to small vessel activity (Dahlheim et al. 1981).

Effects of airborne noise

Ships and small boats produce in addition to the underwater noise also airborne noise. A study on Harbour seal haul-out patterns at Bolinas Lagoon, California, found that all human activities closer than 100 m caused seals to leave haul out sites (Allen et al. 1984). There was almost no difference between power-boats and nonpower boats, the critical clue was the

distance. In this area non power boats were the greatest source of disturbance, because they are more mobile than people in power boats and on foot. Usually the disturbing element left the area at once, and the seals returned to their sites.

In some cases the source of disturbance was commercial bait hunters who stayed there for a prolonged time, and under these conditions the seals stayed away as long as the harvesters stayed in the area. This indicates how the seals can be affected by prolonged disturbance. Paulblitsky (1975) documented a change to nocturnal haul-out pattern among seals at Strawberry Spit, Timburon, as a reaction to an increased human population in the area.

Excessive disturbance may also lead to increased pup mortality. Kenyon (1972) reports that 7 of 18 Hawaiian Monk seals *Monachus schauinslandi* died before weaning on heavily disturbed pupping grounds on Midway Atoll, Hawaii. This is higher than reported pup mortality on less disturbed pupping grounds of Harbour seals in British Columbia (Bigg 1969). Allen et al. (1984) found 3 dead of a total of 12 pups, and at least one of them was killed by a dog.

On further disturbance the site might be abandoned. Increased recreational boating were at least a part of the reason that Harbour seal abandoned a site in Puget Sound (Newby 1971 cited in Allen et al. 1984). If other sites nearby are filled to capacity the abandoning of one site might result in an overall population loss (Kenyon 1972).

Amphibian vessels and Hovercrafts are supposed to have the same effects on marine mammals as the airborne noise from power-boats and small ships.

Humans on foot and ski make the Ringed seal abandon their breathing holes and lairs. This is done up to a distance as far as 600 m from a walking man, and up to a distance of 400 m from a skier. Several times the seals did not react before the distances were less than half maximum distances (Kelly et al. 1988).

Snow-scooters are reported to force Ringed seals to abandon their breathing holes and lairs at 0.5 to 2.8 km distance (Kelly et al. 1988).

Fixed wing aircraft sometimes cause reactions from Bowhead whales if it is at levels below 305 m a.s.l. and it is an initial approach. At 457 m reactions were uncommon, and generally undetectable at 610 m (Richardson et al. 1985). Responses to continued circling were less obvious,

even at 305 m, and Bowheads could be considered 'presumably undisturbed' by the circling fixed wing aircraft. The reactions are most surely a result of visual frightening. The noise signature from an aircraft in level flight over the sea is low and of very short duration (Urick 1972).

At an altitude less than 300 m and at a distance less than 1 km a Twin Otter aircraft gave the result that one of a total of 34 Walruses entered the water after disturbance at a terrestrial haul-out site. During several other disturbances at the same distance and several at longer distance from the haul-out site, the only reaction was raising of their heads (Salter 1979).

Helicopters have resulted in a variety of different reactions. Ringed seals sometimes left their lair when a helicopter was so far away as 5 km and at an altitude of 152 m and sometimes they did not leave at distances of 600 m at an altitude of 122 m (Kelly et al. 1988). Walruses reacted little to a Bell 206 helicopter during terrestrial haul-out. Only once about half the Walruses reacted and withdrew into the sea. This was when the helicopter was flying at an altitude less than 150 m and at a distance of 1.1 - 2.5 km. At other occasions when the helicopter was even nearer the reactions were less (Salter 1979).

Seismic activity and its influence on abandoning breathing holes and lairs have been investigated by Kelly et al. (1988). Results from their aerial surveys along seismic lines and control lines gave no clear answer to whether Ringed seals abandon breathing holes and lairs after seismic activity. In 1981 only one of three surveys resulted in significantly greater abandoning of the seismic line. In 1982 none of the surveys showed higher abandoning along the seismic line, but at one of eight surveys the result was the other way around.

Industrial installations were studied by Sorensen et al. (1984), and they found that the chances of sighting a cetacean in the vicinity of active oil rigs were not significantly different from those found in the same areas when no oil rigs were present.

A survey for Ringed seals around artificial islands in the central Beaufort Sea showed a lower density 0 - 2 nm (nautical miles) away from an active artificial island than 2 - 4 nm away. However the industrialized area where these islands were placed had a higher density than the adjacent areas (Frost & Lowry 1988).

Gentry et al. (1990) reported that Northern Fur seals did not avoid prolonged airborne

constructions sounds from quarrying operations of about 85 dB re 20 $\mu\text{N/m}^2$. They did not seem to react to the ground borne vibrations from heavy equipment working within 100 m or to blastings (sound level 75 dB re 20 $\mu\text{N/m}^2$ measured at a distance of 52 m) either, but would flee at the sight of people. Their conclusion was that the short time effects were negligible, and that the new shores produced by humans would become new habitats.

On some of the atolls of the Leeward Hawaiian Islands the Hawaiian Monk seal declined in numbers from 68 animals to 4 - 6 animals during the decade between 1958 and 1968 at the same time as these atolls were occupied by humans (Kenyon 1972). Daily disturbances by man and dogs resulted in abandoning of the seals' hauling grounds.

Tourists approaching female Harp seals and their pups during the whelping season affected the behaviour of mothers and pups significantly. Mothers left their pups or spent more time alert and less time nursing their pups. The pups were also more alert and engaged in agonistic behaviour. When tourists approached to within 3 m or touched pups, the young seals exhibited a freeze response. 1 hour after the tourists departed, the females had returned to their pups and the behaviour characteristics of undisturbed situations usually had resumed (Kovacs & Innes 1990).

EFFECTS OF THE PLANNED ACTIVITY IN GIPSDALEN TO THE MARINE MAMMALS OF THE ISFJORDEN AREA

Marine mammals of the area

There are many marine mammals in the Svalbard region, and most of them are also found in the Isfjorden area. In the "Assessment system for the environment and industrial activities in Svalbard" (Hansson et al. 1990) only two species of marine mammals are selected as "Valued Ecosystem Components" (VEC's). It is the Walrus and the ringed seal. The Ringed seal are numerous and places with stable ice conditions and a thick snow cover, are used for breeding grounds. The Walrus is regularly in Isfjorden, but in small numbers. There are no breeding grounds or important haul-out sited in the area.

Species not selected as VEC's found in the area are Bearded seal, Harbour seal, Harp seal, Hooded seal, Killer whale, Humpback whale, Minke whale, White whale, and sometimes some different dolphins and porpoises. The Bearded

seal and the White whale are found regularly in the area, the Harbour seal and Minke whale are seen regularly in the outermost part of the fjord, while the other species are seldom seen.

Ringed seals are found in the area all year, and during spring they establish territories where they dig lairs in snow covering a hole in the ice (see Lydersen & Ryg 1990). Places with enough snow on the ice are found in the innermost parts of the fjords where the ice is stable for long periods. Deep snow is usually found besides ice pieces calved from the glaciers, and along pressure ridges. Tempelfjorden is an area where the breeding conditions usually are good. The Von Post glacier in the bottom of the fjord supplies it with icebergs, and the fjord usually freezes up early. This area was found to be a good breeding area for Ringed seal during the ringed seal survey spring 1990. The Gipsvika area and the outer part of Sassenfjorden had poor conditions for ringed seal lairs, and no breeding lairs were found in this area spring 1990. The number of breeding holes were also small.

Types of impact planned

The transport during both the construction and the production phases, are planned to be carried out by means of a large ice-going vessel. This ship is supposed to carry equipment, stores, etc. to Gipsvika, and take out the coal produced. The area affected by the ship traffic will be Gipsvika, the outer parts of Sassenfjorden and Isfjorden. The ship is supposed to return to Gipsvika every third week.

The accommodation, power station, stores and workshops will be placed on barges in Gipsvika. There is no information about the noise produced by these installations. Especially the power station, and perhaps the watermakers producing 100 - 110 tons of water per hour might produce some noise. The frequency range of this noise is not known.

Hovercrafts will be used for transportation of crew between Gipsvika and Longyearbyen, and equipment between Gipsvika and the mine entrance. The Hovercraft produce little underwater noise, but the airborne noise is about 73 dB at a distance of 150 meters.

Amphibious, beltdriven crafts ("Arktos") may be used for transport from the ship to the shore, and crew between Gipsvika and the mine entrance before the harbour and the road are constructed.

Many people placed in the area will produce different kinds of disturbances to the surrounding

area. Snow scooters and small power-boats must be expected to be used for recreational purposes.

Discussion

In Gipsvika the barges, the ship traffic, the Hovercraft and the amphibious, belt driven craft, will contribute to both the airborne and the underwater noise.

The airborne noise will mainly affect the seals hauled-out on the ice. The affected species will be the Ringed seal and to some extent the Bearded seal. The Bearded seal is however found only in minor numbers in the area. The Ringed seals found in the area will most likely not be totally scared away from the area. Around artificial island in the Beafort Sea the number of ringed seal were lower in a belt of 0 - 2 nm around the installations than 2 - 4 nm away, but the numbers remained higher than in adjacent undisturbed areas (Frost & Lowry 1988).

The level of underwater noise from the different installations is not known. The ship however, will go on the UK and central Europe, and return once every third week. This ship traffic will presumably result in little effect on the marine mammals of the area.

The lack of breeding lairs in the area around Gipsvika, is due to few ice pieces frozen in the ice which could have resulted in enough snow on the ice. An icebreaker could possibly change this condition. In tracks after an icebreaker there were found higher levels of birth lairs, than in compared areas (Alliston 1980 cited in Mansfield 1983). There have been no studies on how repeated use of the same track will affect Ringed seals. An icebreaker hitting a birth lair will kill pups up to the age of about six weeks. Older pups and adults have no problems getting away.

It can be concluded that marine mammals in the area concerned, will be little affected by the proposed activity if care is taken to keep the noise down, and restrict the outdoor activity in the spring during the pupping in the inner parts of Sassenfjorden and Tempelfjorden.

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