

FRIDTJOF MEHLUM

EIDER STUDIES IN SVALBARD



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FRIDTJOF MEHLUM

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Cover photo: Common Eider *Somateria mollissima* (male), Kongsfjorden, Svalbard

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Introduction

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The Common Eider *Somateria mollissima* is the most numerous waterfowl species breeding in Svalbard. Nesting mainly on small islands and islets along the coasts, this species is distributed over most of the archipelago. The main part of the total population is found along the western coasts of Spitsbergen.

From literature about Svalbard we know that Eider eggs and down have been harvested by local trappers and hunting expeditions in the past. Many authors have described the plundering of Common Eider colonies during the second part of the last century and the beginning of this century. Records of the amounts of down imported to Norwegian ports during this period indicate the extent of exploitation of Svalbard Eiders (Norderhaug 1982a).

Very little exact historical information is available concerning the population sizes of Eiders in Svalbard. Most records in the literature available do not comprise exact counts of colony sizes. On the basis of the information on down quantities collected, we may conclude that one hundred years ago the total population was probably larger than it is today – just how large is a matter of discussion. Norderhaug (1982a, b) stated that the population in the 1970's was only 10–20% of its original size (100–150 years earlier) due to previous overexploitation.

In order to protect the Common Eider in Svalbard, hunting and the collecting of eggs and down were prohibited in 1963. Later, in 1973, 15 bird sanctuaries were established to protect the most important breeding islands of eiders and geese. During the 1980's the local hunters' association in Svalbard and professional trappers put pressure on the authorities to re-open for eider hunting and down harvesting.

Although the dense breeding colonies of the Common Eider in Svalbard are very suitable for scientific studies, the first major contribution to the knowledge of Svalbard Eiders was not published until 1970 (Ahlén & Andersson 1970). Ahlén & Andersson studied the breeding colonies

in the Kongsfjorden area. The other important previous study of breeding Svalbard Eiders was made by Hagelund & Norderhaug (1975a, b) at Kapp Linné at the mouth of Isfjorden.

The Norwegian Polar Research Institute conducted a programme to study the Svalbard Eider in the 1980's. The main aim of this programme was to obtain information about the development of the Common Eider population after the 1973 conservation measures were put into effect, and to study the Eider's different adaptations for living in the high Arctic. *Norsk Polarinstitut Skrifter 195* presents some of the results of this programme together with additional data collected by the Governor of Svalbard's conservation officer and others.

Paper 1 presents the results of breeding and post-breeding surveys of Eiders over the entire Svalbard archipelago. The total breeding population is estimated at from 13,500 to 27,500 pairs, and the post-breeding population at from 80,000 to 140,000 individuals, including the young of the year. When data from our surveys is compared with the data collected during the 1960's before the sanctuaries were implemented, there is no evidence of any significant increase in the number of breeding pairs in the colonies. Paper 1 gives possible explanations for this lack of increase in the Common Eider population after the implementation of conservation measures. Also discussed is Norderhaug's (1982a, b) estimate of population decline of 80–90% during the first half of this century due to previous exploitation. We believe that Norderhaug overestimated the original population size by misinterpreting the available information on raw down quantities imported from Svalbard to Norway.

Paper 2 gives details from a long-term survey of breeding Eiders in the Kongsfjorden area. This paper illustrates the large year to year fluctuations in the number of breeding pairs and egg clutch sizes at each colony. It also clearly documents the influence of snow and sea-ice conditions on breeding phenology, clutch sizes,

and the total number of pairs breeding. Our study shows that the nesting islands are colonized as soon as the old nest scrapes are free of snow and the islets are free of surrounding sea-ice. In late years, egg clutch sizes are smaller, and the total number of breeders is reduced. In different years birds may move from one islet to another according to the snow and sea-ice conditions. Based on these results we conclude that a single-year survey of a breeding colony is insufficient to assess the status of the local population size. Multi-year surveys are needed in order to account for the significant year to year variation caused by environmental conditions.

In Paper 2 we also indicate that Eiders tend to disperse to the largest nesting island in the area with the most favourable environmental conditions. In late years, Eiders seem to concentrate at smaller islets, which become ice-free relatively early in the season. On the larger islands, Eider nests are more dispersed than in the concentrated colonies on smaller islets. Paper 3 deals with the testing of the prediction that Eiders, if provided with more space, would disperse maximally and thereby minimize nest density. We compiled data on Eiders which occupied two islands in Kongsfjorden. Although the results in general supported the prediction, the dispersal response was slower and less than predicted, probably as a result of some degree of site-tenacity.

Eider breeding colonies in Svalbard suffer from predation by different bird and mammal species. The Arctic Fox *Alopex lagopus* may take virtually all the eggs in a nesting colony. In order to avoid fox predation, the Eiders locate their nesting colonies on islets and islands inaccessible to the foxes. However, foxes sometimes manage to reach such colonies and plunder all the nests. On the main islands of Svalbard, Eiders usually nest dispersed in single pairs or in colonies protected by the Arctic Tern *Sterna paradisaea*, or human settlements. The Polar Bear *Ursus maritimus* also occasionally visits Eider colonies and takes the eggs. This probably occurs more frequently in the eastern parts of Svalbard, but it is unknown to what extent plundering by the Polar Bear actually contributes to limiting the reproductive output. In a recent paper Madsen et al. (1989) showed that the Polar Bear was the main predator on Brent Goose *Branta bernicla* eggs at Tusenøyane in Southeastern Svalbard.

In Eider colonies surrounded by open water

avian predators may take a heavy toll of the egg production. In Svalbard the Glaucous Gull *Larus hyperboreus* is the main avian predator. Paper 4 presents a study of egg predation in a densely populated Eider colony. During two years of the three-year study period, an estimated 77.9% of the eggs laid were lost both seasons. In the third season, when the total number of eggs laid was largest, the estimated total egg loss was lower (41.5%). The largest egg loss occurred between the laying of the first egg and the start of incubation. This is because the female covers the egg and leaves the nest unguarded from predation until she returns to lay more eggs and start incubating. More eggs were lost in the parts of the study plot with the lowest nest density, where gulls could plunder nests temporarily left by the female, without being attacked by neighbouring Eider nesters.

The losses of eggs is relatively low for Eiders breeding at temperate latitudes, while the mortality of ducklings after they leave the nest is demonstrated to be high. The available information on Svalbard Eiders suggests that the mortality of eggs and newly hatched ducklings before leaving the colony is much more important than the mortality of ducklings on the water. The higher mortality of eggs and newly hatched ducklings in the breeding colonies in Arctic areas might be a result of the stronger tendency of Eiders in these areas to colonize thus attracting more predators to the nests.

The Common Eider population of Svalbard might potentially once again be exploited for its high quality down. The major part of the population breeds within bird sanctuaries, and it is doubtful if down harvesting during the birds' incubation period will be compatible with the regulations for the sanctuaries. However, there are a few breeding colonies outside the sanctuaries that might be allowed to be exploited. Eholmen in the Bellsund area, which in 1988 was inhabited by about 1,600 nesting Eiders, is such a locality. Here one trapper, with permission from the Governor of Svalbard, has started a preliminary down harvesting programme. In order to study the potential negative effects of harvesting activity on the nesting success of the Eiders, we undertook a study where the nesting success of harvested nests were compared with the success of unharvested control nests. Paper 5 reports the results of this study. We were unable to detect any differences in nesting success between

the harvested and the control nests. However, the methodology of this study did not allow us to account for a possible generally lowered nesting success due to the presence of the observer who checked the nests.

The female Eider incubates nearly constantly during 24–25 days without eating, resulting in a weight loss of 30–45%. As reported in Paper 4, females only leave the nest on the average of a few minutes every other day. The aspects of the physiology of incubation in Eiders are reported in Paper 6. We were able to measure the oxygen consumption of female Eiders incubating in the wild. The cost of incubation in the Eider was low, and the incubation metabolic rate measured was close to the resting metabolic rate. The Eider nest has extremely good insulation, which minimizes the amount of heat the female must expend to keep the eggs warm. This, together with the high incubation constancy of the female, reduces heat loss from the eggs to the cold surroundings. The incubating female goes through a long starvation period, and in the days just prior to hatching it is so constrained by starvation that it might easily break the incubation to save its own life. Disturbances or increased activities which lead to higher energy expenditure during this period can be fatal to the egg clutch.

The other eider species breeding in Svalbard, the King Eider *Somateria spectabilis*, has not yet

been subjected to intensive study. In Paper 7 the present knowledge of the population size and the breeding and post-breeding distribution is summarized. Apparently, this species has a much more restricted geographical distribution in Svalbard than the Common Eider, and it is confined to specific parts of the western coast of Spitsbergen. The King Eider of Svalbard tends to congregate in a few large and dense post-breeding flocks in shallow waters, thereby becoming very vulnerable to oil pollution.

The papers in this publication will hopefully be valuable for the future management of eiders in Svalbard.

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Population size and summer distribution of the Common Eider *Somateria mollissima* in Svalbard, 1981–1985

PÅL PRESTRUD and FRIDTJOF MEHLUM



Prestrud, P. & Mehlum, F. 1991: Population size and summer distribution of the Common Eider *Somateria mollissima* in Svalbard 1981–1985. *Norsk Polarinstitutt Skrifter* 195, 9–20.

The most important breeding localities of the Common Eider in Svalbard are mapped on the basis of surveys made during the five summer seasons 1981–1985. The breeding populations along the western and eastern coasts are estimated to be 12,000–17,000 and 1,500–3,500 pairs respectively. The most important moulting areas are found along the western coast of Spitsbergen, particularly along the western coast of Prins Karls Forland and Nordenskiöldkysten. There have been no significant increases in the breeding population since the establishment of the bird sanctuaries in 1973. The total late summer population is estimated to be 80,000–140,000 individuals. The population at the turn of the century was probably more, but not as much as 10 times larger as stated in earlier publications.

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Introduction

In the Svalbard archipelago three species of ducks breed regularly, the Long-tailed Duck *Clangula hyemalis*, the King Eider *Somateria spectabilis* and the Common Eider *S. mollissima*. The Common Eider is by far the most abundant species, and the literature about Svalbard tells of heavy exploitation of the Common Eider in the past due to the commercial value of its eggs and down (Løvenskiöld 1964; Norderhaug 1982a). Norderhaug (1982a) states that the average yearly delivery of eider down from Svalbard to Northern Norway in the years 1871–1914 was 1,100 kg, and in 1914 as much as 2,451 kg. The figure from 1914 could represent down collected from nearly 100,000 nests (Norderhaug 1982a).

Because this exploitation threatened to decrease the Common Eider population in Svalbard, conservation measures were put into effect to protect and manage the existing population. In 1963, 15 bird sanctuaries were established to secure the most important breeding areas for eiders and geese (Fig. 1). The selection of these localities was based mainly on the inventories made by Norderhaug (1971).

This paper documents an extensive survey study of the present-day Common Eider population in Svalbard. The surveys were performed by the Governor's Office of Svalbard and the

Norwegian Polar Research Institute during the five summer seasons 1981–1985. The aims of the surveys were

1. To monitor the population trends in the bird sanctuaries and to evaluate the effect of the conservation measures.
2. To locate the most important breeding localities.
3. To locate important summer moulting and feeding areas for adult and juvenile Eiders after the breeding period.
4. To estimate the total late summer Eider population in Svalbard.

Methods

During the summers 1982–1985 all the small islands and about 95% of all the islets along the western and northern coasts between Sørkapp and Gråhuken were visited. The islets were identified on drafts or topographical maps with a scale of 1:100 000. The censuses of breeding Eiders on the visited islands and islets were carried out during, or just after, the breeding season. To avoid disturbing the breeding birds and subsequent egg and duckling losses caused by predation by the Glaucous Gull *Larus hyperboreus*, the following methods were used to estimate breeding pairs:

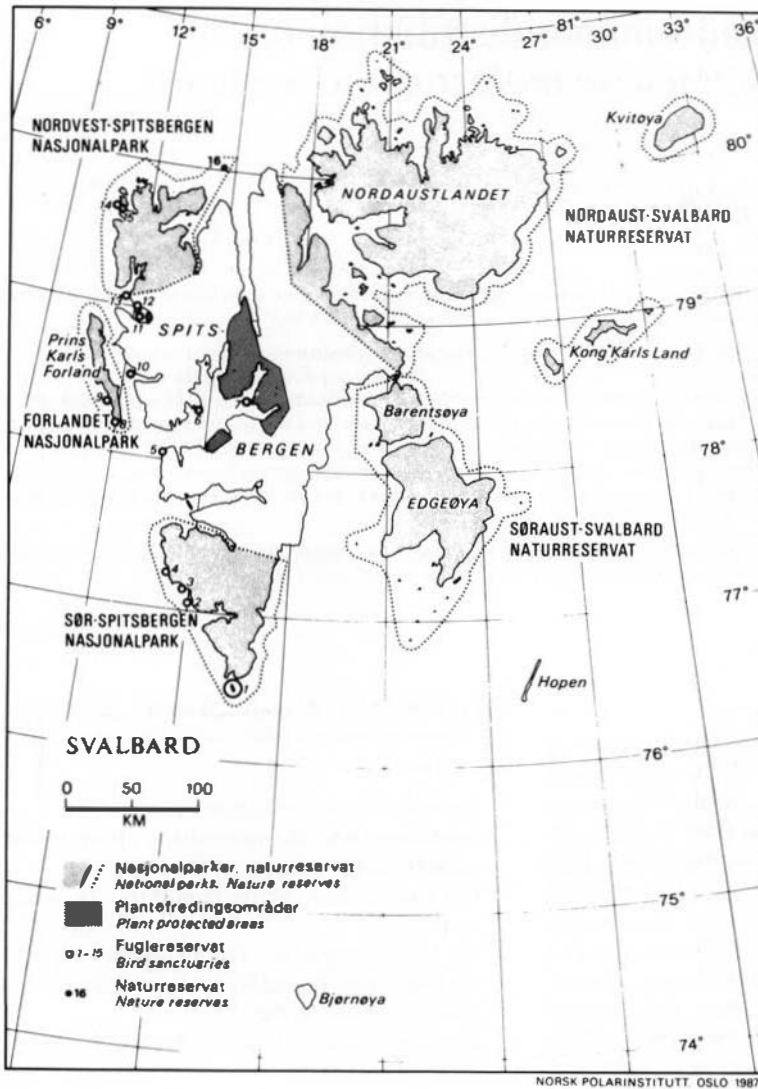


Fig. 1. Map of Svalbard with national parks, nature reserves, plant reserves, and 15 bird sanctuaries.

1. Sørkapp,
2. Dunøyane.
3. Isøyane,
4. Olsholmen.
5. Kapp Linné,
6. Gåsøyane,
7. Bohmanneset,
8. Plankeholmen,
9. Forlandsøyane.
10. Hermansnøya,
11. Kongsfjorden,
12. Blomstandhavna,
13. Kapp Guissecz,
14. Skorpa.
15. Moseøya.

(Source: Norsk Polarinstitutt.)

1. Females on nests were counted from selected points in the breeding colony or from small boats close to the breeding colony.
2. Males on, or around, the breeding colony were counted.
3. Nests with down were counted in some of the colonies just after the end of the breeding season.

During the summers 1981–1984 an intensive survey of the Eider colonies in Kongsfjorden was made by walking through the colonies and counting all the nests.

Some of the possible breeding colonies on

the eastern coasts of Svalbard were also visited during or just after the breeding season in the period 1982–1984, in particular several of the islets and islands in Hinlopen (July 1983), the islets in Murchisonfjorden (August 1983), the islets on the northeast coast of Nordaustlandet, Tusenøyane and the islets in Freemansundet. The estimates from the eastern areas are consequently based on these surveys and counts of females with ducklings seen from helicopters.

Surveys of moulting flocks and females with ducklings along the coasts of Svalbard were performed irregularly by the use of helicopter during routine inspection trips by the Governor's

office in 1982–1984. In 1984 male Eiders were systematically counted by helicopter along the west coast of Spitsbergen between Sørkapp and Verlegenuken in the period 30 June–5 July. Eiders were also counted in August–September 1984 along the eastern coasts of the archipelago in connection with an aerial survey of Polar Bears performed by the Governor's Office. This survey was performed systematically at Barentsøya, Edgeøya (apart from the southernmost part), the northern and western coast of Nordaustlandet and most of Kong Karls Land. The number of females with ducklings was also estimated in this survey. Fig. 2 shows where the aerial surveys were carried out in 1984. All the aerial surveys were carried out from a Bell 206 or Bell 212 helicopter from altitudes about 100 feet and at a speed of about 60–80 knots. One or two trained observers carried out the surveys.

Results

Breeding colonies

Along the western and northern coasts Eiders were breeding on nearly all the surveyed islets/islands (Table 1, Fig. 3) between Sørkapp and Gråhøken. The breeding population was estimated at 12,000–17,000 pairs. Only two colonies (Kapp Linné and Ny Ålesund) were located on the mainland where they are accessible to the Arctic Fox (*Alopex lagopus*).

We have few records from the breeding season in the eastern part of Svalbard due to difficult accessibility because of sea-ice. According to Løvenskiold (1964) and Jepsen (1984), Eider colonies in the eastern areas of Svalbard are generally small. Based on our survey numbers of females with ducklings and counts of nests with down, it may be stated that Eiders dispersely breed along the entire eastern coast of Svalbard. Breeding colonies are found on the islets in Hinlopen (estimated 200–500 pairs), the islets in Murchinsonfjorden (estimated 50–100 pairs), islets in the northeastern part of Nordaustlandet including Storøya and Kvitøya (estimated 300–600 pairs), Tusenøyane (estimated 300–500 pairs), islets at Martinodden, Edgeøya west (estimated 50–150 pairs), islets in Freemansundet (estimated 100–500 pairs) and Heleysundet (estimated 100–300 pairs). The breeding population in the eastern part of Svalbard can roughly be estimated to be 1,500–3,500 pairs.

Comparison of colony sizes with older data

For some selected colonies it is possible to compare our results with older surveys.

Sørkapp.—Løvenskiold (1954) states the number of breeding pairs at Tokrossøya in 1950 to be 200, but that there is no evidence of breeding on Stjernøya and Sørkappøya, although many old nest scrapes had been found on these two locations. Our data show a similar number of pairs on Tokrossøya (150–250) but also 200–400 pairs at Sørkappøya with the surrounding islets, and 50–100 pairs in Stjernøya.

Emoholmen.—Norderhaug (1971) reported 40–50 breeding pairs, compared to our 80–110 pairs in 1982.

Dunøyane.—In Table 2 the number of breeding pairs on each of the islands in the group is separated and compared with data from Norderhaug (1971).

Isøyane.—Norderhaug (1971, 1977) reported 150–200 pairs breeding in the area in 1965 and 60–80 pairs in 1977, while we recorded 120–200 and 150–200 pairs in 1982 and 1984 respectively.

Steinvika.—Norderhaug (1971) reported 60–70 pairs, while we recorded 40–70 pairs in 1982.

Olsholmen.—Our 1982 counts (60–80) are similar to the approximate figure of 80 pairs reported by Norderhaug (1971).

Mariaholmen.—Løvenskiold (1954) reported a breeding population of 15 pairs on this island in 1948. In 1982 we counted 60–100 pairs. In 1983 nests were ravaged by Arctic Foxes and only 10–15 nests with incubating females were registered.

Kapp Linné.—At this locality data on the number of breeding pairs are available from seasons in the period 1957–1982 (Table 3).

Gåsøyane.—Our data comprise 500–600 pairs in 1982 and 600–800 pairs in 1983, while Norderhaug (1971) reported 600 pairs in 1970.

Bohemanneset.—At this locality our number from 1983 (120–150 pairs) was lower than that reported by Norderhaug (1971), 200–300 pairs.

Plankeholmane.—Norderhaug (1971) reported 170 pairs in 1968, while our data from 1982 comprise 250–300 pairs.

Forlandsøyane.—Kolthoff (cited in Løvenskiold 1964) estimated the breeding population in 1900

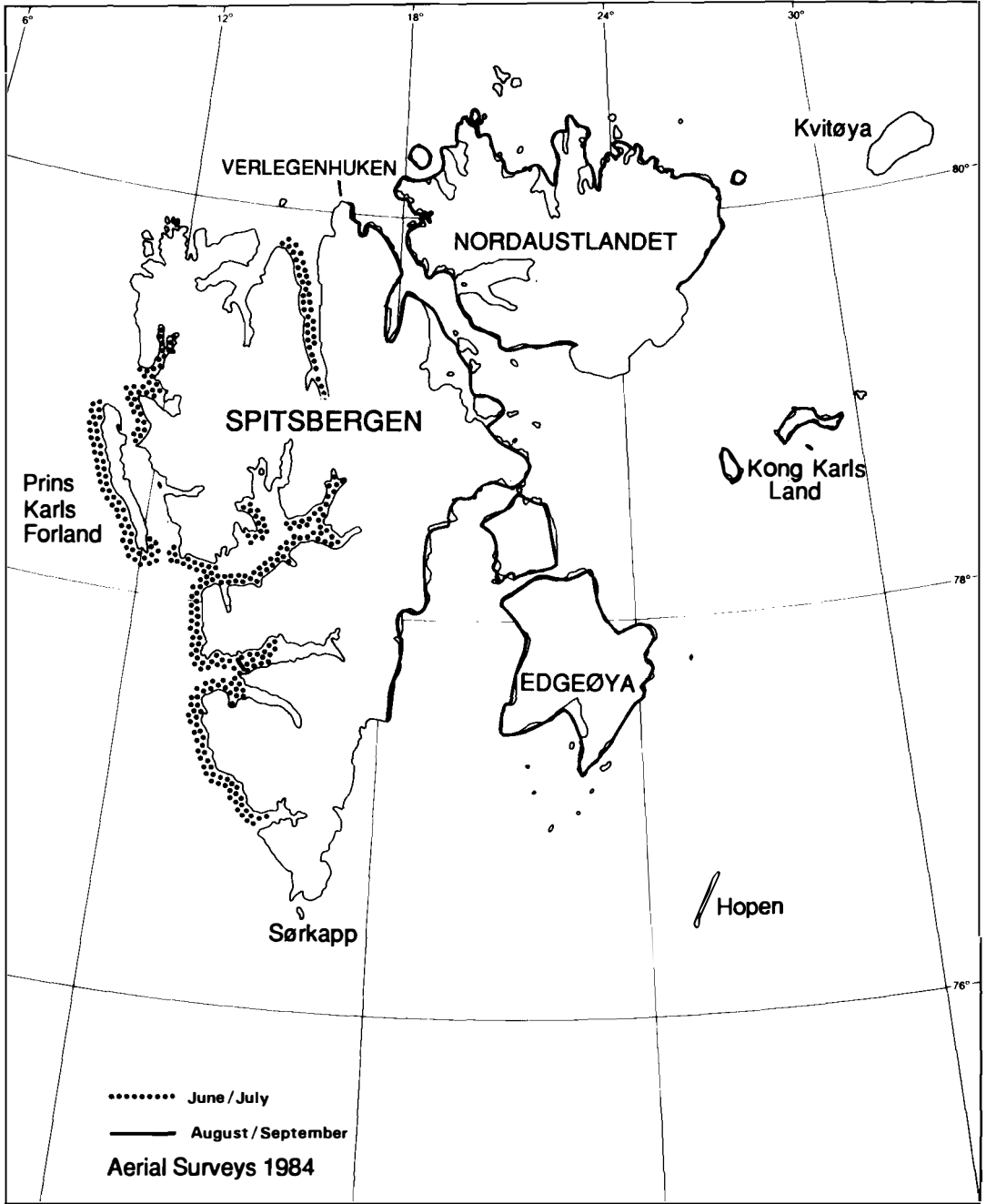


Fig. 2. Areas surveyed by helicopter in the period June–Sept 1984. The survey in June/July counted male Eiders. The survey in August/September counted male Eiders and female Eiders with ducklings.

Table 1. Eider breeding localities along the western and northern coasts of Spitsbergen. Loc. numbers refer to Fig. 3.

Loc.	Name	No. of pairs	year
1	Sørkappøya with islets ¹	200-400*	-82, -84
2	Stjernøya ¹	50-100	-82, -84
3	Tokrossøya ¹	150-250	-82, -84
4	Rafenodden and Raksodden	50-100??	
5	Småholmane v/Suffolk-pynten	50-100??	-83
6	Islets Palffyodden-Gåshamna, Hornsund	50-150	-83
7	Emoholmane	80-110	-82
8	Islets Isbjørnhamna-Hyttevika, Hornsund	50-100*	-82, -83
9	Islets in Steinvika	40-70	-82
10	Dunøyskjæra ¹	50-100	-82
11	Dunøyane ¹	400-600	-82, -83, -84
12	Kvartsittskjæra	10-20	-82
13	Pytholmen	none	-82
14	Isøyskjæra	30-50	-82
15	Isøyane ¹	150-250	-82, -84
16	Flatholmen	10-20	-82, -84
17	Skarvholmen	20-40	-83
18	Olsholmen ¹	60-80	-82
19	Gråholmane and islets of Hannevigodden	80-130	-82
20	Oddholmane	10-20	-82
21	Islets in Dunderbukta	10-20*	-83
22	Straumholmane	30-50	-83
23	Stjernerøya	5-10	-82, -83
24	Eholmen	600-800	-82, -83, -84
25	Mariaholmen	60-100	-82, -83
26	Akseløya	50-100	-82
27	Reiniusøyane	100-200*	-83
28	Islets at Kapp Martin and Lågneset	30-60	-82, -84
29	Diabasodden	20-40	-83, -84
30	St. Hansholmane	80-100	-83
31	Kapp Linné ¹	325	-82
32	Islets Nordenskiöldkysten	50-150??	
33	Gåsøyane ¹	800-1,000	-82, -83
34	Islets at Bohemanneset ¹	120-150	-83
35	Selmanneset	10-20	-83
36	Islets at Daudmannsøya	80-150	-82, -83
37	Tvìholmane	100-200	-82
38	Marineholmane, Gudrunholmen, Fregattholmane	300-400	-82, -83
39	Islets Alkhornet-Marineholmane	80-120	-82, -83
40	Hermansenøya ¹	80-130	-83
41	Islets Salpynten-Aitkenodden, PKF	200-300	-82, -84
42	Plankeholmane ¹	250-300	-82
43	Forlandsøyane ¹	400-600	-82, -83, -84
44	Storkobben and Snadden	100-150??	-83, -84
45	Lortholmen	50-100??	-83, -84, -85
46	Knivodden	30-60??	-83, -85
47	Islets Kaldneset-Aitkenodden, PKF	100-200*	-85
48	Kapp Sieto/Vernodden	15-25	-84
49	Islets Aitkenodden-Fuglehuken, PKF	50-150*	-85
50	Guissezholmane ¹	170-190	-84
51	Mietheholmen ¹	350-550	-81, -82, -83, -84
52	Prins Heinrichøya ¹	60-170	„
53	Lovénøyane ¹	600-1,600	„
54	Eskjeret ¹	50-1,000	„
55	Gerdøya ¹	10-20	-79
56	Blomstrandhamna ¹	200-500	
57	Islets Kapp Mitra	10-40*	-83
58	Fugleholmane and islets in Magdalenafjorden	80-150	-82, -83
59	Mesteinane	20-30	-82
60	Mosøya ¹	700-900	-82, -84
61	Skorpa and islets at Harpunodden ¹	50-80	-82

Table 1. continued

Loc.	Name	No. of pairs	year
62	Albertøya	300-450	-83
63	Æøya	30-60	-82
64	Likholmen	20-50	-82
65	Fugløya and islets in Fuglefjorden	400-550	-82
66	Steggholmen	60-100	-82
67	Cummingøya	30-50	-82
68	Ørnenøya	100-200*	-83
69	Risen	100-250	-82, -83
70	Vesle Andøya	20-30	-82
71	Store Andøya	10-20	-82
72	Ringholmen	40-60	-82
73	Stasjonsøyane	100-150	-82
74	Islets of Store Andøya	400-500	-82
75	Måkeøyane	200-300	-82
76	Islets at Texas Bar	none	-82
77	Lernerøyane	none	-82
78	Moffen ¹	200-400	-82

¹Located within bird sanctuaries.

* Estimates only based on no. of males on or around the locality, or of no. of nest scrapes counted after the breeding season.

?? - Supposed breeding number, not based on countings.

PFK = Prins Karls Forland.

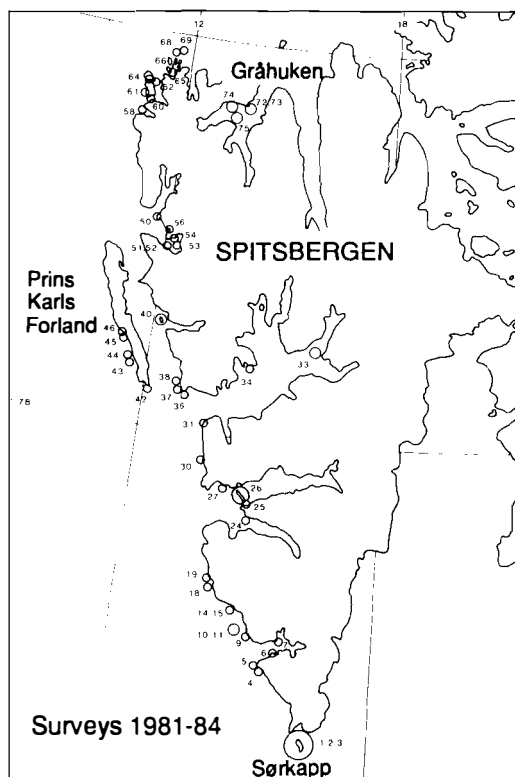


Fig. 3. Locations of breeding colonies on islets/islands along the western and northern coasts of Spitsbergen, between Sørkapp and Gråhukken. Colonies with less than 50 breeding pairs are not shown. For breeding population see Table 1.

Table 2. Number of breeding Common Eiders on the different islands in the Dunøyane group.

	1965*	1982	1983	1984
Store Dunøy	-	200-300	-	200-300
Nordre Dunøy	-	100-125	100-200	120-145
Fjørholmen	-	100-130	-	100-120
Total	285	400-550	-	420-575

*Norderhaug (1971).

to be about 10,000 pairs. The figures for the later censuses are much smaller (Table 4).

Guissezholmane.—Ahlén & Andersson (1970) reported 54 and 225 pairs in 1964 and 1967 respectively, while Norderhaug (1971) reported 170 pairs in 1968, similar to our 170-190 pairs in 1984.

Kongsfjorden.—Intensive studies of the Eider colonies in the Kongsfjord area have been performed by F. Mehlum and co-workers in the period 1981-1987 (Mehlum 1991, this volume). The number of breeding pairs at different islands during the period 1964-1984 are presented in Table 5.

Aerial censuses of moulting males and feeding areas

The male population along the coastline surveyed (Fig. 2) in the period 30 June - 5 July 1984 comprised 15,100-17,400 individuals (Table 6).

Table 3. Breeding pairs of Common Eider at Kapp Linné in the period 1957–1982.

Years	1957	1964	1968	1969	1970	1971	1977	1982
Pairs	200	300	450	600	550	600	550	325

Sources: 1957 Løvenskiold (1964)
1964–1977 Norderhaug (1977)
1982 this study

Table 4. Breeding Common Eiders at Forlandsøyane.

Year	1900	1956	1968	1982	1983	1984
Søndre Forlandsøy	–	–	–	20	20–30	12–13
Midtre Forlandsøy	–	–	–	120–200	120–175	300–400
Nordre Forlandsøy	–	–	–	60	160–220	150–230
Total	10,000	200–300	1,740?	200–300	300–450	460–650

Sources: 1900 Kolthoff (1903)
1956 Løvenskiold (1964)
1968 Norderhaug (1971)
1982–1984 this study

Table 5. Breeding Common Eiders in Kongsfjorden 1964–1984.

Loc.	1964	1966	1967	1968	1977	1981	1982	1983	1984
1	200	38	99	17	113	117	60	167	191
2	110	158	384	54	245	482	670	320	269
3	1,200	–	1,623	1,192	–	138	1,315	971	554
4	877	–	510	850	–	77	559	1,146	1,629
5	–	–	206	30–35	–	200	372	340	501
Total	–	–	2,822	2,143	2,100	1,014	2,976	2,944	3,144

Loc: 1) Prins Heinrichøya, 2) Mithelholmen, 3) Eskjeret, 4) Lovénøyane, 5) Blomstrandhamna.
Sources: 1964 and 1967–Ahlén & Andersson (1970)
1966 and 1968–Norderhaug (1971)
1977–Norderhaug (1977)
1981–1984 Mehlum (1991)

Most males were found at the outer coast in large flocks of sizes up to 1,000–1,500 individuals. Combined with the occasional aerial surveys in 1982–1984, the male population between Sørkapp and Wijdefjorden is estimated to be 23,300–32,800 individuals (Table 6).

We have no systematic censuses of males from the eastern part of Svalbard. The estimates (Table 7) are based on the occasional aerial surveys of the total population performed by the Norwegian Polar Research Institute and the Governor's Office in 1983–1984. The total eastern population of Eiders is estimated to be 10,600–16,200 individuals (Table 7).

The most important moulting/feeding areas are shown in Fig. 4.

Discussion

Breeding colonies

The majority of Svalbard's Common Eider population breeds on islets and small islands along the coast, thus avoiding predation by the Arctic Fox (Løvenskiold 1964; Ahlén & Andersson 1970; Norderhaug 1971). The Common Eider avoids inhabiting areas which are situated too close to mainland shores, surrounded by sea-ice most summers, or so large that they are regularly visited or inhabited by Arctic Foxes. The northern and western coasts are generally free from sea-ice during the breeding season. However, since there are relatively few islets and small islands

Table 6. Censuses and estimated numbers of male Eiders along the western coast of Svalbard in July (the estimates are based both on systematic censuses in 1984 and on occasional censuses carried out in 1982 and 1983).

Area	Males counted 30 June – 5 July 1984	Estimated Male population along the western coast (July)
Sørkapp–Hornsund	–	1,100– 1,400 (July –83)
Hornsund	–	300– 400 (June –82)
Hornsund–Bellsund	700– 800	1,800– 2,500 (July –83)
Bellsund	1,500– 1,700	2,100– 2,300
Van Keulenfjorden	–	200– 300 (assumed)
Van Mijenfjorden	–	500– 700 (assumed)
Nordenskiöldkysten	1,600– 1,800	1,600– 1,800
Isfjorden with Daudmannsøyra and Kapp Linné	3,400– 4,100	3,400– 4,500
Forlandet, West	7,700– 9,000	8,000–10,000
Forlandsundet with St. Johnsfjorden	–	1,000– 1,500 (July –82, –83)
Kongsfjorden	–	100– 300 (assumed)
Krossfjorden	145	200– 300
Kapp Mitra–Magdalenafjorden	–	300– 500 (assumed)
Smeerenburg–Fuglefjorden	–	600– 1,100 (July –82, –83)
Woodfjorden–Liefdefjorden	–	800– 1,200 (assumed)
Wijdefjorden, West	–	1,800– 2,500 (July –84)
Wijdefjorden, East	–	500– 1,500 (Sept. –83)
Total	14,900–17,400	23,300–32,800

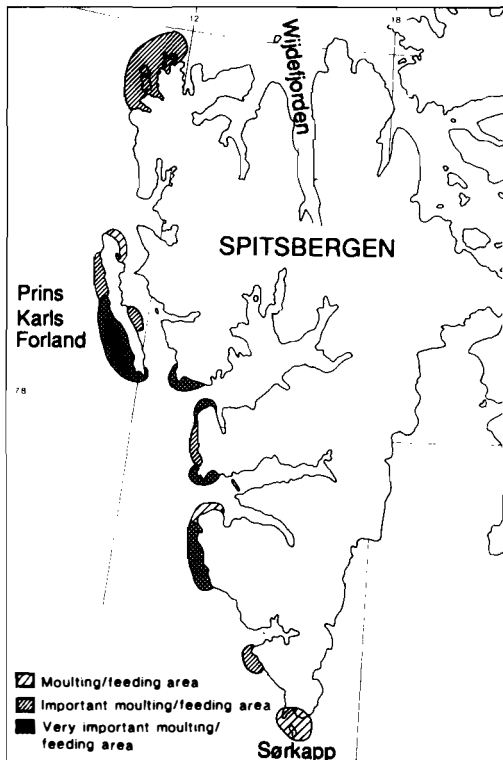


Fig. 4. Eider Moulting and feeding areas based on aerial surveys/censuses of the male population along the western coastline 1982–1984.

along these coasts, incubating females can be found in large concentrations at a restricted number of localities. Only two breeding colonies, Ny-Ålesund and Kapp Linné, were found on the mainland. At these two localities the Eider is protected by the human activity which keeps the foxes away. At Ny Ålesund most Eiders also breed within colonies of Arctic Terns *Sterna paradisaea*, thereby partly protecting themselves from fox predation. The estimated number of breeding pairs between Sørkapp and Gråhuken is based on censuses of most of the breeding colonies along this coast.

Due to the female's excellent camouflage colours, it is not possible to obtain an exact number of breeding Eiders without walking through the colonies. Censuses from distances to avoid disturbing the colonies (as we preferred, apart from the colonies in Kongsfjorden) entail uncertain estimates. This was a real problem on the islands and greater islets that could not be totally surveyed at a distance by telescope. In these cases counts of male Eiders provided an important basis for our estimates. According to Ahlén & Andersson (1970) and Campbell (1975) the male Eider in the Arctic stays together with the female for some time after the onset of incubation, as opposed to the populations farther south. According to Mehlum (unpubl.), the male

Table 7. Censuses and estimates of Eiders along the eastern coast of Svalbard.

Area	No. of birds observed	Estimated population	Comments
Hinlopen	350– 500 (July –83) 500– 800 (Aug. –84)	500–1,000	No eiders in Wahlenbergfjord
Murchisonfjorden– Nordkapp	740– 870 750– 900	1,300–1,800	Aug. –83 Sept. –84
Sjuøyane	–	100– 300	Assumed
Rijpfjorden	300– 500		Sept. –83, –84
Rijpfjorden – Isispynten with Storøya and Kvitøya	1,200–1,700	2,000–2,500	Sept. –84
Kong Karls Land	400– 700	500– 800	Sept. –83, –84
Edgeøya	1,400–1,800	2,000–2,800	Sept. –84
Barentsøya	800–1,100	1,200–2,000	Sept. –84
Storfjorden	2,500–3,500	3,000–5,000	Aug., Sept. –83, Sept. –84
Total	–	10,600–16,200	–

stays at the breeding grounds for 1–2 weeks after the female starts incubating. The males then gather in flocks (usually 100–200 individuals in each) close to the colonies and later move to the outer coastal areas where the moulting takes place. Along the western coast of Spitsbergen the males start their movement to the outer coastal areas at the end of June or beginning of July. The majority of the male population is present along these coasts during the last half of July. In the northern and eastern areas the incubation period starts later and thus also the movements of the males to moulting areas.

Most of our surveys of the northern and western coasts took place during the period 19 June–4 July, or shortly afterwards with counts of nests with down. According to Ahlén & Andersson (1970) the period 19 June–4 July falls in the middle of the breeding season, so we can conclude that our estimates based on counts of males are fairly accurate.

The number of breeding females in Svalbard fluctuates from year to year depending on the sea-ice and snow conditions (Hagelund & Norderhaug 1975a, b; Ahlén & Andersson 1970). These conditions were relatively similar during the three years comprising the main survey period (1982–1984), and large fluctuations in the breeding populations could not be shown (Tables 4 and 5). Consequently the estimates from the different years are comparable.

The estimate of 12,000–17,000 breeding pairs between Sørkapp and Gråhuken is a minimum estimate because:

- Females on nests are difficult to detect.
- Some males will always leave the colony immediately after the onset of breeding.
- Some colonies are not detected.

In addition, an unknown proportion of the population breeds on the mainland. It is not possible to survey this part of the population because the breeding is very dispersed. Most of the nests are found on the flat tundra at the outer coasts, but Eiders are also found breeding far inland from the coast. We have for instance found Eider nests 13–14 km away from the coast in Adventdalen, and males have been observed on the ground in the breeding season 20–25 km away from the coast in Helvetiadalen (Prestrud unpubl.). Based on counts of males and females at the outlet of Adventelva shortly before the beginning of the breeding season, and on observations of males in Adventdalen, the breeding population in Adventdalen is estimated to be about 20–30 pairs. Norderhaug (1982b) conjects that 10% of the Eider population breeds on the mainland. The essential part of the population undoubtedly breeds on islets and small islands. Our guess is that 5–30% of the Eider population breeds on the mainland.

Taking these factors into consideration the total breeding population between Sørkapp and Gråhuken is estimated to be 13,000–24,000 pairs.

Because of the tougher climate, and the sea-ice which makes most of the islands and islets accessible to the fox most of the breeding season, the breeding population along the eastern coasts of

Svalbard is much less than along the western coasts. The surveys carried out on the eastern coasts are not nearly as detailed as the surveys from the western and northern coasts. The estimate of the breeding population on the east coast (1,500–3,500 pairs) is based on registrations of females with ducklings in July/August and records of incubating females and nests with down on some of the islands in Hinlopen, Tusenøyane, and Nordaustlandet. Jepsen (1984) has surveyed the Eider population in parts of Nordaustlandet and Kong Karls Land in 1979. He recorded 109 females with ducklings late in July and August. We have estimated the breeding population on Nordaustlandet to be about 500–1,000 pairs. We find that this agrees well with Jepsen's (1984) results when we take into consideration that his surveys were carried out on less than half the coastline of Nordaustlandet, and that his results are minimum figures.

The total breeding population of common Eiders in Svalbard during the first half of the 1980's is consequently estimated to be 13,500–27,500 pairs. It must be noted however that the breeding population fluctuates considerably from year to year due to variations in the snow and ice conditions.

Surveys of the total population

Use of aircraft is a very effective method for surveying Eider populations (Almkvist & Andersson 1972; Jepsen 1984; Karlsen & Mehlum 1986), in particular with regard to the males which, in their breeding plumage, gather in large flocks at the moulting and feeding areas just after they leave the breeding colonies. Our estimate of 15,100–17,400 males along the surveyed coastline in June/July is a minimum estimate. Several flocks and single individuals are probably not recorded. In addition, observers have a tendency to underestimate the sizes of the flocks (Almkvist & Andersson 1972; Karlsen & Mehlum 1986). The survey performed by Karlsen & Mehlum (1986) in July/August 1984 from the western coast of Spitsbergen (Sørkapp–Prins Karls Forland), agrees well with our estimates. They estimated 43,200 individuals of both sexes in the surveyed area.

Combining the survey of males from June/July 1984 with earlier surveys from the same area gives an estimate of 23,300–32,800 males along the coastline between Sørkapp and Wijdefjorden

in 1982–1984 (Table 6). Compared with the estimate of breeding pairs from the same area this estimate sounds reasonable.

The estimate of the total population on the eastern coasts (10,600–16,200 individuals) is based on surveys of Barentsøya, the northern part of Edgeøya, Kong Karls Land and Nordaustlandet, while the rest of the area was only occasionally surveyed. Jepsen (1984) estimated the number of Eiders at the northern and western part of Nordaustlandet to be about 3,000 individuals in late July and August. This corresponds fairly well with our estimate (3,400–4,600) from Nordaustlandet, since the eastern and southern coasts of Nordaustlandet are totally covered by glaciers.

Based on the estimates of breeding Eiders in Svalbard (13,500–27,500 pairs), males along the western and northern coasts (23,300–32,800), the total population at the eastern coast (10,600–16,200), and Jepsen's (1984) and Karlsen & Mehlum's (1986) results, a rough estimate of the total late-summer or autumn population of Eider in Svalbard may be given. An equal number of males and females is assumed, as well as the production of 1–2 ducklings for each breeding pair. The total Svalbard population of Eiders in the late summer/autumn is then estimated to be 80,000–140,000 individuals.

Norderhaug (1982a, b) discusses whether the population was higher at the turn of the century than it is today. His conclusion is that the population in the 1970's had been reduced to 10–20% of the original size due to gathering of down and eggs at the breeding grounds during the first part of this century. His arguments and references are as follows:

- Kolthoff (1903) reported 10,000 pairs of breeding Eiders at Forlandsøyane in the year 1900.
- 50,000 kg of down were brought to Norway in the period 1871–1914. 2,451 kg of down were imported in 1914, which, according to Norderhaug (1982a, b), represented down from 81,000–98,000 nests.
- Løvenskiold (1964) reported several stories of the plundering of Eider colonies. During one summer, 15,000 eggs were gathered by the crew from a single sealing vessel.

Although Eider colonies in Svalbard have undoubtedly been exposed to plundering by trappers and hunters during the first part of the century, one should be careful about drawing

the conclusion that the breeding population was much larger at the turn of the century than it is today. If it was possible to gather down from nearly 100,000 nests 90 years ago, the breeding population must have been even much larger, maybe 150,000–200,000 pairs!

We cannot exclude the possibility that Kolthoff (1903) has over-estimated the breeding population at Forlandsøyane. Upon landing on Forlandsøyane, one is overwhelmed by the great number of birds and it would be easy to over-estimate the breeding population. Kolthoff's estimate is only mentioned a few times, and it is not evident how the estimate has been brought to light. Other publications by Kolthoff (1900, 1901a, b) mention the visit to Svalbard and Forlandsøyane without giving any estimate of breeding Eiders. It is thus difficult to assess the validity of Kolthoff's 1903 estimate.

Norderhaug (1982a, b) does not give any references as to the source of his figures on imported down to Norway. Hoel (1949) estimates the total quantity of down imported from Svalbard to be less than Norderhaug's estimate. According to Hoel the quantity was normally about 300–1,000 kg each year. In a single year (1924), however, 2,500 kg down was imported. Norderhaug (1982a, b) assumed the weight of uncleaned down from one nest to be 25–30 g. This is most probably too low. Today, trappers in Svalbard report the weight of uncleaned down to be 100–110 g per nest (L. Nielsen pers. comm.). Reed (1986) suggests that 120 nests in Canada yield 1 kg of uncleaned down. He also reports that the amount of cleaned down represents 20–23% of cleaned. This is equivalent to 36–42 g uncleaned down per nest. It is also evident from Hoel (1949) and Rossnes (1986) that the share of cleaned down can vary a great deal. This means that one should be careful about giving a fixed weight on down from single nests in Svalbard when the weight is based on calculations from Canada (Norderhaug 1982a, b).

Also important to consider when using quantities of down as a basis for estimating the breeding population of Eiders is that many geese breed together with Eiders on the islets and islands along the coasts of Svalbard. We know that the Brent Goose *Branta bernicla* bred in large numbers in the area at the beginning of the century (Løvenskiold 1964). This means that a considerable part of the imported down probably originated from goose nests. Moreover, it was

customary to gather down from the same nest two or three times during one breeding season.

One also has to take into consideration the possibility that down could have been gathered from other areas than Svalbard. Several sealing vessels were known to visit Novaja Semlja during the summer where we know there are large Eider colonies (Belopolskii 1961).

Altogether these factors tend to reduce the validity of Norderhaug's (1982a, b) basis for estimating the breeding population of the Common Eider in Svalbard at the turn of the century. The documented quantities of down, although giving no certain basis for asserting a population estimate 10 times larger at the turn of the century, do however give a fairly strong indication that the total Svalbard breeding population must have been larger than it is today.

Comparison of our results with earlier surveys of single colonies (Tables 2, 3, 4, and 5) leads to the conclusion that there have not been any significant changes in the number of breeding Eiders in Svalbard since the protection measures taken in 1963 and the establishment of bird sanctuaries in 1973. If the population had been strongly decimated as a consequence of hunting and disturbances at the breeding grounds, it would have been expected to increase after the measures to protect the species were put into effect. It is not clear why this expected increase has not taken place. Several authors attribute the lack of increase to predation (Ahlén & Andersson 1970; Campbell 1975; Hagelund & Norderhaug 1975b). However, it has not been possible to document any increase in the predator populations (Glaucous Gull, Arctic Fox).

Prestrud & Børset (1984) speculate on the possibility that interspecific competition between the Eider and the Barnacle Goose *Branta leucopsis* may explain the lack of increase in the Eider population. The Barnacle Goose also prefers breeding on small islands and islets along the outer coast. The Barnacles now breed in large numbers on several of the islets where Eiders dominated earlier. At Forlandsøyane for instance, about 1,500 pairs of Eiders and only 25 pairs of Barnacles were breeding in 1968. In 1982–82 only 300–400 pairs of Eiders bred here while the Barnacle Goose population had increased to 300–400 pairs. On the islets in Kongsfjorden and Isfjorden the Eider breeds in large numbers while the Barnacle is nearly absent. Although this hypothesis has not directly

been documented, the general tendency is that we do not find a high concentration of Barnacle Geese and Common Eiders in the same colony.

In conclusion, we have through our survey study successfully located and mapped the important breeding and summer moulting and feeding localities of the Common Eider in Svalbard. The results of this survey, as well as our selective treatment and evaluation of earlier literature touching on the fate of the Common Eider in Svalbard, provide a valuable foundation for future monitoring of the Eider's population trends. Although our estimation of the late summer Eider population in Svalbard was not in proportion to what had been expected after implementation of the conservation measures of 1963 and 1973, our expectations were based on earlier estimates; closer scrutiny of these earlier sources revealed that the figures quoted can be erroneous, or based on erroneous or undocumented information. The lack of marked increase in Eider population since the 1963 and 1973 conservation measures, however, remains to be explained. The above hypothesis is perhaps only one of the explanations which will be researched and documented in future Eider population studies.

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Breeding population size of the Common Eider *Somateria mollissima* in Kongsfjorden, Svalbard, 1981–1987

FRIDTJOF MEHLUM



Mehlum, Fridtjof 1991: Breeding population size of the Common Eider *Somateria mollissima* in Kongsfjorden, Svalbard, 1981–1987. *Norsk Polarinstitutt Skrifter* 195, 21–29.

The breeding population size of the Common Eider *Somateria mollissima* was censused during a seven year period (1981–1987) in Kongsfjorden, Svalbard. The total number of breeding pairs fluctuated between 1,000 and 3,400 depending on the sea-ice conditions in the fjord. In seasons with late breakup of sea-ice in the fjord (1981 and 1986), fewer Eiders occupied their breeding islands than in seasons with early breakup. The proportion of breeding pairs on each island also varied with the years. In years with early ice breakup and snow-melt the major part of the Eiders nested at relatively low density on the largest island in the area. In years with late breakup and snow melt, most of the breeding birds inhabited the smaller and outermost islands. Egg clutch sizes varied with egg-laying dates, with the smallest clutches late in the season.

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Introduction

Most islands in the Kongsfjorden area (79°N, 12°E) are traditional breeding sites for the Common Eider *Somateria mollissima* (Løvenskiold 1964). Kongsfjorden normally freezes during the winter, and the time of breakup of the fjord ice varies from year to year. In some years the fjord is still ice-covered in late June or early July. In other years only the inner parts of the fjord freeze, and there is open water around the nesting islands of the Eiders several weeks before the start of the breeding season from late May to mid-June, depending on ice and breakup times. Eiders will not occupy their breeding sites before there is open water around the islands. This prevents predation by the Arctic Fox *Alopex lagopus*. Before breeding, Eiders usually swim in concentrations close to the ice edge and wait for their nesting islands to become free of sea-ice.

The population of the Common Eider in Svalbard is thought to have declined dramatically since the beginning of this century (Norderhaug 1982). Several conservation measures have therefore been initiated to protect and manage the Eider population. In 1963 hunting and the collection of eggs and down were prohibited, and in 1973 a total of 15 bird sanctuaries were established to secure the main breeding islands for eiders and geese (see Prestrud & Mehlum 1991, fig.1, this volume). Two of these areas, the

Kongsfjorden and Blomstrandhamna Bird Sanctuaries, are located in inner Kongsfjorden.

The aim of the present study was to perform a census of the breeding population in Kongsfjorden which would supply us with data for evaluating the effects of the conservation measures, and for analyzing the year to year variation in onset of breeding, number of breeding pairs, and egg clutch sizes on the different islands in relation to the sea-ice conditions and snow coverage. A detailed analysis of the influence of sea-ice on the nesting density on two of the islands in the fjord is presented elsewhere (Parker & Mehlum 1991, this volume).

Material and methods

In the Kongsfjorden area a major part of the breeding Eiders nest on islands. Most of the islands are located in the inner part of the fjord, where Lovénøyane constitute the dominating island group (Fig. 1). The Blomstrandhamna Bird Sanctuary consists of two islands situated in a bay on the north side of the fjord, west of Blomstrandhalvøya and close to an arm of the glacier Blomstrandbreen which separates Blomstrandhalvøya from the mainland. Only the outermost of the two islands (Blomstrandøya) is densely populated by Eiders. The islands in the Kongsfjorden area vary in size, and all are more

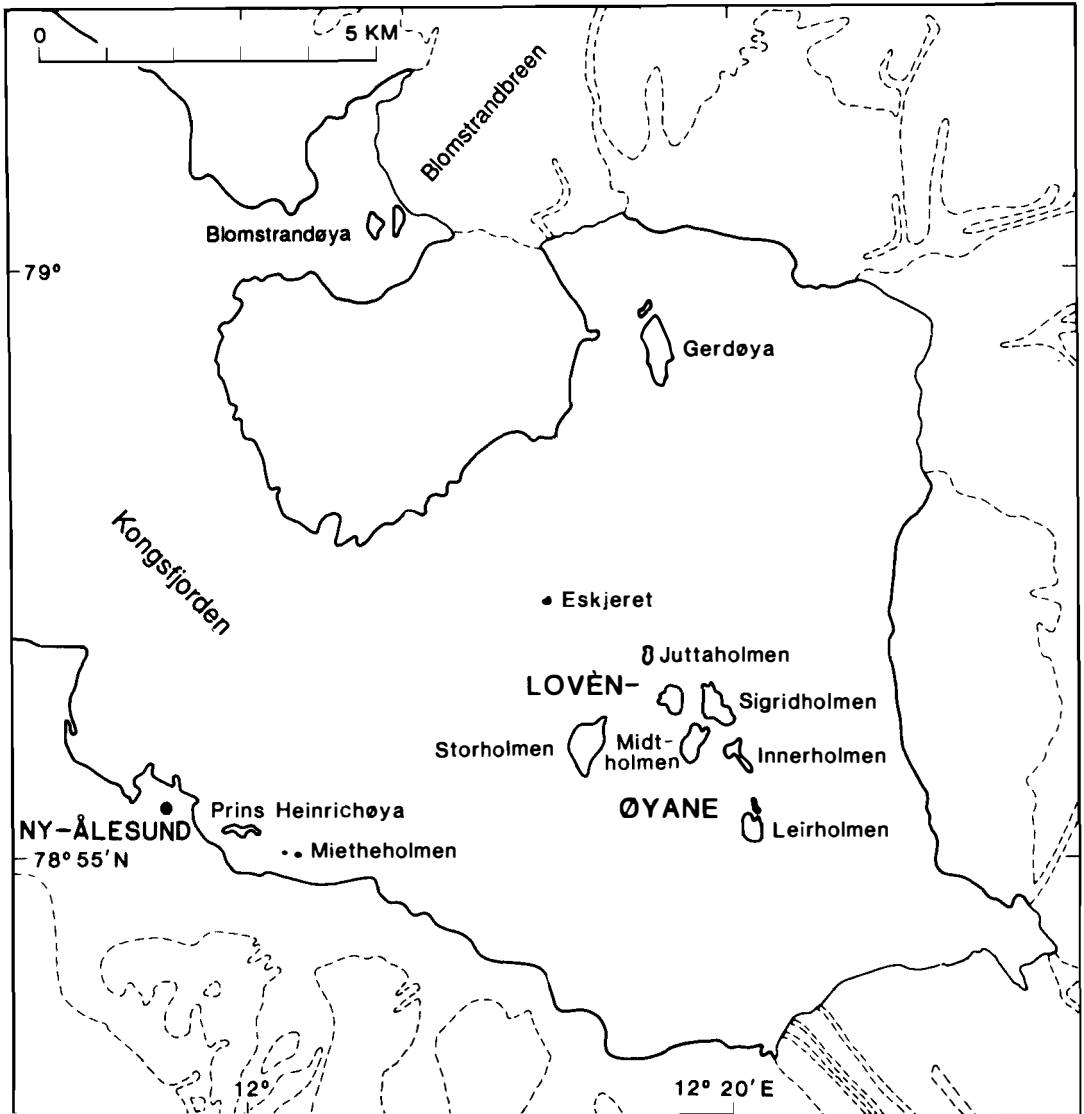


Fig. 1. Location map of the Kongsfjorden area.

or less covered with vegetation lower than 5 cm. To the observer all these islands seem suitable as potential breeding places for Eiders.

All islands in the Kongsfjorden area were censused each year from 1981 to 1987. The islands were visited at least once after the completion of egg-laying, and the number of nests and eggs were counted by carefully flushing the female off the nest. In the cases when several surveys were made on the same island during one season, the largest number of occupied nests

obtained was used. The recorded clutch size represents the actual number of eggs in the nest. It is not corrected for eggs lost to predators prior to the census and the fact that some nests might comprise incompleated clutches. However, most censuses were taken in the middle of the breeding season when most clutches were complete. An incubation period of 25 days (Hagelund & Norderhaug 1975) is applied for recalculating egg-laying dates from the hatching dates.

Results

Sea-ice conditions and breeding Eiders on different islands

Breakup of the fjord ice during spring varies largely from year to year. The innermost of the Lovénøyane are generally not ice-free until late in the season, so that Arctic Foxes are able to reach these islands from the mainland nearby. The same is true for Gerdøya. On the other hand, islands such as Eskjeret, Storholmen, Blomstrandøya, Mietheholmen and Prins Heinrichøya usually become ice-free earlier in the spring. At Prins Heinrichøya an ice-bridge to the mainland may be present even weeks after the sea-ice has withdrawn from this part of the fjord.

The variation in spring breakup of the fjord ice for the period 1981–87 is illustrated in Fig. 2, A–E. No map is shown for 1984 and 1987, because during these years the islands of Kongsfjorden were free of surrounding sea-ice well before the onset of breeding. The ice-bridge from Prins Heinrichøya to the mainland is not shown in the figure. The data on ice breakup around Blomstrandøya are scarce and are not included. 1981 was an extremely late breeding season for birds in the Kongsfjorden area. The ground was covered with snow and the fjord was full of ice during the entire month of June, when Eiders usually occupy their breeding habitats. In 1982 the ice conditions were somewhat better for the Eiders, and the island Mietheholmen was free of surrounding sea-ice in the first half of June. In the three succeeding seasons (1983–1985), the sea-ice was absent from most islands (except the innermost ones) several weeks before the Eiders usually start egg-laying (from the end of May to mid-June (Løvenskiold 1964)). Then again in 1986, the breakup season was rather late and the islands were not free of surrounding sea-ice until the beginning of July. In 1987 the ice disappeared early (between April–May).

A more detailed account of the establishment of breeding Eiders at the different islands during each of the seven years studied is given below.

1981.—In 1981 the ice edge was located just outside the Ny Ålesund settlement in mid-June. A large proportion of the ice was pack-ice. Several hundred pairs of Eiders were seen along this edge. From about 15 June some of these birds colonized the shore along Ny Ålesund and Prins Heinrichøya and then started egg-laying.

The Arctic Fox had access to both colonies, and during the last week of June more than 100 nests were plundered in each colony, the main predators being the Arctic Fox and the gulls. Mietheholmen was the first island to become free of sea-ice, and egg-laying began around 18–20 June. About half of all Eider nests recorded in the Kongsfjorden area during 1981 were located at Mietheholmen. Eskjeret, which normally has one of the largest colonies, became ice-free very late (in the first week of July), and the number of breeding Eiders was less than 10% of the maximum registered during the seven-year investigation period. On the innermost islands some Eiders attempted to breed, but almost all were subject to predation by Arctic Foxes which had access to the islands as long as the islands were connected to the mainland by fjord ice. At Storholmen, for example, about four fifths of the total area was snow-covered on 27 June, and 110 predated nests were registered.

1982.—In 1982, as in 1981, Mietheholmen was the first island to become free of sea-ice (10 June). Egg-laying started around 12–15 June (first hatching recorded at 11 July). On nearby Prins Heinrichøya, land-bound ice facilitated the access of Arctic Foxes to the island until 30 June. The main egg-laying on this island occurred in the first part of July. The sea-ice disappeared completely from Lovénøyane in the beginning of July, at which time the main egg-laying period started. At Juttaholmen the egg-laying started somewhat earlier (about 20 June), but all the nests were plundered (one Arctic Fox seen on 23 June). The fox left the island with the sea-ice, and later a maximum of 252 nests with eggs were recorded. At Eskjeret egg-laying probably started before 20 June, since the first eggs had hatched when the island was visited on 15 July.

1983.—In 1983 egg-laying started early on most islands and was not delayed by sea-ice around the colonies. At Mietheholmen the sea-ice had disappeared by 5 May (H. Parker, pers. comm.), and at our first visit to the island (4 June) about three quarters of the area was free of snow. The colonization of Eiders had already started and 41 nests with eggs were counted. At nearby Prins Heinrichøya the ice-bridge to the mainland disappeared much later than at Mietheholmen (2 June), and the Eiders started egg-laying immediately afterwards. At Storholmen about half of the area was snow-free on 4 June, especially

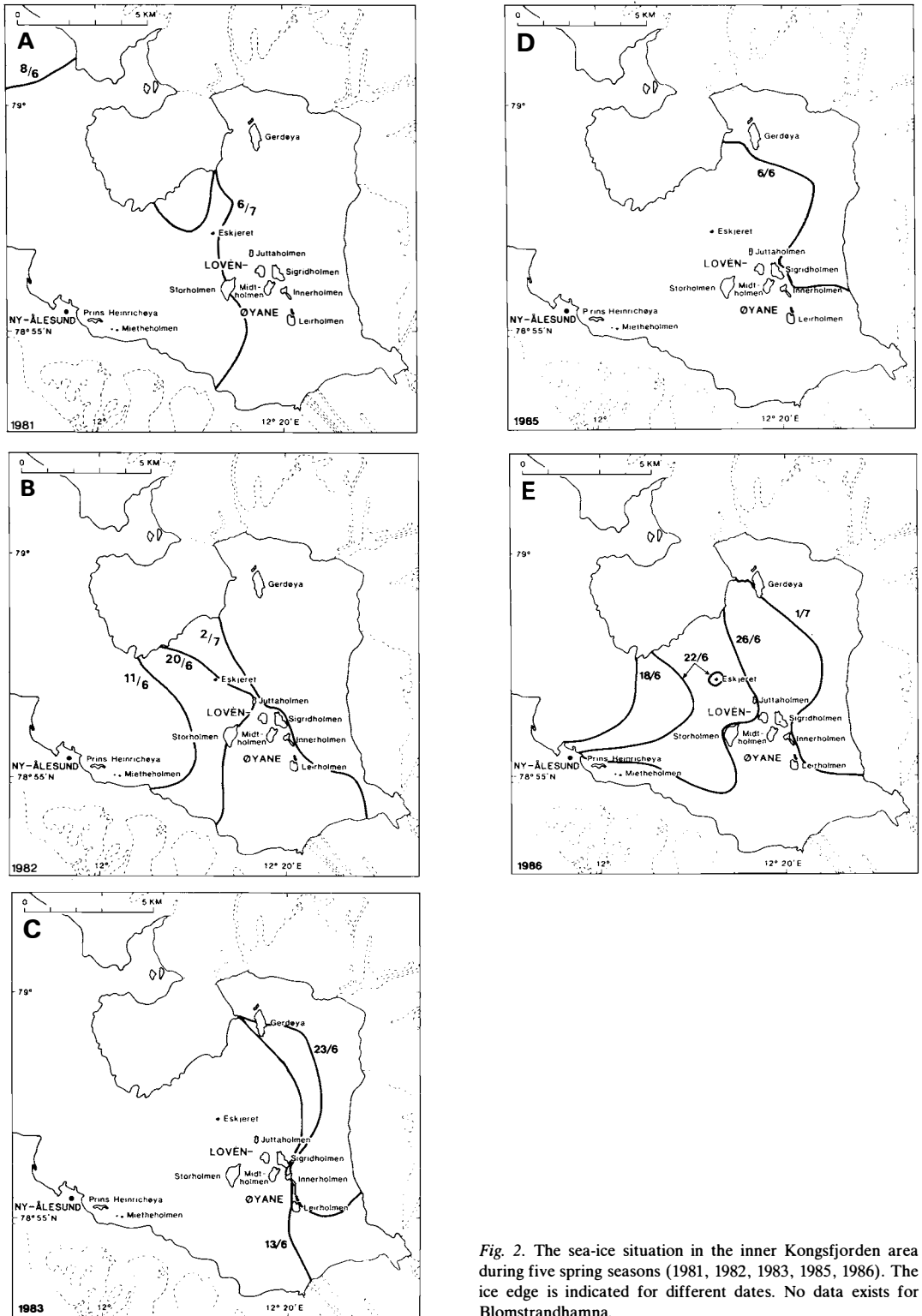


Fig. 2. The sea-ice situation in the inner Kongsfjorden area during five spring seasons (1981, 1982, 1983, 1985, 1986). The ice edge is indicated for different dates. No data exists for Blomstrandhamna.

on the eastern flat parts. Blomstrandøya was visited on 10 June; half of the island was snow-free and no sea-ice was seen around the island. The conditions for breeding seemed to also be suitable at this time on Eskjeret and Storholmen, and about 71% of all the nests in the Kongsfjorden area were found on these two islands.

1984.—In 1984 very little ice formed during the winter. Mietheholmen and Prins Heinrichøya were free of surrounding ice in mid-March, while the ice had disappeared from Storholmen and Eskjeret by April (Lydersen & Gjertz 1986). This provided an earlier establishment of the breeding colonies. At Mietheholmen the first two nests (with one egg in each) were recorded at 24 May (H. Parker, pers. comm.), and at the same time at least 20 pairs had colonized Eskjeret (H. Ottesen, pers. comm.). On our visit to Mietheholmen (1 June) and to Prins Heinrichøya (2 June), 39 and 33 nests with eggs were recorded respectively. Both islands were almost snow-free. At Storholmen the entire eastern part of the island was free of snow cover. However, the ground was wet and large parts of the area were therefore unsuitable for nesting. In the drier areas of this island many Eiders had already started egg-laying, and 214 nests with eggs were counted (5 June). On Juttaholmen only 7 nests with eggs were recorded, while several hundred pairs had already colonized Eskjeret (based on rough estimates made from a boat). This indicates the little attractive value of Juttaholmen when the neighbouring colonies are available for nesting. We have no data on the snow and sea-ice conditions at Blomstrandøya in 1984. However, reflected by the observation of hatched young on 28 June, the egg-laying began early.

1985.—In 1985, as in the two previous years, there was little sea-ice in the fjord in June, but more snow covered the islands at the beginning of June than at the same time both in 1983 and 1984. This fact probably generally delayed the start of egg-laying on most islands. However, at Mietheholmen, where three quarters of the area was snow-covered on 6 June, 151 nests with eggs were recorded on 9 June. The number of nests recorded on the different islands was similar to that of 1984, but more nests were recorded on the innermost islands (Midtholmen, Leirholmen, Sigridholmen, Observasjonsholmen, and Innerholmen) than during any of the other six seasons investigated. The total number of nests at Stor-

holmen was slightly lower than in the previous year. Therefore some of the Storholmen birds may have shifted to the neighbouring islands in 1985 due to more favourable breeding conditions. One possible reason for this change may be the fact that parts of the breeding areas of Storholmen were extremely wet in mid-June.

1986.—In 1986, when we again experienced a late snow-melt and late breakup of sea-ice, the total number of breeding Eiders decreased. The course of retreat of the sea-ice was somewhat between the situations in 1981 and 1982. Eskjeret was the first island to become ice-free (between 18 and 22 June), and 32% of all the nests were found on this island. Another 27% of the nests were found on Blomstrandøya. No data on snow and sea-ice conditions are available from this area. Islands which were late in becoming ice-free (Prins Heinrichøya and Storholmen) had fewer nests compared to seasons without sea-ice (92 and 329 nests respectively). Estimated by observations of hatched chicks, egg-laying started just before 25 June at Blomstrandøya, Mietheholmen and Eskjeret, and still later at Storholmen and Juttaholmen.

1987.—In 1987 the winter sea-ice started drifting out of the fjord during the last week of April, and all the Eider islands were ice-free by the end of May. Snow still covered nine tenths of the coastal tundra in the Kongsfjorden area in the middle of June. However, the Eider islands were snow-free at that time and egg-laying started early. The first chicks were observed on 25 June. As in other early years, a large number of birds nested on Storholmen. The number of recorded breeding females was 1,780, i.e. the highest number during the seven year survey. Similarly, at Prins Heinrichøya 334 nests were recorded, also the highest number during the survey. The ice bridge between Prins Heinrichøya and the mainland disappeared early in the season (5 May). At Mietheholmen the lowest number of nests during the seven year study was recorded (100 nests). However, another 50 deserted nests were present, probably lost due to gull predation.

Breeding population size and distribution

The counts of number of nests with eggs on the different islands are summarized in Table 1. The number of nests on each island varied considerably from year to year. Both the total number of

Table 1. Maximum number of Eider nests with eggs on different islands in the Kongsfjorden area during the seven year period 1981–87.

Island	1981	1982	1983	1984	1985	1986	1987
Blomstrandøya	200	372	340	501	576	543	547
Prins Heinrichøya	117*	60	167	191	277	92	334
Mietheholmen	482	670	320	269	268	262	100
Eskjeret	138	1,315	971	554	507	646	474
Storholmen	0*	294	1,128	1,510	1,329	329	1,780
Juttaholmen	75	252	0*	77	88	166	126
Midtholmen	0	6	13	9	17	–	3
Leirholmen	2	2	5	12	26	–	42
Sigridholmen	0	0	0*	9	34	0	2
Observasjonsholmen	0	3	–	14	46	0*	18
Innerholmen	0	2	0	–	4	0	0
Gerdøya	0	0	–	0	–	–	–
Total	1,014	2,976	2,944	3,146	3,172	2,038	3,426

* Arctic Fox present on the island and the nests predated.

– no data available.

breeding pairs in the area and the distribution of nests on the different islands were influenced by the extent of sea-ice cover. In years with extreme late disappearance of sea-ice (1981 and 1986), the total breeding population was lower than during the other years.

In seasons when no sea-ice surrounded the islands, another type of nest distribution was observed. In such years as 1983, 1984, 1985, and 1987, most birds nested on the largest island, Storholmen. The proportion of the Kongsfjorden Eider population nesting on Storholmen varied between 38 and 52% within these four years. Even if the total number of nests on Storholmen was high during these years, the density of nests per area unit was much lower (58 nests per hectare) than on smaller islands such as Mietheholmen and Eskjeret (270–1,800 and 300–3,900 nests per hectare, respectively). This observation indicates that a large proportion of the Eiders in Kongsfjorden prefer nesting in high numbers but at low densities on large islands. The actual sizes of the islands may not be crucial. Other characteristics of the large islands in Kongsfjorden may be responsible for this preference.

In late seasons more birds nested on the outermost islands where the sea-ice first disappeared (Table 1). The most important breeding islands in such seasons are Eskjeret and Mietheholmen. In 1981, however, the ice broke up around Eskjeret too late for the Eiders to start egg-laying. In 1986 Mietheholmen did not fulfill its potential as an outermost nesting island, and only 262 nests were recorded. The ice broke up late

and egg-laying started much later than in other late years such as 1981 and 1982.

Clutch sizes

Clutch sizes varied among the islands during the same season, and from year to year on the same island (Fig. 3). The extreme mean values were 2.0 and 5.5 eggs per clutch. However, most means were between 2.5 and 4.0. The major deviation from the average clutch size was recorded at Mietheholmen in 1982, which was probably due to dump nesting. This assumption is based upon the fact that in many nests more than five eggs were laid during a five day period (Fig. 4). Dump nesting is probably also responsible for the high proportion of large clutches obtained at Mietheholmen in 1981. In both years Mietheholmen was the first ice-free island, and during such situations high competition for nest scrapes may lead some females to lay in occupied nests.

In years with little sea-ice in the fjord (1983, 1984, 1985, and 1987), a larger mean number of eggs per nest was recorded at Storholmen than on the other islands (Fig. 3). For all the years and islands this was significant at the $p < 0.001$ – level (t-test). Since we also found large breeding numbers on this island in such years, the Eiders at Storholmen contributed to a major part of the egg production of the entire Kongsfjorden population.

In Fig. 5 the mean egg clutch sizes on different islands and years are divided into three categories

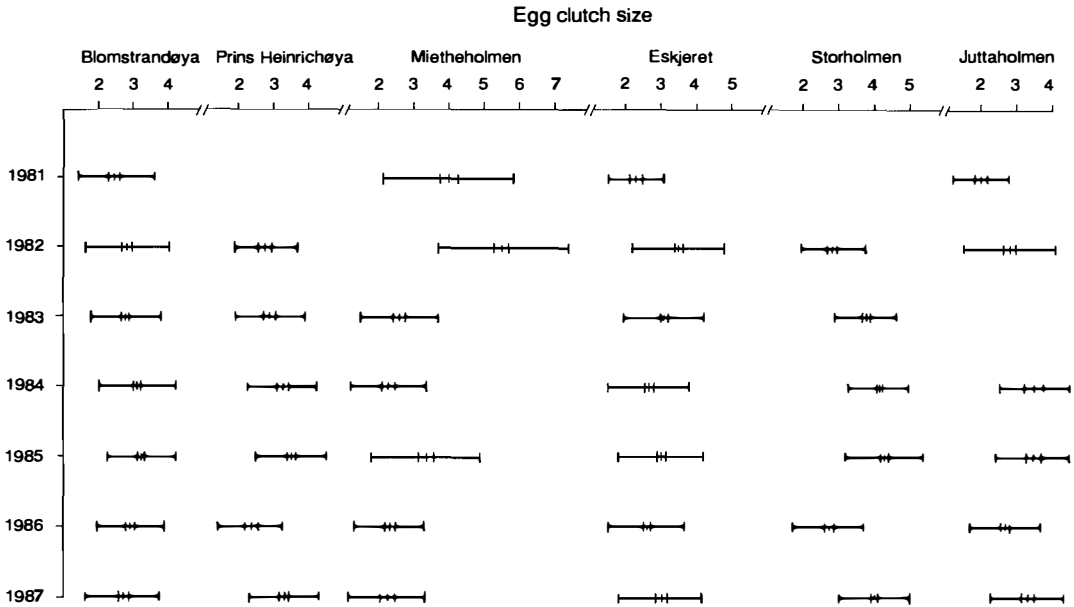


Fig. 3. Maximum egg clutch sizes (mean \pm 2 s.e. and 1 s.d.) during different years in main breeding Common Eider colonies in Kongsfjorden. Missing values represent cases where all nests were predated by the Arctic Fox *Alopex lagopus*.

according to what time the main egg-laying period occurred: earlier than 5 June, between 5 and 25 June, or later than 25 June, respectively. The data from Mietholmen are excluded because of frequent dump-nesting on that locality. There was no difference between egg-clutch sizes on islands where clutches were laid early com-

pared to clutches laid 5–25 June. However, the sizes of clutches laid late in the season (after 25 June) were significantly lower than those laid before 5 June and those laid in the period 5–25 June, respectively (< 5 June vs. > 25 June, $U = 11.5$, $p < 0.001$; 5–25 June vs. > 25 June, $U = 7$, $p < 0.01$, Mann-Whitney U-test).

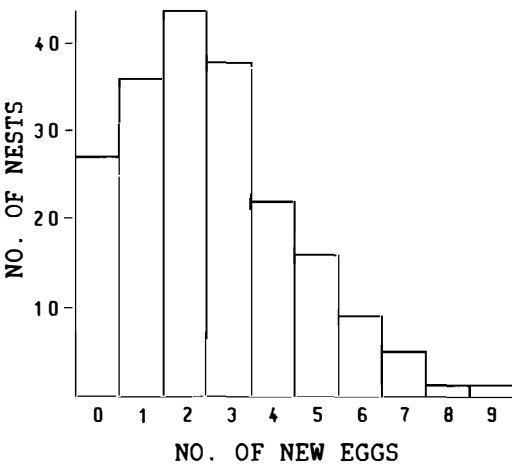


Fig. 4. Number of recorded newly laid eggs in a sample of 200 nests at Mietholmen between 19 and 24 June 1982.

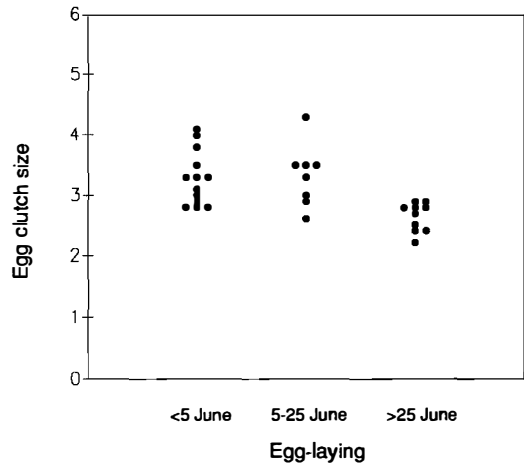


Fig. 5. Mean egg clutch sizes on different islands (Eskjeret, Storholmen, Juttaholmen, Blomstrandøya, Prins Heinrichøya) in the period 1981–87. The data grouped according to the differences in egg-laying periods.

Discussion

This investigation shows that the total number of breeding Eiders in the Kongsfjorden area is clearly influenced by the time of breakup of sea-ice surrounding the nesting islands. In years with late breakup the number of breeders is much less than in years with early breakup. In 1981, for example, only one third of the "normal" population bred. This illustrates the importance of using censuses from more than one breeding season when attempting to obtain a valid estimate of Eider populations in areas where sea-ice conditions vary from year to year.

Several censuses of the Common Eider have been conducted in the Kongsfjorden area prior to this study. The information available on breeding numbers during the period 1963–1987 is summarized in Fig. 6. Even if information is scarce on the methods used by previous investigators and on the time they performed the census, Fig. 6 indicates that the total breeding population has been fairly stable during the last 25 years. Thus the protection of Eiders from 1963 and the establishment of the Kongsfjorden and Blomstrandhamna Bird Sanctuaries have not resulted in a distinct increase in the breeding population size.

Table 1 indicates a steady increase in the numbers of breeding Eiders at Blomstrandøya during the years 1981–87. Ahlén & Andersson (1970) recorded 195 nests on this island in 1967, and Norderhaug (1971) recorded 30–35 nests in 1968. These records give evidence of a significant increase of nesting Eiders on this island. The increase might be explained by the retreat of the glacier Blomstrandbreen from the island during the first half of this century. The island was

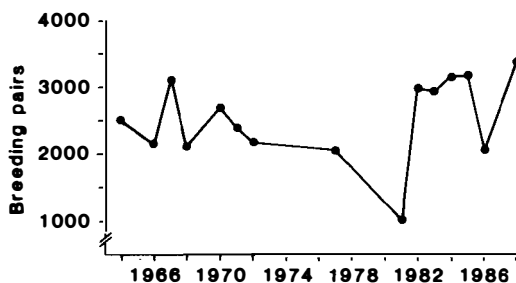


Fig. 6. Total number of breeding pairs of Common Eiders on islands in the Kongsfjorden area 1964–1987. Sources: 1964 and 1967 (Ahlén & Andersson 1970); 1966, 1968, 1970, 1971, 1977 (Norderhaug 1981); 1972 (Anderson et al. 1974), 1981–1987 (this study).

probably suitable as a nesting ground for Eiders from the 1950's.

One can only speculate about why the Eider population in Kongsfjorden has stabilized at about 3,000 breeding pairs, and why no significant increase in numbers has been recorded after the implementation of conservation measures. This size may be the carrying capacity of the area at present. Groups of old nest scrapes can be found on the innermost islands in the fjord, such as Midtholmen, where only a few Eiders have nested in recent years. The existence of these abandoned nesting places shows that Eiders have inhabited these islands in earlier days, probably when ice conditions were more favourable to the birds and Arctic Foxes had no access to the islands. However, this does not necessarily mean that the population was larger earlier, as the nesting population tends to disperse and use new islands which become available with the disappearance of ice.

In addition to controlling the onset of breeding, the sea-ice conditions also influence the egg-clutch sizes. Observed egg-clutch sizes vary with the time of egg-laying. The laying of smaller clutches in late seasons may be interpreted as an adaptation for minimizing energy expenditure during incubation. Females depend mainly on fat reserves built up prior to the breeding season for energy resource during pre-incubation and incubation. When egg-laying is delayed, the physical condition of the females at the start of incubation is probably inferior to that of early breeders due to weight loss. The depletion of energy reserves during incubation is also large, and very lean females may leave the nest before hatching (Mehlum, unpubl.). For late breeders, the laying of smaller clutches conserves energy and thereby increases the chances of successful hatching.

The clutch sizes are also influenced by avian predators, mainly the Glaucous Gull *Larus hyperboreus* (Mehlum 1991), and the predatory rate may vary among the islands. No systematic count of avian predators has been performed on the islands, but the general impression is that densely populated smaller islands are more subject to predation by gulls than dispersed colonies on larger islands. The higher predation pressure on dense colonies on small islands (such as Eskjeret) may be a possible explanation for the observed preference of Eiders for dispersed colonies on large islands (such as Storholmen)

even in years when sea-ice conditions allow dense nesting.

An important observation of this study was that Eiders breed in the highest numbers in dispersed colonies on large islands in years without sea-ice around the islands. Parker & Mehlum (1991, this volume) further tested whether Eiders would choose to disperse maximally, thereby minimizing nest density, if provided with more space in the form of more islands and favourable ice conditions. Observations from a six-year period showed a slow dispersal response which was less than maximal, and a high density nesting tendency which reflected a forced nesting situation in seasons with reduced accessibility to nesting places due to snow cover or sea-ice.

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Influence of sea-ice on nesting density in the Common Eider *Somateria mollissima* in Svalbard

HOWARD PARKER AND FRIDTJOF MEHLUM



Parker, H. & Mehlum, F. 1991: Influence of sea-ice on nesting density in the Common Eider *Somateria mollissima* in Svalbard. *Norsk Polarinstitutt Skrifter* 195, 31–36.

High arctic Common Eiders often nest in dense colonies on small islands, particularly in years when late breakup of sea-ice limits the number of nesting islands available. High-density nesting under these conditions appears to be a forced response, and it was predicted that if provided with more space in the form of more islands, nesting Eiders would choose to disperse maximally, thereby minimizing nest density. This prediction was tested during 6 years of generally favourable ice conditions and results indicated that nesting females did disperse when provided with more space, but that the dispersal response was both slower and less complete than predicted. The observed lag in dispersal was suggested to be a result of site-tenacity, i.e. females tended to return to previously used nesting islands despite having originally been “forced” to nest there due to late spring breakup.

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Introduction

Throughout its range the Common Eider *Somateria mollissima* (hereafter called Eider) normally nests on small coastal islands as defense against predation from land mammals, particularly foxes. In high arctic regions, selecting a predator-free nesting island is often complicated by late-melting sea-ice which frequently connects islands to the mainland during spring and early summer. These ice bridges give the Arctic Fox *Alopex lagopus* easy access to nesting islands. To avoid nest predation Eiders returning in the spring usually wait until ice bridges have melted before attempting to nest (Lack 1933; Ahlén & Andersson 1970; Quinlan & Lehnhausen 1982; Mehlum 1991, this volume). During years when spring breakup is late, females are often forced to delay laying by many weeks. When breakup eventually comes, birds tend to congregate densely on those islands which first lose their ice bridges to the mainland (Ahlén and Andersson 1970). Consequently, the timing and pattern of ice-melting can strongly influence both individual island selection and nesting density, though dense nesting may occur in the complete absence of sea-ice (Anderson et al. 1974).

Eiders are customarily referred to as colonial nesters, and indeed normally nest in clumped, often dense, distributions, particularly in the high

arctic (Ahlén & Andersson 1970; Anderson et al. 1974; Meltote 1978; Mehlum 1991, this volume). However, they may not necessarily be obligate colonial nesters. For example, when few birds nest on large islands in Kongsfjorden they tend to disperse over most of the usable area sparsely, rather than nest in one or more dense clumps (Parker unpubl.). Anderson et al. (1974) similarly noted that Eiders at Scottish sites usually nested at much lower density than those that had been observed in Kongsfjorden. Accordingly we predicted that nesting Eiders, if provided with adequate space in the form of several nesting islands of similar quality, would choose to disperse maximally over these rather than nest densely on one.

During the 6 breeding seasons (1982–87) described here, natural sea-ice conditions allowed us to study in detail the way in which Eiders adjusted their nesting density to a generally increasing availability of nesting space. A year with late spring breakup was followed by a year with little ice, two subsequent years with no ice, another year with late spring breakup, and again a year with no ice. Available nesting space thereby increased markedly (with the exception of 1986) while the number of breeding birds in the fjord (again with the exception of 1986) remained about the same (Mehlum 1991, this volume).

Study area

The investigation was conducted in the Kongsfjorden region of western Spitsbergen ($78^{\circ}55'N$, $12^{\circ}00'E$) in the Svalbard Archipelago during 1982–87. The study area consisted of two small islands, Mietholmen (MH, 0.37 hectares) and Prins Heinrichøya (PHØ, 2.43 hectares) located in the inner part of the fjord near the research station at Ny-Ålesund (Fig. 1), and about 5 km from other major nesting islands. Both islands are flat and low with gravelly soil and a sparse cover of tundra vegetation rarely exceeding 5 cm in height. Both contain very little natural nesting cover in the form of rocks or driftwood, and most Eiders nested completely open. The islands are 600 metres apart and both lie about 250 metres from the mainland. Thus, apart from size, there was no appreciable difference between them regarding nesting habitat quality. MH however usually loses its ice bridge to the mainland about 2–4 weeks earlier than PHØ, apparently due to slight differences in depth and current near the two islands.

Eiders also nested regularly on 3 other major

islands 5–6 kilometres further in the fjord, as well as on the mainland near the research station at Ny-Ålesund. No Glaucous Gulls *Larus hyperboreus* nested on either island during the study. Around 3000 female Eiders nested within the confines of the fjord during 1982–85 as well as in 1987, while about 2000 nested in 1986 (Mehlum 1991, this volume).

Methods

During 1982–84 the number of occupied nests with eggs was counted on PHØ every 2–3 days and on MH about once a week throughout the laying and incubation periods. During 1985 both islands were visited approximately once every 14 days and in 1986–87 once shortly after the completion of laying. The largest count of occupied nests was used as an estimate of the number of nesting females on each island during each year, as few nests were initiated after hatching began. Birds adjusted rapidly to our frequent visits and most remained sitting, or moved only a few metres from the nest, when we approached.

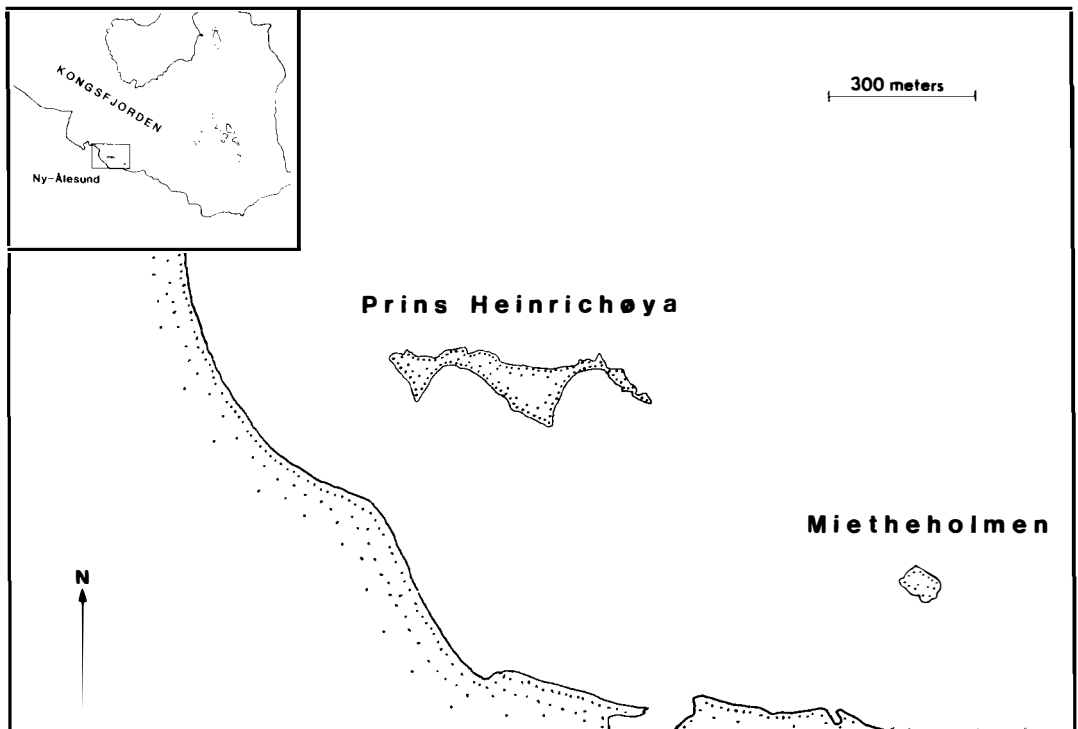


Fig. 1. Location of the two study islands, Prins Heinrichøya and Mietholmen, in the Kongsfjorden region of West Spitsbergen, Svalbard.

Consequently, egg loss to gulls due to our activity was negligible as reported in several other similar Eider studies (Ahlén & Andersson 1970; Götmark & Åhlund 1984; Hagelund & Norderhaug 1975).

Beginning in early spring both islands were observed daily and the dates on which (1) the ice bridge disappeared, (2) Eider pairs were first seen on land, and (3) the first nest of the year was initiated were recorded for each island. Data on points (2) and (3) were not available for 1985–87.

Results and discussion

Pre-laying activity

Most Eiders returned to the Kongsfjorden area during the last half of April after wintering further south. Birds then concentrated in open water near the mouth of the fjord where intense foraging occurred prior to nesting. During the first half of May small groups of Eiders began making low reconnaissance flights to the inner fjord, apparently to investigate conditions near the breeding islands. If open water existed they often landed and showed brief courtship activity before returning again to the outer fjord to feed. These reconnaissance visits increased in duration as nesting approached. Pairs were often seen resting on pack-ice or along the shoreline of nesting islands before ice bridges disappeared, but rarely up on the island itself until bridges had melted.

During years when late ice-melting delays nesting, large groups of birds may be seen loafing near the nesting islands while waiting for break-up. During such years birds usually begin ascending the island to select a nesting site on the same day that the ice bridge disappears.

Ice conditions and nesting chronology

1982.—Sea-ice was late in leaving the inner part of the fjord in 1982. On the evening of June 10 the bridge between MH and the mainland disappeared. Early the following day a spot count by telescope from the mainland revealed 254 females and 268 males on the water in the immediate vicinity of the island, with 6 females and 10 males up on land. A similar count near PHØ, which still had an ice bridge, showed 50 females and 60 males, none of which were up on the island. On June 13 about 200 pairs were counted on MH and laying had begun.

The ice bridge to PHØ finally disappeared 20 days later on June 30. However, several pairs quite unexpectedly were seen up on the island on June 13, and two days later the first nest was initiated. During the next 15 days approximately 40 different females attempted to nest on PHØ. All eggs however were removed by a fox during two different visits to the island, one on June 25 and another on June 30. The majority of females had only laid 1–3 eggs when the fox arrived and most appeared to have attempted a re-nesting, apparently on the same island. Laying proceeded normally after the ice bridge disappeared.

1983.—This was an intermediate ice year. The ice bridge to MH disappeared on May 5, just a few days before Eiders were first seen in the vicinity of the two islands. Thus few if any Eiders could actually have observed the ice bridge from MH to the mainland this year. Birds were first observed up on land on May 31 and the first nest was started on about June 2.

The bridge to PHØ disappeared on June 2, i.e. 27 days later than on MH, but only 3 days after birds were first seen on MH. The first eggs were laid on PHØ on June 4.

1984.—Little ice formed on Kongsfjorden during the winter of 1983–84 and by mid-March both islands had lost their ice bridges. Furthermore, by April 19 (about 5 weeks before nesting) the other 3 major nesting islands in the fjord also had lost their ice connections to the mainland (Lydersen & Gjertz 1986). Thus all the major nesting islands in the fjord were ice-free and available as nesting sites long before Eiders began making reconnaissance flights over the area in late April. Birds were first seen ashore on both islands on May 20, and the first eggs were found on MH on May 24, and on PHØ on May 26.

1985.—Ice conditions in 1985 were a near repeat of 1984, with both of the study islands free of ice bridges long before Eiders entered the inner fjord. Consequently, females were able to select freely between both study islands, unhindered by ice, for the second year in a row.

1986.—Spring breakup occurred very late. The ice bridge between MH and the mainland disappeared on June 25, and between PHØ and the mainland June 29.

1987.—Both islands were ice-free in early May 3–4 weeks prior to laying.

Nesting numbers and density

Table 1 shows the number of nesting females on both islands each year. Nesting numbers were considerably influenced by the availability of other islands as nesting habitat in the fjord. This was in turn affected by ice conditions (Mehlum 1991, this volume).

Birds nested dispersedly over the greater part of both islands, though densities varied somewhat locally within the islands, apparently due to slight differences in habitat quality and the annual pattern of snow melting (Parker and Mehlum unpubl.). Fig. 2 shows the density of nesting females hectare⁻¹ on both islands during each year. The greatest difference in density between the two islands occurred in 1982 when late ice-melting delayed laying on both islands. MH in turn became ice-free 20 days ahead of PHØ, and many birds which might have otherwise nested on PHØ were seemingly forced to nest on MH.

The pattern of nesting density on the two islands in 1982 may have been slightly influenced by two factors. First, Eiders unexpectedly began nesting on PHØ before the ice bridge disappeared there. This initially may have stimulated some individuals to nest on PHØ that otherwise would have nested on MH, had not the "false start" been made. On the other hand, the two fox visits may have frightened some birds from PHØ to MH. The impact of these two factors was impossible to assess, though our impression was that they were of only minor importance. Indeed, the main division of birds between the two islands seems to have occurred already before the disappearance of the ice bridge to MH on June 10, judging from the obviously larger group of birds gathered in the near vicinity of MH then (no accurate count available).

The main dispersal of nesting females between the two islands occurred in 1983. The density on MH was reduced by more than half, and more than doubled on PHØ. MH was ice-free before birds arrived, which may have affected their initial choice. However, PHØ lost its ice bridge

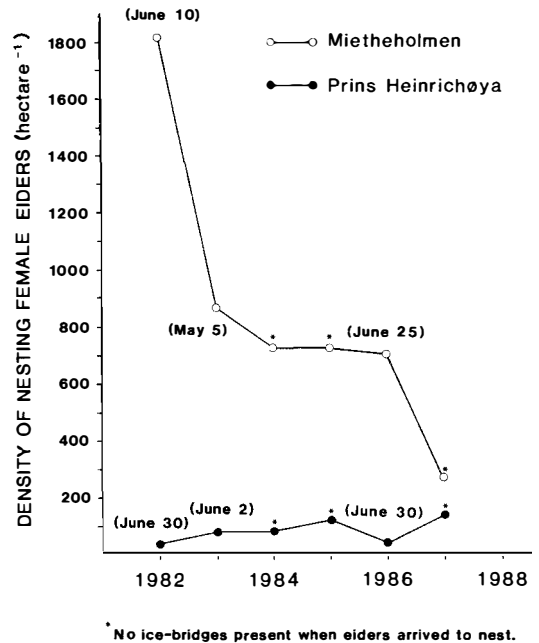


Fig. 2. Density of nesting female Common Eiders on the two study islands, Mietholmen and Prins Heinrichøya, during 6 years. Date on which the ice bridge to the mainland disappeared each year is indicated in parentheses.

on the same day that laying began on MH, thus making PHØ available for nesting from the start of laying. Under these conditions it was predicted that the nesting density between the two islands would even out, and this did in fact occur.

In 1984 and 1985 birds could nest unhindered by ice bridges, and our hypothesis predicted that nesting density would be the same on both islands during these years. This obviously did not occur, though there was a weak tendency in this direction (Fig. 2). In 1985, after 2 years without ice, nesting density was still 6.4 times greater on MH than on PHØ and significantly different from that predicted by hypothesis ($X^2 = 614.8$, 1 df, $p < 0.001$).

In 1986 late spring breakup delayed nesting in Kongsfjorden. MH became ice-free 4 days before PHØ, and again many birds were apparently

Table 1. The number of nesting female Common Eiders on two islands in Kongsfjorden, Svalbard, during 6 breeding seasons.

	1982	1983	1984	1985	1986	1987
Mietholmen	670	320	269	268	262	100
Prins Heinrichøya	60	167	191	277	92	334

“forced” to nest at high density on MH. As predicted, the difference in nesting density between the two islands increased (18.6 times greater on MH) relative to 1985 when both islands were ice-free before laying started. The difference in density in 1986 however was much less than that in the other late ice-year of 1982 (73.3 times greater than MH), probably in part because PHØ lost its ice bridge only 4 days after MH, compared to 20 days after in 1982.

In 1987 both islands were ice-free long before nesting started and birds could again choose freely between them. Accordingly, nest density on MH declined to only 2.0 times that on PHØ, though still significantly greater ($X^2 = 37.3$, 1 df, $p < 0.001$). Thus, the difference in nest density declined from 73.3 to 2.0 times greater on MH during 5 successive breeding seasons, 3 of which were totally unaffected, and one only slightly so, by late ice breakup.

Why was dispersal slower than predicted?

Eiders in both temperate and arctic regions show high site-tenacity, usually returning to previous nesting islands, and often to the original nesting bowl (Cooch 1965; Reed 1975; Wakely & Mendall 1976). It is not known how tenacious Svalbard Eiders are, though site-tenacity in this population must be influenced by the highly variable ice conditions there. Site-tenacity, however, seems to be the most likely explanation for the comparatively slow dispersal of nesting birds between the two islands, particularly in 1984 and 1985. Despite the availability of considerable space on PHØ during these 2 years, birds returning to this immediate area may have preferred to continue nesting at high density on MH simply because they had nested there previously, even though high density nesting there had originally been “forced”. Likewise, some birds may have preferred not to nest on MH in 1982 (despite its being ice-free long before PHØ) and instead wait for PHØ, again because they had nested on PHØ earlier. It is also conceivable that females nesting for the first time tend to return to the island they had hatched on, which would further strengthen the time lag in nesting dispersion.

There is further evidence to support the contention that choice of a nesting island in Kongsfjorden is influenced by the previous year's pattern of island selection. During the winter of 1971–72 Kongsfjorden did not freeze over

permanently (Anderson et al. 1974), and in the spring of 1972 birds could freely select among the 5 major nesting islands in the fjord. Despite this abundance of space, the majority crowded onto the 2 smallest islands, namely the 2 that are usually ice-free first (Anderson et al. 1974). During the previous nesting season of 1971 the spring breakup had come late (Gullestad 1973), and most Eiders presumably had been forced to nest densely on these 2 islands. Thus birds in 1972 seem to have returned to the two small islands they had been forced to use the year before, despite having a much greater nesting area available to them. Also, in 1982 considerably more Eiders were seen near MH *before* either island was ice-free, indicating that some preliminary selection was occurring before spring breakup, possibly due to site tenacity. Indeed, nesting density had been 27 times greater on MH the previous year (1981) due to late ice conditions (Mehlum 1991, this volume).

Belopol'skii (1961) and Ahlén & Andersson (1970) believed that dense nesting among arctic Eiders was in part a protective adaptation against avian predators such as gulls. If this is the case, then why would few Eiders nesting on a large island tend to disperse rather than nest clumped together (Parker unpubl.). There is good evidence that high density nesting on islands in arctic regions is initially a result of Eiders having been forced to nest on few islands during late ice years (Ahlén & Andersson 1970; Mehlum 1991, this volume). This high density is then somewhat prolonged in subsequent years, seemingly due to the stabilizing effect of site-tenacity. Thus dense nesting *per se* is probably not an important part of the Eider anti-predator strategy as reported for obligate colonial nesters (see Perrins and Birkhead 1983), but rather the result, at least initially, of a drastic reduction in suitable nesting area during late ice years. Whether nesting Eiders on islands in Kongsfjorden would eventually disperse maximally after many years without ice is unfortunately a difficult hypothesis to test.

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Egg predation in a breeding colony of the Common Eider *Somateria mollissima* in Kongsfjorden, Svalbard

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Mehlum, F. 1991: Egg predation in a breeding colony of the Common Eider *Somateria mollissima* in Kongsfjorden, Svalbard. *Norsk Polarinstitutt Skrifter* 195, 37–45.

Egg predation was studied in a colony of Common Eiders *Somateria mollissima* in Svalbard during three breeding seasons, 1982–1984. The colony was located on the small island Mietheholmen (3700 m²) and was inaccessible to the Arctic Fox *Alopex lagopus* after the late spring breakup of the surrounding sea-ice. Egg-laying started after the island was free of ice. The main predators on Eider egg was the Glaucous Gull *Larus hyperboreus*. Based on mean daily egg predation rates during different parts of the breeding period, an estimate of the total egg loss was made. A total of 41.5, 77.9 and 77.9% of all eggs laid were subject to predation or in other ways lost during the 25-day incubation period in the three breeding seasons 1982–1984 respectively. The lowest predation rate was registered in the most densely populated parts of the colony. All predation observed occurred while the female was away from the nest for short rest bouts on the sea.

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Introduction

In Svalbard the main predators on Common Eider *Somateria mollissima* eggs are the Arctic Fox *Alopex lagopus* and the Glaucous Gull *Larus hyperboreus*. Most Eiders nest in more or less dense colonies on islands, where the nests are inaccessible to the fox after the breakup of the winter ice.

The Svalbard Eider population is thought to have declined dramatically during the last century due to exploitation of eggs and down. To protect the population, hunting was prohibited in 1963, and 15 bird sanctuaries comprising the main breeding island and island groups were defined in 1973. However, the expected increase in population size as a result of these protection measures has not been evidenced. A compilation of the number of breeding Eiders in the Kongsfjorden area during the last two decades shows a relative stable population (Mehlum 1991, this volume). It is suspected that an increase in the population of the Glaucous Gull may be depressing the growth of the Eider population.

This paper gives an account of the impact of egg predation, especially by the Glaucous Gull, on an Eider Colony in Svalbard. Different aspects of the predation on Eider eggs and ducklings have been studied and documented in Svalbard in recent years. Ahlén & Andersson (1970) presented estimates of egg predation based on data from only a part of the incubation period. Hagelund & Norderhaug (1975a, 1975b)

have studied the reproduction of the Eider at a mainland habitat at Kapp Linné, but there the Arctic Fox had access to the nests and was probably responsible for a significant part of the predation recorded.

Study area

The Eider colony at the small island Mietheholmen (Fig. 1) in Kongsfjorden (78°55'N, 12°10'E) was selected as the study area. Eiders

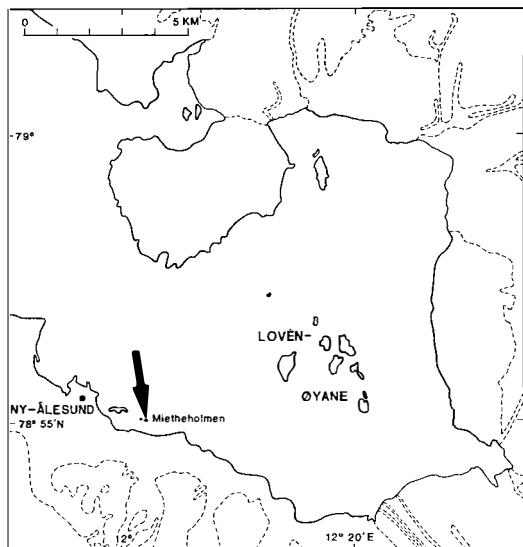


Fig. 1. Location map.

breed at relatively high density on this island. During counts in 1981, 1982, 1983 and 1984 respectively 482, 670, 320, and 269 nests with eggs were recorded on the 3,700 m² island. The nests were placed in shallow scrapes on a flat plateau 2–3 m above sea level. The very scarce vegetation is dominated by tiny specimens of *Cochlearia officinalis*. Some of the nest rims were covered with *Poa alpigena*. Mieteholmen is usually one of the first islands in the fiord to be free of surrounding sea-ice, and is thereby inaccessible to foxes living on the mainland.

Material and methods

The investigation was carried out in June and July of 1982, 1983 and 1984.

In 1982 the first visit to the island was made on 19 June, and then the egg-laying had just started. An area of approximately 750 sq.m. consisting of 200 nests was selected for detailed study. Each nest in this study plot was registered and every egg labelled with egg and nest numbers. On four later occasions (24 June, 30 June, 6 July, and 11 July) the content of every nest in the area was controlled. All the newly established nests in the previous period were also registered. In order to minimize the influence of human disturbance the number of visits made to the island was limited. A total of 297 nests were registered in the study plot.

In 1983 the first visit to the island was made on 4 June, just after the start of the egg-laying period. The study plot was slightly expanded compared to the previous year, and the eggs and nests labelled in the same way. The study plot was revisited nine times, the last visit being on 17 July. A total of 235 nests with eggs were recorded.

The study was continued in 1984 with the same procedure as in 1983 with ten visits between 1 June and 15 July. A total of 184 nests with eggs were recorded in the study plot.

The nest attendance of incubating females was monitored in 1983 by use of time-lapse video recordings. The monitoring was made in the period 26 June–5 July, i.e. when most females were in the second half of the incubation period. A total of 11 nests were monitored and the mean observation time per nest was 178 h, 31 min. In some instances the observation time was not continuous due to disturbances by people or bad video quality.

At the end of the breeding seasons all nests were mapped according to a coordinate system. An accuracy of 10 cm was used. This mapping was done to calculate an index for the density of other nests surrounding each nest. The index is based on the number of nests within a circle with a radius of 1 m surrounding the nest. The index value is given in number of nests per square metre. Nests regarded as subjected to predation are those where eggs have completely disappeared from the study plot during egg-laying and incubation. The true predation may be a little less than the actual disappearance of eggs. Some eggs may have been moved away from the study plot by the Eiders themselves. A female Eider was seen to fly away from the nest with an egg in her beak and then drop it into the nearby sea. Empty nests at the end of the incubation period could be the result either of predation or of the hatching of the eggs. In the few cases which were doubtful, the eggs were supposed to have been hatched. This assumption does not influence the general picture of the predation.

Our presence on the breeding islands during the nest controls may to some extent have influenced the predation of eggs. However, we tried to minimize the disturbance as much as possible, and only a negligible number of eggs were seen taking by the gulls during our visits.

Results

Breeding phenology

The occupation of nests and the eggs laid during the three breeding seasons are shown in Figs. 2–4. Fig. 2 illustrates the number of occupied nests during different parts of the breeding season, while Fig. 3 shows the cumulative number of occupied new nests. A comparison of the courses of egg-laying during the three years is presented in Fig. 4.

1982.—In 1982 the sea ice around Mieteholmen broke up on 9 June, and from about 11 June the Eiders occupied the island. On that date 10 males and 6 females were observed resting on the island. The number of birds present increased rapidly, and when we first visited the island on 19 June, incubation had already started. In the study plot 67% of the total number of nests were occupied at this time. During the next five days another 25% of the nests were established.

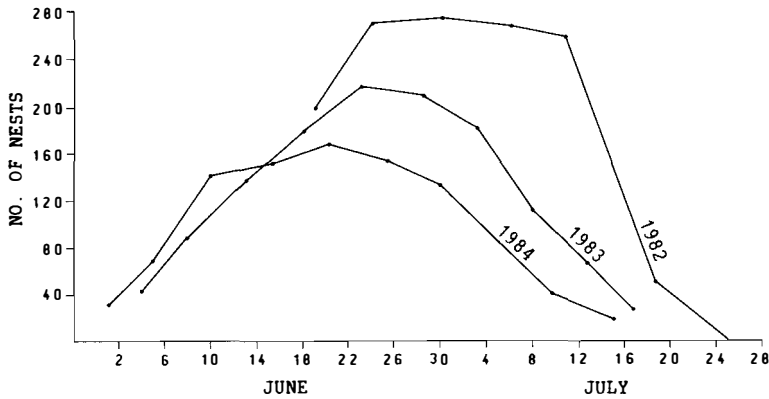


Fig. 2. Number of Eider nests with eggs during different parts of the breeding season in the study plot at Mietholmen 1982-1984.

1983.—In 1983 the sea-ice around the island broke up on 5 May, and the first Eiders were seen ashore on 31 May. At our first visit to the colony on 4 June, 41 nests had been established. The increase in the number of occupied nests was lower than in 1982, and the total number of nests also (Fig. 3). The median egg-laying date was six days earlier in 1983 than in 1982 (Fig. 4).

1984.—In 1984 the sea-ice conditions were still more favourable to the Eiders than the previous year, and the ice around Mietholmen broke up as early as mid-March. On a visit to the island on 23 May two Eider nests were found, each with one egg, but most of the island was snow-covered and thereby unsuitable for the Eiders (H. Parker, pers. comm.). By 1 June the island was almost

completely snow-free and 33 nests were established. The occupation of nest sites shows a similar pattern to 1983, but levelled off at a lower number (Fig. 3). The median egg-laying date was five days earlier in 1984 (Fig. 4).

The incubation period of Svalbard Eiders has been stated to be 24-25 days (Hagelund & Norderhaug 1975a). In 1982 the hatching had just started when we visited the colony on 11 July. This implies that the incubation must have started in some nests as early as 16 June. On 19 July the number of nests with incubating birds was 48, and on our last visit to the island, on 25 July, the whole colony had left the island.

The first hatching in 1983 was recorded on 28 June, which indicates that incubation started before 3 June. The corresponding values for 1984

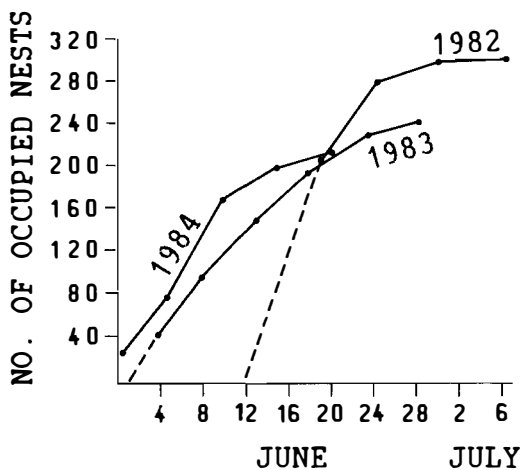


Fig. 3. Cumulative number of occupied new nest sites in the study plot in the three different seasons. The hatched lines are extrapolations to the start of egg-laying.

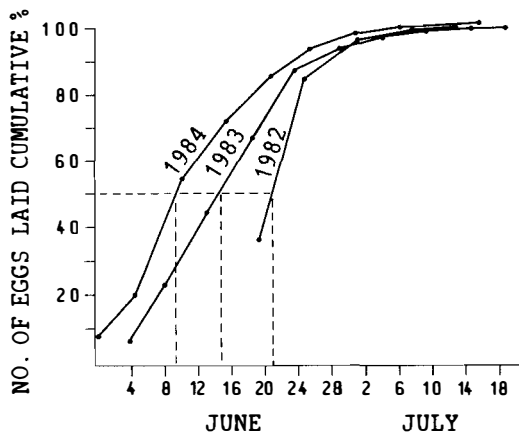


Fig. 4. The course of egg-laying in the study plot during the three years. The median laying dates are indicated by the hatched lines.

were 25 June for the first hatching and 31 May as the start of incubation.

The maximum values of mean clutch sizes within the study plot in the different periods were higher in 1982 (mean \pm s.d. = 5.4 ± 2.0) than in both 1983 (2.7 ± 1.1) ($t = 13.4$, $p < 0.001$) and 1984 (2.5 ± 1.2) ($t = 16.5$, $p < 0.001$). The large clutch size in 1982 was partly due to dump nesting. An analysis of the clutch sizes are presented in further details elsewhere (Mehlum 1991, this volume). In 1982 a total of 1687 eggs were reported in 297 nests in the study plot. Both the total egg (982) and nest (235) number were considerably lower in 1983. Still lower values were recorded in 1984 (744 eggs in 184 nests).

Presence of predators

The main avian predator of the Eider eggs was the Glaucous Gull, but one or two individuals of

the Great Black-backed Gull *Larus marinus* were also frequently seen near the island. One or two specimens of Arctic Skua *Stercorarius parasiticus* were seen a few times and a Great Skua *Stercorarius skua* was seen flying low over the colony once. In all three years 5–10 gulls were normally present on or in the immediate vicinity of the island during the periods investigated.

Predation

The egg predation for the different time periods between visits during the three breeding seasons is summarized in Table 1. Of the 1687 different eggs laid in 1982, 493 (or 29.2%) were subject to predation during the 22-day study period. In 1983, 583 (or 59.4%) of 982 eggs were lost during the 43-day study period. In 1984, 432 (or 58.1%) of 744 eggs were lost during the 45-day study period, almost the same as the percentage of 1983.

Table 1. Egg predation between successive visits in the study plot at Mietheholmen 1982, 1983 and 1984.

Year/period	No. of nests with eggs*	% of nests subjected to predation	Total no. of eggs*	Mean clutch size*	Eggs lost in period				
					Total	%	/day	/nest	/nest/day
<i>1982</i>									
19–24 June	200	8.0	605	3.0	19	3.1	3.8	0.10	0.02
24–30 June	274	22.3	1,442	5.3	121	8.4	20.2	0.44	0.07
30 June–6 July	278	32.7	1,507	5.4	229	15.2	38.2	0.80	0.13
6–11 July	271	22.1	1,326	4.9	124	9.4	26.6	0.49	0.09
All periods	–	–	1,687	–	493	29.2	22.4	–	0.09
<i>1983</i>									
4–8 June	41	53.7	67	1.6	29	43.3	7.3	0.71	0.18
8–13 June	89	58.4	198	2.2	76	38.4	15.2	0.85	0.17
13–18 June	139	43.2	331	2.4	88	26.6	17.6	0.63	0.13
18–23 June	182	30.8	469	2.6	88	18.8	17.6	0.48	0.10
23–28 June	218	22.9	573	2.6	90	15.7	18.0	0.41	0.08
28 June–3 July	211	28.4	552	2.6	99	17.9	19.8	0.47	0.09
3–8 July	183	16.9	425	2.3	50	11.8	10.0	0.27	0.05
8–13 July	113	15.9	308	2.7	39	12.7	7.8	0.35	0.07
13–17 July	66	16.7	162	2.5	24	14.8	6.0	0.36	0.07
All periods	–	–	982	–	583	59.4	13.6	–	0.09
<i>1984</i>									
1–5 June	31	54.8	61	2.0	23	37.7	5.8	0.74	0.17
5–10 June	69	47.8	139	2.0	43	30.9	8.6	0.62	0.12
10–15 June	143	45.5	353	2.5	108	30.6	21.6	0.76	0.15
15–20 June	153	31.4	381	2.5	76	19.9	15.2	0.50	0.10
20–25 June	171	28.1	389	2.3	70	18.0	14.0	0.41	0.08
25–30 June	157	23.6	372	2.4	50	13.4	10.0	0.32	0.06
30 June–5 July	134	13.4	320	2.4	30	9.4	6.0	0.22	0.04
5–10 July	84	11.9	190	2.3	15	7.9	3.0	0.18	0.04
10–15 July	40	25.0	89	2.2	17	19.1	3.4	0.43	0.09
All periods	–	–	744	–	432	58.1	9.8	–	0.09

(* = at the beginning of period).

As seen from Table 1, 1983 and 1984 show very similar predation patterns with the highest percentage of plundered nests during the first part of the nesting season, coinciding with the low number of eggs and nests. In 1982 the egg-laying was more synchronous with the number of nests and eggs increasing rapidly after the first occupation of the island. During the first five-day period a very low predation rate was recorded.

During all three breeding seasons the highest absolute predation occurred in the middle of the nesting period. However, except for during the establishment of the colony, the daily number of eggs lost was generally higher in 1982. The actual predation during the last three periods between nest controls in the years 1983 and 1984 may be higher than the values indicated in Table 1 due to difficulty in discriminating between nests plundered just before hatching and nests empty after the hatching of eggs (as pointed out in Methods). Excluding these six periods, the rest of the predation data from 1983 and 1984 may be compared with the 1982 data.

In Fig. 5 the course of predation is shown for eggs laid during different time-intervals in the years 1982–1984. For all time-intervals in the years 1983 and 1984 the predation was highest during the first days after egg-laying. In the relatively late and synchronous year 1982, however, the predation was generally low during the whole incubation period.

Estimates of the probability of an egg being taken during the 25-day long incubation period are presented in Table 2. The estimates are obtained by extrapolating the mean daily predatory rate for observation periods of 17–22 days in length. In the late and synchronous season of 1982 an egg had a 41.5% risk of being taken, while eggs in both 1983 and 1984 had the corresponding value of 77.9%.

Predation and nest attendance

The time-lapse video recording showed that of the 11 nests studied, 8 were plundered. During the 178 h, 31 min monitoring time, a total of 40 absences were recorded. These observations yielded a nest attendance of 99.86%. The mean of the absence periods was 4 min, 10 sec; the distribution of absence period lengths is shown in Fig. 6. The number of absence periods varied among individuals (from 1 to 8), but the mean number of absences per day was 0.49. This value

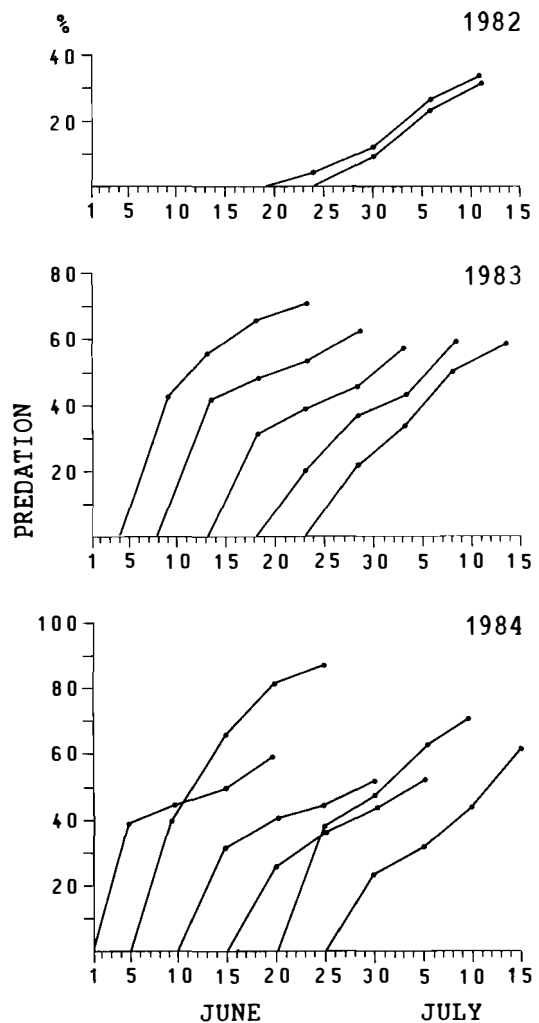


Fig. 5. The course of predation of Eider eggs laid during different parts of the breeding season. Eggs are laid during the days just before the date where the lines cross the X-axis.

means that the average time span between each absence period of an incubating Eider was 49.2 hours.

There was no significant difference between the number of absence periods during the night (1800–0600, $n = 23$) and day (0600–1800, $n = 17$) ($\chi^2 = 0.9$, $p > 0.1$).

All predation occurred while the female was away from the nest for short rests on the sea. On 10 occasions (25% of all absence periods) Glaucous Gull activity at the nest was noticed while the female was away. On 5 of these 10 occasions (50%), eggs were removed by the gulls.

Table 2. Predation rates of eggs laid during different time intervals in the years 1982–1984. Estimates of predation rate for the total incubation period are based on the mean daily predation rates.

Egg laying period	Observation period (days)	No. of eggs lost	% of eggs laid
<i>1982</i>			
before 19/6	19/6–11/7 (22)	194	32.4
19/6–24/6	24/6–11/7 (17)	233	30.7
Estimated for 25 days incubation period			41.5
<i>1983</i>			
before 4/6	4/6–23/6 (19)	47	70.1
4/6–8/6	8/6–28/6 (20)	103	63.6
8/6–13/6	13/6–3/7 (20)	122	58.4
13/6–18/6	18/6–8/7 (20)	140	62.5
18/6–23/6	23/6–13/7 (20)	114	61.0
23/6–28/6	28/6–17/7 (19)	42	59.2
Estimated for 25 days incubation period			77.9
<i>1984</i>			
before 1/6	1/6–20/6 (19)	36	60.0
1/6–5/6	5/6–25/6 (20)	84	87.5
5/6–10/6	10/6–30/6 (20)	135	52.7
10/6–15/6	15/6–5/7 (20)	72	54.5
15/6–20/6	20/6–10/7 (20)	61	71.8
20/6–25/6	25/6–15/7 (20)	44	63.8
Estimated for 25 days incubation period			77.9

One or several gulls approached the unguarded nest shortly after the female had left the area (after 1 minute on the average). The gulls were usually attacked by neighbour female Eiders, which lowered the gulls' success in robbing the nests.

Although all the predation recorded during the video monitoring period occurred after the female had covered the eggs with down and left the nest for a short rest, we have also observed that the gulls can actively pull the female away from the nest and take the eggs.

Predation and clutch size

We suggested that some nests were more vulnerable to predation than others. First we looked at the number of eggs in the nests at the start of a period and then we registered egg loss at the end of the period. The recorded data from the seasons are presented in Fig. 7. The data from 1983 and 1984 show a significantly higher predation rate of nests with only one egg than in larger clutches. In 1983 46.6% of the eggs in one-egg clutches were taken compared to 12.3% in nests with clutch sizes > 1 egg ($X^2 = 158.2$, $p > 0.001$). Similarly, in 1984 36.7% of the eggs in

one-egg clutches were taken, compared to 21.3% of the nests with larger clutch sizes ($X^2 = 26.8$, $p < 0.001$). In 1982 the data seem to indicate a slightly higher predation rate on clutches with one egg or more than five eggs. However, no significant differences in the predation rate between predation on these clutches compared to others were found.

Predation and nest density

A closer look at the spacing of nests subjected to predation reveals that the density and the distribution of neighbouring nests are of importance for the predation rate. Because of the relatively long period of nest establishment in 1983 and 1984, the number of neighbouring nests for each nest varied greatly. Only data from 1982 are therefore used in the following analysis. Of the 200 nests occupied before 19 June in 1982, eggs were lost in a total of 120 nests. Of these, 91 nests were classified as high density nests (i.e. more than or equal to 1 neighbouring nest per sq.m) and 109 nests as low density nests (i.e. less than 1 nest per sq.m). Of the high density nests, 45 (or 49.5%) were subjected to predation; of the low density nests 75 (or 68.8%) were plundered. The difference is statistically significant ($X^2 = 7.74$, $p < 0.01$).

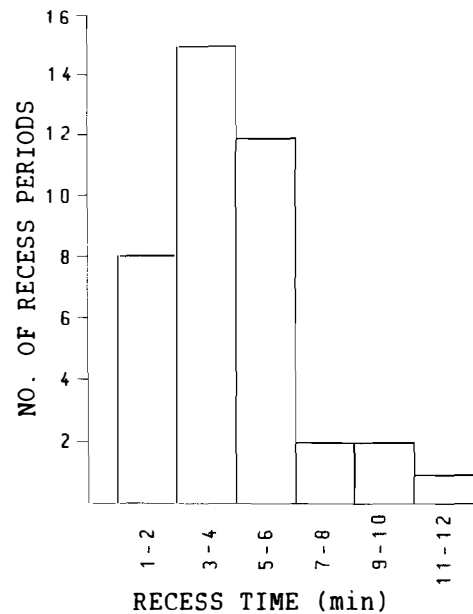


Fig. 6. Distribution of the lengths of absence periods in incubating Eiders.

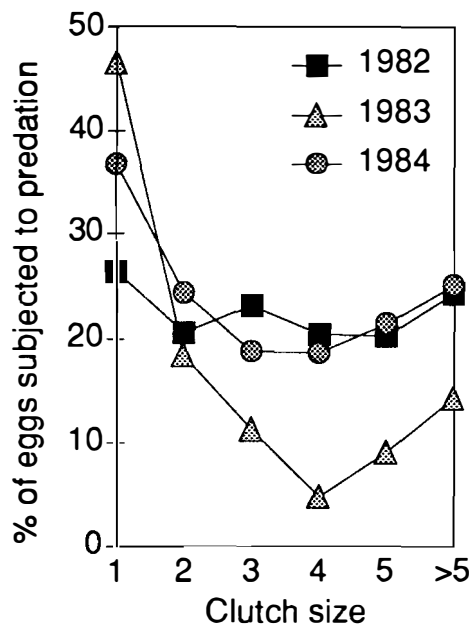


Fig. 7. The percentage of eggs subjected to predation in Eider nests with different clutch sizes.

We suppose that the difference in predation between high and low density nests might be due to the predator's need for space to avoid attacks from neighbouring Eiders when it approaches to plunder a nest. To test if high density nests were chosen randomly by predators, or if nests with unevenly distributed neighbour nests were selected, we divided a circle with a radius of 1 m around each nest into four sectors of 90 degrees. Of all the 91 high density nests, 24 had neighbours in all four sectors, and of these 6 (or 25.0%) nests were plundered. Of the 67 nests with neighbours in less than four sectors, 39 (or 58.2%) were plundered. The difference between these two groups is statistically significant ($X^2 = 7.88$, $p < 0.01$). The results indicate that nests evenly surrounded by close neighbours suffer less predation than nests with fewer or no close neighbours.

Discussion

The daily number of eggs subject to predation in 1982 was about twice the number in 1983 and 1984. However, the total number of eggs lost during the whole season was similar for the three years. This is due to the difference in breeding

synchronization between 1982 and the two succeeding years. The 1982 season was much shorter than the 1983 and 1984 seasons. This indicates that the total predation pressure is fairly constant from year to year, regardless of the number of nests and eggs present.

Previous studies reveal a great variation in the hatching success of the Eider (Table 3). The studies performed in Svalbard (Ahlén & Andersson 1970; Campbell 1975; Hagelund & Norderhaug 1975b; this study) all indicate a generally low hatching success of Eider eggs. Campbell (1975) also reported that the highest duckling predation occurred in the nest, while he believed that the proportion of ducklings taken by predators on the water was low. Hagelund & Norderhaug (1975b) also claimed that the loss of the young due to predation after leaving the nest was negligible in the Kapp Linné area. Other Eider populations suffer a high duckling mortality due to predators while on the water (Milne 1974; Swennen 1983; Mendenhall & Milne 1985). The Common Eiders in Svalbard leave their breeding grounds just after hatching and gather in groups along the outer coasts. This probably reduces the risk of gull predation of the ducklings. The high arctic population of the Common Eider seems therefore to have adapted to high egg and nesting mortality and low mortality of ducklings on the water.

Our studies (Mehlum 1991, this volume; this study) in the Kongsfjorden area and other Eider studies in Svalbard (Ahlén & Andersson 1970; Hagelund & Norderhaug 1975b) show that the clutch sizes and predation rates of eggs may vary extensively from year to year and from one breeding colony to the other. The situation may be quite different on two neighbouring islands. The predation rate may also be lower in densely settled colonies than in more scattered nesting colonies, as is also pointed out by Ahlén & Andersson (1970). In colonies with low nesting densities, the gulls do not risk the attacks of neighbouring female Eiders when approaching a nest. The presence of Arctic Terns *Sterna paradisaea* in a colony may also lower the predation by gulls (Ahlén & Andersson 1970).

The total egg loss at Mietheholmen was highest during the middle of the nesting season. However, a major part of the nests were subjected to predation either before completion of egg-laying or during the first days of incubation. The latter

Table 3. Egg predation and hatching success obtained in different Eider studies.

Locality	% egg production and other losses	% Hatching	Reference
Kongsfjorden, Svalbard	16.2–27.2*		Ahlén & Andersson 1970
Kongsfjorden, Svalbard	41.5–77.9		This study
Kapp Linné, Svalbard		50.4–72.2	Hagelund & Norderhaug 1975b
Northwest Territories, Canada	14.5–23.4		Cooch, 1965
St. Lawrence Est. Canada		15.5–52.0	Guignion 1968
St. Lawrence Est. Canada		14.4	Milne & Reed 1974
Beafort Sea Coast, Alaska		58**	Schamel 1977
Maine, USA		25.7	Paynter 1951
Sands of Forvie, Scotland		40.3–79.0	Milne 1974
Gulf of Bothnia, Finland	>24.7		Hildén 1964
South Sweden	1.4– 2.2		Gerell 1985
Netherlands		66.9–95.5	Swennen 1983

* Colonies without Arctic Fox predation.

** Eider and King Eider *Somateria spectabilis* combined.

is in accordance with the findings of Ahlén & Andersson (1970). The nests are especially vulnerable to predation between the start of egg-laying and the onset of incubation. After the first egg is laid, the female covers the egg with moss and other plant material, leaves the nest and does not return until she is ready to lay the next egg. Incubation usually starts after the laying of the third egg (Cooch 1965).

Since most of the observed predation during the incubation period occurred while the female was off the nest, the almost continuous nest attendance is an important factor in minimizing egg loss. As a consequence of this required high incubation constancy, the female is not able to feed during the incubation period and loses a considerable part of its body mass (Gabrielsen et al. 1991, this volume).

Small islands with densely populated Eider colonies are apparently very attractive to Glaucous Gulls and other avian predators. This study indicates that on such islands that Eiders should place their nests in close groups in order to obtain help from neighbours in defending their eggs against predators. Similar results have also been obtained by Schmutz et al. (1983) in his studies of the Hudson Bay Eider *S.m. sedentaria*.

Cooch (1965) stated that egg predation in the Eider is negligible when the population size is close to the carrying capacity of the area. At lower population sizes, however, predation may be an important factor to suppress the population growth to reach the carrying capacity. The present study partly supports this suggestion, since the percentage of eggs lost was significantly lower during the 1982 season (with the highest population density of breeding females) than in the two following years. In contrast to Cooch (1965), we also recorded a substantial predation at high population size (in 1982).

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Effect of down harvesting on nesting success in a colony of the Common Eider *Somateria mollissima* in Svalbard

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Mehlum, F., Nielsen, L. & Gjertz, I. 1991: Effect of down harvesting on nesting success in a colony of the Common Eider *Somateria mollissima* in Svalbard. *Norsk Polarinstitutt Skrifter* 195, 47–50.

The effect of down harvesting in a high arctic colony of breeding Eiders *Somateria mollissima* was studied in Svalbard in 1987. An experiment was conducted with three groups of harvested nests and one control group of unharvested nests. The nests were harvested in the first half, second half, or in both halves of the incubation period. A total of 716 nests were included in the experiment. No difference in nest success or egg loss was recorded between harvested and unharvested nests.

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Introduction

Egg and down harvesting of Common Eiders *Somateria mollissima* have long traditions in many places in the northern hemisphere. In some areas, for example in Iceland and northern Norway, local people contributed substantially to their annual incomes by “farming” Eiders (Doughty, 1979; Wold 1982). The Eider farms were privately owned and managed by the same families for decades. In Svalbard, as in most of Canada (Reed 1986), Eider colonies are located on public land. During the previous and the first part of this century eggs and down from Eiders were collected in large quantities in Svalbard, both by overwintering trappers and by summer hunting expeditions. A review of the down harvesting activity of this period is given by Rossnes (1986). Many different groups participated in this uncontrolled harvesting, which evolved into an overexploitation which caused a steady decline in the breeding Eider population.

There is still a market for eiderdown in Europe because of the recognition of its excellent quality as an insulating material in outdoor winter clothing and sleeping equipment. Down harvesting can therefore provide a profitable part-time income for traditional trappers working in Svalbard. It is thus important to know what effects this activity might have on the breeding success of the Svalbard Eider or on other bird species nesting within the Eider colonies. Some potential negative effects can be:

1. Increase in predation by gulls. When a person walks through a breeding colony, the breeding female Eiders leave their nest for some time before returning to continue incubation. While the female is away, the nest is subject to predation by Glaucous Gulls *Larus hyperboreus* or other avian predators. Mehlum (1991a, this volume) studied incubating Eiders in Kongsfjorden. These birds occasionally made short excursions (each lasting only a few minutes) to the sea, and 12.5% of the unattended nests were plundered by gulls.
2. Increase in energy expenditure of the incubating Eiders. There is a strong temperature gradient in high arctic environments between the inside of the nest and the ground below (Rahn et al. 1983). The insulating properties of the down reduces heat loss from the eggs to the cold ground. When down is removed from the nest, the thickness of the insulation layer is decreased and the female Eider must produce more heat in order to maintain a sufficiently high egg incubation temperature. Under normal conditions the female Eider loses ca. 40% of its body mass during the incubation period (Gabrielsen et al. 1991, this volume). An increased energy expenditure during incubation might cause the female to abandon the nest before hatching in order to secure its own survival.
3. Increased egg mortality due to changes in the nest microclimate. During normal develop-

ment eggs lose about 15% of their weight during incubation (Rahn et al. 1983). This weight reduction is primarily due to water loss, which is regulated by the gradient of water vapor pressure between the inside and outside of the nest.

Removal of down might change the humidity of the nest, ultimately increasing egg mortality.

To our knowledge no detailed studies have been performed to investigate the effects of down harvesting activity on the nesting success of Eiders. Reed (1986) made a pilot study in Canada, but the results were inconclusive. The present study examines the effects of down harvesting activity on the nesting success in a colony of Eiders in Svalbard. The design of the study did not allow us to identify to what extent the three above mentioned possible effects were influenced by harvesting.

Material and methods

The study was performed in 1987 at the islet Eholmen (77°36'N, 14°56'E) located at the mouth of Van Keulenfjorden along the western coast of Spitsbergen. One person (L.N.) was present on the island almost permanently during the experimental period (16 June – 19 July). The island covers an area of about 0.6 km². Eiders nest over most of the island, and a total of 1,499 nests were recorded, some of which probably represent renesting ducks. We estimated the total number of breeding pairs in 1987 at c. 1,400. Other breeding bird species in 1987 included Barnacle Goose *Branta leucopsis* (17 pairs), Pink-footed Goose *Anser brachyrhynchus* (one pair), Glaucous Gull (c. 10–15 pairs), Great Black-backed Gull *Larus marinus* (one pair), Arctic Skua *Stercorarius parasiticus* (one pair), Great Skua *Stercorarius skua* (one pair) and a colony of Arctic Terns *Sterna paradisaea* (unknown number). At the beginning of the experiment a total of approximately one hundred Glaucous Gulls were observed at two resting places on the northern and southern ends of the island.

A total of 800 Eider nests were included in the study. Each nest was marked by a numbered wooden stick and the number of eggs and quantity of down recorded. The quantity of down was classified by four categories: no down, small, medium or large amounts of down. Only nests

with medium or large amounts of down (n = 716) were regarded as fully laid and were included in the harvesting experiment. These nests were divided into one control group and three experimental groups according to how they were harvested:

- Group 1: Down not collected (control group)
- Group 2: Down collected in first half of the incubation period
- Group 3: Down collected in the second half of the incubation period
- Group 4: Down collected twice, both in first and second half of the incubation period

The incubation period of Common Eiders in Svalbard is 24–25 days (Hagelund & Norderhaug 1975). For many of the nests we did not know the exact date of the start of incubation. However, this was estimated by the occurrence of new nests in the colony, or at the end of the incubation by records of hatching eggs or newly deserted nests. The treatment of the different nests was selected at random. Varying amounts of down were collected from each nest, leaving the assumed minimum amount needed for sufficient insulation and covering of the eggs.

When performing the experiment the observer moved carefully through the colony, minimizing the disturbance of the incubating Eiders. All nests were visited once during the first half of the incubation period, and those nests in which down were sampled in the second half of the incubation period were visited twice. Additionally all nests were inspected at the time of hatching or just after desertion.

The hatching success of each nest was estimated by 1. counting the number of chicks in the nest, 2. counting the number of “pipping” eggs, or 3. counting the number of eggshells in newly deserted nests not disturbed by predators. The hatching success could only be determined for c. 56% of the nests initially selected for the experiment. Total hatching success or failure for almost all (n = 714) the nests could be determined.

To reduce predation, the number of Glaucous Gulls in the area was kept down with shooting. This was done to stimulate a situation where a down harvester employs predator control to increase the total nest survival. A total of 45 gulls were shot during the experimental period, mostly during the first part. We assumed that the predator control would have the same influence on the three experimental groups and the control

group since all four groups had been randomly selected within the colony.

The total mean egg clutch size at the start of the experiment was 3.1. There were no significant differences in clutch sizes among the four groups before down collection (Table 1). The number of chicks leaving the nests averaged 2.2, which gave an egg loss of 29.1% in nests which had not completely failed. As in the case of egg clutch size, there were no significant differences in the number of chicks produced per nest among the four groups. The mean nest loss for all the nests was 12.3%, ranging from 10.4% in nests where down was collected twice to 14.7% in unharvested nests. An analysis of variance shows that there was no statistical difference among nests of the three experimental groups and of the control group.

Based on our data on egg and nest losses, we can estimate the total egg survival in the colony between the first egg control and hatching:

$$\begin{aligned} \text{Total egg survival} &= \text{egg survival} \times \text{nest survival} \\ &= 0.709 \times 0.877 \\ &= 0.622 \text{ (or 62.2\%)} \end{aligned}$$

This estimate is equivalent to a total egg loss of 37.8%.

Discussion

The mean egg clutch size recorded in this study was within the normal range for the different islands studied in the Kongsfjorden area (Mehlum 1991b, this volume). We do not know the exact incubation stage of each of the nests during the first control. The estimated egg loss between the first nest control and hatching is

therefore probably an underestimate of the total egg loss between egg-laying and hatching. However, egg loss during incubation is high, and the actual value is likely to be close to the lower end of the range (41.5–77.9% of eggs laid) given for a colony studied by Mehlum in Kongsfjorden (Mehlum 1991a, this volume). This high loss is remarkable considering that the number of predators was kept down by shooting.

Down harvesting was not responsible for this high egg loss since the losses in the control group were not significantly different from the losses in the 3 experimental groups where down was collected. The presence on the island of a field worker could have contributed to an increased egg loss, but this is unlikely to be an important factor since the Eiders soon became accustomed to the human disturbance.

In this study we were unable to document any negative effects of down harvesting on the nesting success of Eiders. Reed (1986) had made a preliminary study in the St. Lawrence estuary, Canada, and found a 12% increased nest loss due to down harvesting. He also pointed out that the effect of down harvesting may vary from colony to colony according to predator abundance, climate, nesting cover and other factors. Reed's samples, however, were small and his results were not conclusive.

If down harvesting causes an increased weight loss of females (possible negative effect 2. of down harvesting, see Introduction) one would expect an increased rate of nest desertion by the females. We have no data on the physical condition of female Eiders at the time of egg hatching. However, we did not observe more deserted nests among the harvested than in the

Table 1. Summary table of clutch sizes and nest losses in harvested and unharvested nests. Results are presented as means \pm s.d. (No. of observations in brackets)

	Down not collected	Down coll. early	Down coll. late	Down coll. early and late	Differences (ANOVA) down not collected/collected		
					F	df	sign.
Egg clutch size at 1st control	3.19 \pm 1.11 (185)	3.09 \pm 0.98 (178)	3.16 \pm 1.07 (189)	3.05 \pm 1.05 (164)	0.660	3,712	n.s.
No. of chicks per clutch	2.23 \pm 1.57 (111)	2.14 \pm 1.48 (87)	2.25 \pm 1.59 (111)	2.22 \pm 1.45 (94)	0.082	3,399	n.s.
Nest losses (%)	14.7 (184)	12.4 (178)	11.7 (188)	10.4 (164)	0.663	3,710	n.s.

control nests. Thus, we have no evidence that the condition of the incubating birds was significantly affected by down harvesting. Our results also indicate that there was no increased egg mortality due to changes in nest microclimate (possible negative effect 3, see Introduction).

The energy expenditure of the incubating birds might be higher in harvested nests although we did not detect any differences in breeding success. Female Eiders with very low energy reserves after hatching might abandon their chicks. Most abandoned chicks will be adopted by other females in better condition. But the overall results might be a lowered chick survival. Other possible consequences are increased winter mortality in energetically stressed females, or lower energetical investment in breeding the next year if there is a negative correlation between investment in two successive years.

In the years following the conclusion of this study, down harvesting, with predator control, has continued. The total number of breeding Eiders on the island has increased steadily, and in 1990 c. 2000 nests were recorded (L. Nielsen, unpubl.). This indicates that the present down harvesting activity is not negatively influencing Eider population growth. This also indicates that lowered chick survival, increased female winter mortality, and lowered breeding investment by the females are not likely caused by down harvesting activity.

In conclusion, the present experiment did not evidence any significant negative effect of down

harvesting activity on the nesting success of Eiders at Eholmen. It was not possible to measure the effect of the permanent presence of a field observer on the island. The unexplained relatively high overall egg loss in the colony despite partial predator control is a subject for further investigation.

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Energy cost during incubation and thermoregulation in the female Common Eider *Somateria mollissima*

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Metabolic rate during incubation (IMR) was measured in two wild incubating Eiders at Ny-Ålesund, Svalbard (79°N). IMR, measured toward the end of incubation (day 15–20), averaged 0.80 ml O₂/g·h. The respiratory quotient (RQ) was 0.70, indicating that fat was the major metabolic fuel during this long period of fast. Both birds showed a decrease in mean daily energy expenditure with decreasing body mass but no significant decrease in specific resting metabolic rate.

Thermoregulation was studied in 12 non-incubating Eiders in the laboratory. Resting metabolic rate (RMR) averaged 0.86 ml O₂/g·h, thermal conductance (TC) 0.0240 ml O₂/g·h·°C and deep body temperature 40.1°C. The RMR value of non-incubating Eiders tended to be 7.5% higher than the IMR value of incubating birds (0.05 > p > 0.10, t-test). Both IMR and RMR values were above predicted values based on equations by Lasiewski & Dawson (1967) and Aschoff & Pohl (1970). TC was lower than values predicted from equations of Herreid & Kessel (1967) and higher than those predicted by Aschoff (1981).

Calculation of daily energy expenditure (DEE) during incubation (day 20) based on weight loss was 24% and 29% less, respectively, than DEE measurements derived from indirect calorimetry of incubating and non-incubating eiders. Measurements of water influx rate close to hatching suggested that Eiders increased their water consumption then.

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Introduction

The energy cost of incubation in birds has been estimated from measurements of loss of body mass (Prince et al. 1981; Croxall 1982; Croxall & Ricketts 1983; Grant & Whittow 1983), oxygen consumption (Norton 1973; Ricklefs 1974; Biebach 1979; Gessaman & Findell 1979; Vleck 1981; Haftorn & Reinertsen 1985; Gabrielsen & Unander 1987) and the doubly labelled water (DLW) technique (Pettit et al. 1988). Most metabolic studies have been performed in the laboratory and few on free-living birds (Brown 1984; Grant & Whittow 1983; Brown & Adams 1984), and most have shown the energy cost of incubation to be greater than the basal metabolic rate. Grant & Whittow (1983) and Brown (1984) however, reported the oxygen consumption of incubating Laysan Albatross (*Diomedea immutabilis*) and Marcaroni Penguins (*Eudyptes*

chrysolophus) to be significantly lower than that of non-incubating resting birds.

Female Common Eiders (hereafter called Eiders) abstain from feeding during 25 days of incubation resulting in a weight loss of 30–45% (Maline 1963, 1976; Cantin et al. 1974; Korschgen 1977). Little is known about the physiological adaptations to fasting in birds. Geese and penguins show a 30–50% decrease in resting metabolic rate (RMR) after 30 days of fasting (Benedict & Lee 1937; Le Maho et al. 1981). The thyroid hormones are involved in controlling oxygen consumption and metabolic rate (Falconer 1971; Etkin 1978). In birds it has been demonstrated that the level of thyroxin (T₄) increases while triiodothyronine (T₃) decreases after food deprivation (May 1978).

In this study we measured oxygen consumption and plasma concentrations of thyroid hormones of both incubating and non-incubating Eiders.

Estimates of energy expenditure based on oxygen uptake were compared to values calculated from weight loss of incubating females. Close to hatching we used tritium to study the water influx rate to determine if birds were drinking water toward the end of the incubation fast, as this could influence calculations of energy expenditure based on weight loss.

Material and methods

Metabolic Rate Measurements

Field work.—The field work was carried out at Ny-Ålesund on the north-western coast of Spitsbergen, Svalbard (Fig. 1). During the summer of 1983 we studied the incubation metabolic rate in two female Eiders nesting close to the settlement of Ny-Ålesund. On the fifteenth day of incubation each nest with clutch (4 and 5 eggs) and down was removed from the nest bowl and placed inside a plexiglass box (40 × 30 × 30 cm) at the original nest site. This procedure required about 30 minutes, and the females returned to the nest within 10–20 minutes to resume incubation. The chamber consisted of two hinged parts, the upper part of which was lowered down from a distance with a rope before performing the measurements (Fig. 2). The incubation metabolic rate (IMR) was measured in an open system in which the plexiglass box functioned as the metabolic chamber. The chamber was connected to a carbon dioxide (Binos-1, Leybold-Heraeus) and an oxygen (S-3A, R-1 and N-22M, Applied Electrochemistry Inc.) analyzer by means of a plastic tube. Air was dried and pumped through the system with a flow of 3.5–4.0 l/min. Airflow was measured in each experiment with a Tri-Flat flowmeter (10 A 3200, Fischer & Porter). Temperature in the box and in the bottom of the nest was measured with copper-constantan thermocouples connected to a digital thermometer (2190A, Fluke). Both birds were weighed at the end of the experimental period using a Pesola spring balance (± 5 g). In order to reduce overheating in the plexiglass box, we performed metabolic measurements only on cloudy days. Measurements were performed 1–2 times daily in 2–3 hour periods. All measurements were performed between day 15 and 20 of incubation.

Laboratory study.—The laboratory study of 12 non-incubating adult females was carried out at the research station of the Norwegian Polar

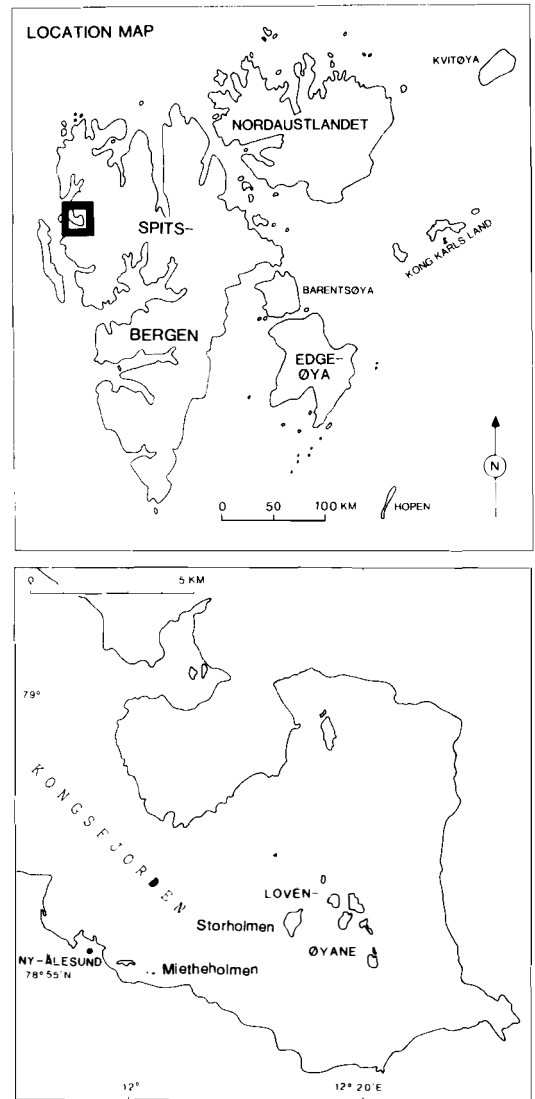


Fig. 1. Over, the Svalbard archipelago (with the exception of Bjørnøya to the south) showing the inner Kongsfjorden area and the location of Ny-Ålesund (enlarged, under) where the field work was carried out.

Research Institute in Ny-Ålesund during the summers of 1984–85. Birds were either captured on the nest using a bamboo pole with a nylon snare or caught with a net-gun (Coda Enterprises) while swimming. They were kept in individual outdoor cages without food for 1–2 days and given water ad lib. Metabolic measurements were performed within a minimum of 12 hours after capture according to the methods described by Gabrielsen et al. (1988). A metabolic chamber

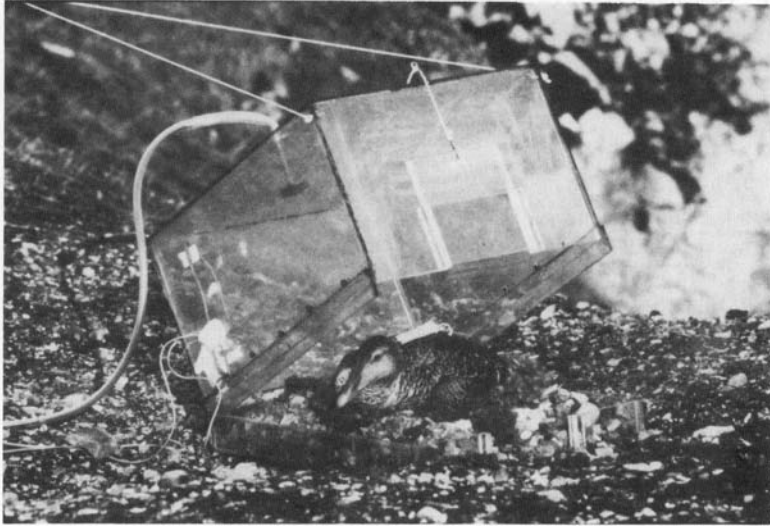


Fig. 2. A wild Eider duck incubating in a respiration chamber.

was briefly placed inside a climatic chamber where temperature could be controlled within $\pm 1^\circ\text{C}$ from -25 to $+30^\circ\text{C}$. Instrumentation was the same as that used in the study of incubating Eiders with the exception of air flow which was measured with a flowmeter (F 113, Hi-Tec) connected to a readout (Model E-0020). Temperature in the climatic and metabolic chambers was measured by thermocouples connected to a Fluke thermometer. Body temperature was measured continually by means of an epoxy-coated thermocouple inserted approximately 7 cm into the colon. Birds were exposed to a given chamber temperature for a minimum of 1.5–2.0 hour periods. The measurements were performed under full light conditions since these birds experience 24 h of daylight during the breeding season. Oxygen consumption ($\text{ml O}_2/\text{g}\cdot\text{h}$) and CO_2 -production ($\text{ml CO}_2/\text{g}\cdot\text{h}$) were measured during stable resting periods. Respiratory quotient (RQ) and energy expenditure (kJ/day) were also calculated. In calculating energy expenditure from oxygen consumption the conversion coefficient of 4.7 kcal per litre oxygen ($\text{RQ} = 0.71$) was used (Schmidt-Nielsen 1983; 1 kcal = 4.185 kJ). The final values for oxygen consumption and CO_2 production are accurate within $\pm 5\%$. All results are given at STPD and mean values are shown with \pm standard deviation.

Body weight measurements

Females nesting on the islands of Storholmen and Mietholmen in the Kongsfjorden area were

captured and weighed throughout incubation. The number of days each bird had incubated was estimated by measuring the density of the eggs in the nest. Egg weights in air were measured on a battery operated Ohaus digital scale (accuracy ± 0.1 g) and in water on a 50 g Pesola spring balance (accuracy ± 0.1 g). From mean egg density the number of days the female has been incubating could be estimated by using the equation $y = 1634.788 - 4878.271 x + 5034.848 x^2 - 1777.747 x^3$ (y = days of incubation, x = mean density of eggs). By using this equation it was possible to determine the number of days of incubation to within ± 2.5 days ($p < 0.01$) (Karlsen et al. in prep.).

Body weights of Eiders prior to egg-laying and 7–14 days after incubation were obtained from birds captured with a net-gun in Kongsfjorden.

Thyroid hormones

Birds collected for body weight measurements were also used for studies of plasma concentrations of thyroid hormones. A blood sample (2–3 ml) was taken from the wing vein using a heparinized syringe. The blood samples were kept on ice during transport to the laboratory for centrifugation. Plasma was thereafter stored at -20°C until assayed at the Norwegian College of Veterinary Medicine in Oslo, Norway. The total thyroxine (T_4) level in the plasma was determined by radioimmunoassay described by Larsen et al. (1973) and modified by Andresen et al. (1980). The antiserum used has been

described by Kruse (1976). The total triiodothyronine (T_3) level in the plasma was measured by a commercially available solid phase radioimmunoassay (Coat-a-Count, Diagnostic products Corp., Los Angeles, USA).

Water influx rate

Ten incubating Eiders close to hatching (mean = 23 days) were injected in the pectoral muscle with 0.75 ml tritium (1.34 mCi in each bird) and weighed before release. One to two hours after the injection, when the isotope had mixed thoroughly in the body water fluid (Degen et al. 1981; Williams & Nagy 1984), we recaptured the birds to obtain the initial blood sample. Blood samples were taken from the wing vein and the birds were released. Over the next 2–3 days we recaptured, weighed and sampled 6 of these birds once or twice. Blood samples were stored in heparinized microhematocrit capillary tubes and vacuum-distilled to obtain pure water. Isotope levels in water were measured by liquid scintillation spectrometry (Wood et al. 1975). Water flux rates were calculated by using equation 4 in Nagy and Costa (1980). Water volumes at recapture were calculated as initial fractional water content multiplied with body mass at recapture.

Thermal Conductance

Thermal conductance (TC) in non-incubating birds was calculated from the mass specific metabolic rate at ambient temperatures below the lower critical temperature. The TC was calculated by dividing oxygen consumption by the difference between body and ambient temperature at ambient temperatures below 0°C. TC (ml O_2 /g·h·°C) is expressed as “wet” conductance since evaporative heat loss was not excluded.

The lower critical temperature was determined from the intersection of the lines representing metabolic rate at low ambient temperatures and the line representing resting mean metabolic rate in the thermoneutral zone.

Results

Ambient, chamber, and nest temperatures

In Ny-Ålesund the means for daily ambient, maximum and minimum temperatures for June 1983 were 2.1, 4.0 and 0.6°C respectively. In July, respective temperatures were 5.2, 7.2 and

3.6°C (The Norwegian Meteorological Institute). While performing the field metabolic studies of female Eiders the mean temperature in the metabolic chamber and nest were 12.2°C (SD = 4.7°C) and 31.9°C (SD = 2.5°C) respectively.

Body weight loss during laying

Immediately prior to egg-laying the mean body weight of females was 2,442 g (SD = 149, n = 6). Some of these birds, however, may have already laid 1–2 eggs despite having been caught on the water. Female Eiders often cover their first egg and return to the water for some time before egg-laying is resumed. After laying the second egg, however, they leave the nest only occasionally for short periods (Hagelund & Norderhaug 1975). At the start of incubation female body weight averaged 2,106 g (SD = 156, n = 11) (Fig. 3) or 336 g less than pre-laying weight. The mean density of the eggs of these birds was 1.075 which is close to the density of freshly laid Eider eggs (Rahn et al. 1983). The average number of eggs produced by female Eiders nesting on Storholmen in 1984 was 4.4 g (Mehlum 1991a, this volume). With a mean initial egg weight of 98 g, this gives a mean clutch weight of 392 g. Thus this initial weight loss can mainly be ascribed to egg production.

Body weight loss during incubation

The mean body weight of female Eiders at hatching was 1,357 g (SD = 71, n = 16). The total weight loss during 25 days of incubation was 749 g or 35.6%. Weight loss from pre-incubation to hatching was 1,085 g or 44.4%.

Assuming an incubation period of 25 days, the average weight loss was 30 g per day. Weight loss, however, was clearly a non-linear function of time (Fig. 3). (Polynomial regression $y = 2114.5 - 52.188x + 1.064x^2 - 0.006x^3$, $r^2 = 0.80$, $y =$ body weight, $x =$ days of incubation).

The mean body weight of the birds, accompanied by their ducklings and caught 7–14 days after the main hatching period, was 1,713 g (SD = 136, n = 4). Since these birds were not accompanied by other females, we assume that these Eiders had laid and incubated.

Thyroid hormones

The variation in plasma T_3 and T_4 concentrations are shown in Fig. 4. Mean T_3 concentration was

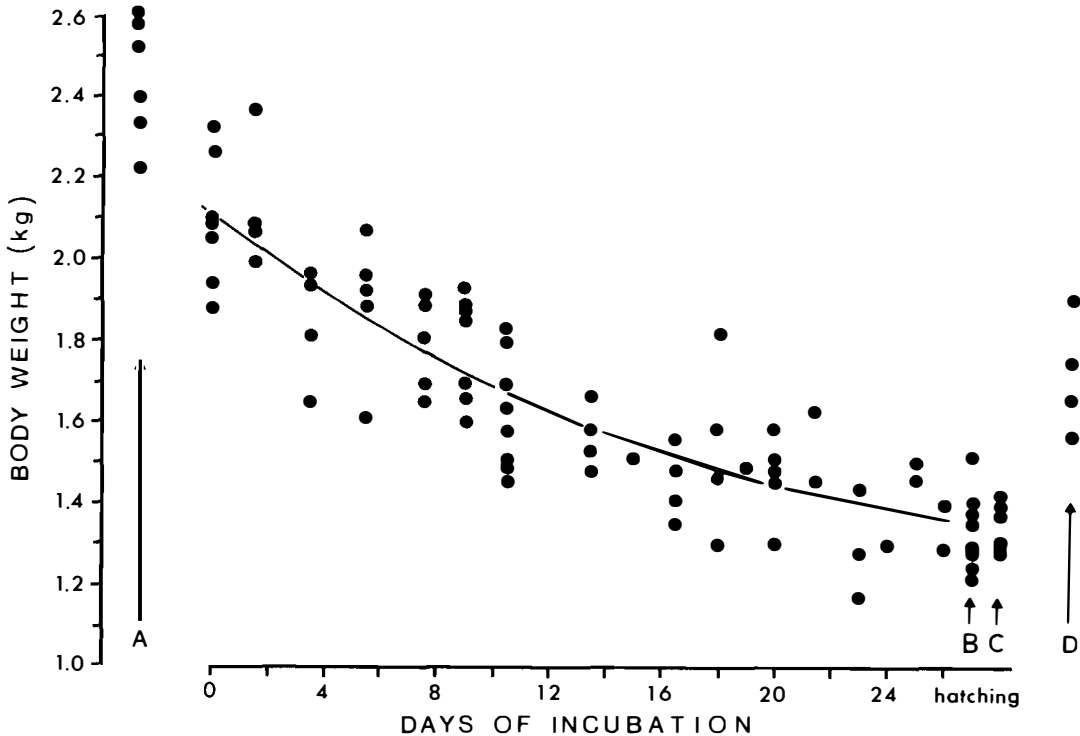


Fig. 3. Body weight of female Eiders before egg-laying (A), during incubation, at hatching (B), with newly hatched chicks but still in nest (C) and with ducklings 10–14 days after the main hatching period (D). Number of days of incubation was determined by the mean density of eggs in the nest using the following equation: $y = 1634.788 - 4878.271x + 5034.848x^2 - 1777.747x^3$ (y = days of incubation, x = density of eggs).

The weight loss curve is based on the following equation: $y = 2114.5 - 52.188x + 1.064x^2 - 0.0063x^3$ (y = body weight, x = days of incubation).

1.65 ng/ml (SD = 0.65, $n = 80$) and varied between 0.53 and 4.50 ng/ml. The egg-laying T_3 level was 1.48 ng/ml (SD = 0.81, $n = 6$) and 10–14 days after hatching level was 1.65 ng/ml (SD = 0.65, $n = 4$). Plasma T_3 levels increased throughout the incubation period ($y = 0.044x + 1.062$, $p < 0.001$, $r^2 = 0.23$, y = plasma T_3 concentration, x = days of incubation). There was no significant variation in plasma T_4 levels throughout the study period ($y = 0.028x + 13.841$, $r^2 = 0.00$, y = plasma T_4 concentration, x = days of incubation). The mean T_4 concentration was 14.26 ng/ml (SD = 4.68, $n = 87$) and varied between 5.8 and 35.5 ng/ml. The egg-laying T_4 level was 11.28 ng/ml (SD = 5.33, $n = 6$), and 10–14 days after hatching the level was 17.93 ng/ml (SD = 6.82, $n = 4$).

Incubating Metabolic Rate

The mean body weight of the two incubating female Eiders, measured at day 20, was 1540 g and 1580 g. The females did not struggle when the upper part of the metabolic chamber was lowered. Stable measurements were obtained within 1 hour. The mean incubating metabolic rate (IMR) was 0.80 ml $O_2/g \cdot h$ (SD = 0.02, $n = 13$) and the corresponding mean RQ was 0.70 (SD = 0.01). The mean daily energy expenditure of the incubating Eiders decreased as body weight decreased, though there was no significant decrease in the specific metabolic rate throughout the experimental period. The mean energy expenditure was calculated to 604.4 kJ/d (SD = 15.1, $n = 2$).

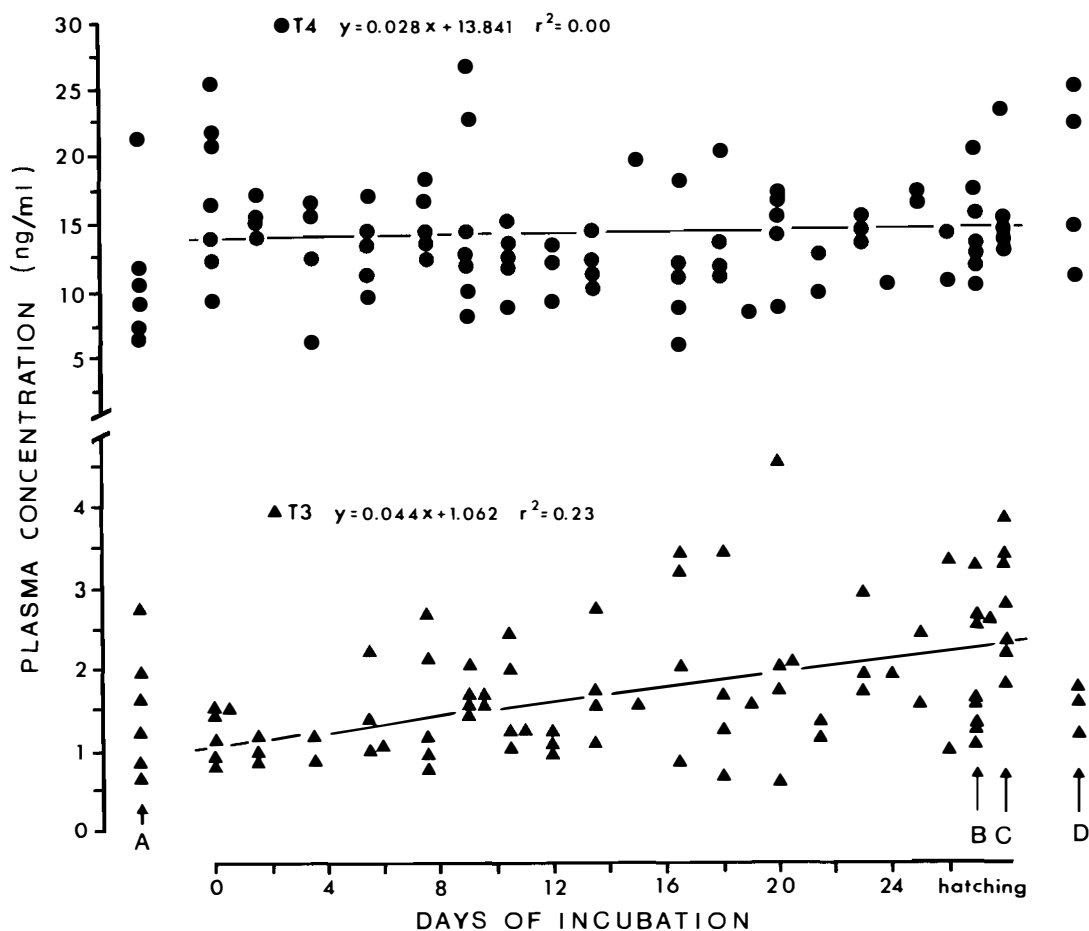


Fig. 4. Plasma concentrations of thyroxine and triiodothyronine in birds at egg-laying, during incubation and 10–14 days after hatching. A, B, C and D as in Fig. 3.

Resting Metabolic Rate/Thermal Conductance

The mean body weight of the 12 non-incubating Eiders was 1,661 g (SD = 251, number measurements = 18). This weight was used when calculating the mean metabolic rate. Birds caught on the nest did not differ ($p < 0.05$) in RMR from those caught while swimming. The mean RMR value at thermoneutrality was 0.86 ml $O_2/g \cdot h$ (SD = 0.07) (Fig. 5). The corresponding mean RQ was 0.71 (SD = 0.02). The RMR value of non-incubating females tended to be 7.5% higher than the IMR values of incubating birds ($0.05 < p < 0.10$, t-test).

The mean daily energy expenditure (DEE) of the resting non-incubating Eiders (1,600 g)

at thermoneutrality was calculated to be 649.4 kJ/d (SD = 52.9, $n = 12$).

The average body temperature was 40.1°C (SD = 0.7, number of measurements = 18). Oxygen consumption increased linearly below the lower critical temperature of 7°C. The regression line ($y = 1.052 - 0.025x$, $x = \text{amb. temp.}$, $y = \text{ml } O_2/g \cdot h$) intersected the abscissa close to Eider body temperature. Thermal conductance (TC) was 0.0240 ml $O_2/g \cdot h \cdot ^\circ C$.

Energy budget calculation based on weight loss

Calculation of DEE during incubation based on weight loss (Fig. 3) was done for birds between 19 and 20 days of incubation. The daily weight

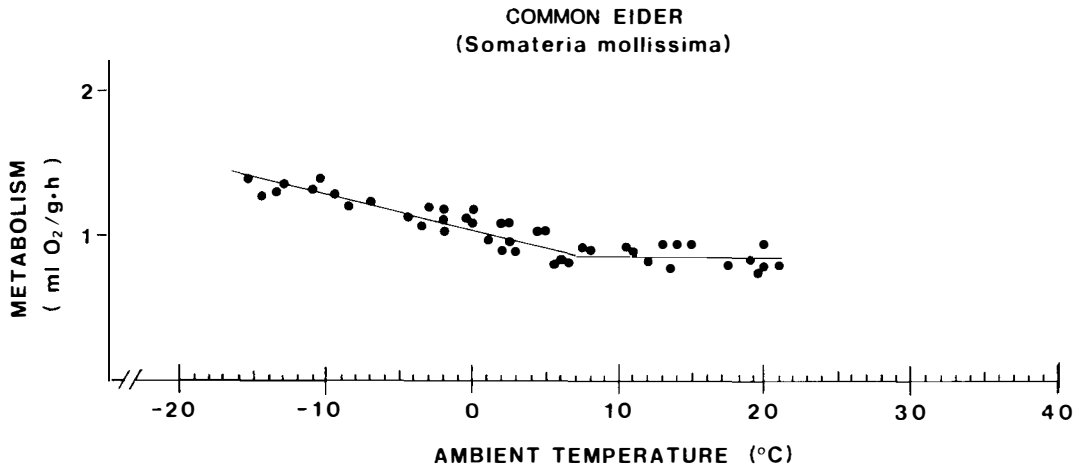


Fig. 5. Oxygen consumption and energy expenditure of non-incubating female Eiders at different ambient temperatures. The regression line below the lower critical temperature intersected the abscissa at an ambient temperature close to the measured body temperature.

loss on day 20 was 17.7 g. Since there was no value available for body composition between day 19 and 20, we have used an average value for loss of fat and protein throughout incubation. Body composition analysis of Eiders from Maine, USA (Korschgen 1977) and Svalbard (Parker & Holm 1990) indicate that based on a weight loss of 17.7 g/day, 11.0 g is lost as fat, 1.8 g as protein and 4.8 g as water. The energy equivalents of fat and protein were 38.53 kJ/g and 19.67 kJ/g, respectively (Parker & Holm 1990). Based on body weight loss, DEE during incubation at day 20 was calculated to 460 kJ/day. This is 24% and 29% lower than the DEE values obtained by indirect respirometry on incubating and non-incubating birds, respectively.

Water influx rate

The mean body weight of 6 incubating female Eiders (measured close to hatching) was 1,438 g (SD = 121, n = 8) (Table 1).

During the study period (2–3 days) the body mass change was 1.26%/day, i.e. a loss of 18.1 g per day. The water influx rate was 90.06 ml/day (SD = 56.36, n = 8). Based on a weight loss of 18.1 g per day the metabolic water production was calculated to 12.3 g per day using values of 0.11 g water formed per kcal burned (Schmidt-Nielsen 1983). One bird (No. 446), during the first experimental trial, had a water influx rate of only 18.11 ml/day, while all the others varied between 37.65 and 194.45 ml/day (Table 1).

These values indicate that female Eiders consumed water close to or at hatching.

Discussion

In previous studies on small bird species (<0.5 kg) the energy cost during incubation has been estimated to be 15–30% higher than the resting metabolic rate (RMR) of non-incubating birds (Biebach 1979, 1981; Vleck 1981; Haftorn & Reinertsen 1985; Gabrielsen & Unander 1987). Small birds often have limited resistance to starvation and leave the nest periodically to forage. Recently, studies of larger birds that tolerate periods of fasting and show high nest attendance have revealed incubation costs similar to or lower than RMR or non-incubating individuals (Grant & Whittow 1983; Grant 1984; Brown & Adams

Table 1. Water influx rate in incubating Eiders at Ny-Ålesund, Svalbard, 1987.

Bird No.	Body weight (gram)	Body weight change (%/day)	Water influx rate (ml/day)
444	1,470	-1.42	121.14
445	1,295	-2.45	81.04
446	1,420	-0.75	18.11
446	1,405	-2.14	77.34
447	1,285	-0.82	194.45
448	1,420	-0.76	54.63
450	1,600	-0.33	37.65
450	1,610	-1.42	147.89
Mean	1,438	-1.26	90.06
SD	121	0.74	56.36

1984; Brown 1984; Groscolas 1988; Pettit et al. 1988). Metabolic measurements of incubating Eiders within the thermoneutral zone in our study indicated the energy cost during incubation to be similar to or slightly lower than RMR of non-incubating birds.

Our indirect measurement of daily energy expenditure (DEE) in incubating birds (604 kJ/day) was higher than Korschgen's (1977) of 401 kJ/day, Parker & Holm's (1990) of 490 kJ/day, and ours of 460 kJ/day. This difference may be due in part to the random fluctuations associated with small samples. Also, the contribution of the embryos to the total energy cost of incubation increases as incubation proceeds. In a study of the Blue Tit (*Parus caeruleus*) Haftorn & Reinertsen (1985) calculated that during the last days of incubation the clutch (13 eggs) accounted for 15% of the total oxygen consumption. In a similar study of incubating American Kestrels (*Falco sparverius*) Gessaman & Findell (1979) estimated that during the last 5 days of incubation the clutch of five eggs contributed 19–25% of the total energy required for incubation. In three species of shorebirds Norton (1973) estimated that embryos close to hatching contributed 35–40% of the total energy cost of incubation. Steen & Gabrielsen (1988) calculated that a clutch of four pipped eggs contribute 125 kJ/d or 20% of the total DEE of incubating Eiders. In the present study, oxygen consumption and carbon dioxide production of the eggs was not subtracted from the incubation metabolic rate (IMR) measurements. However, based on a study of oxygen uptake in common fowl eggs Høiby et al. 1983), the oxygen uptake in Eider eggs incubated 15–20 days was calculated to vary between 12–15% of the total DEE. Therefore, the IMR in incubating individuals may be about 20–25% lower than the RMR of non-incubating birds.

Nest insulation may also reduce the net energy expenditure of an incubating bird relative to that of a non-incubating individual. Walsberg & King (1978) found the energy expenditure in the Red-winged Blackbird (*Agelaius phoeniceus*), Willow Flycatcher (*Empidonax traillii*) and White-crowned Sparrow (*Zonotrichia leucophrys*) to be 15–18% less when incubating in a bowl-shaped nest than when perched in the open. Gessaman & Findell (1979) concluded that incubation in American Kestrels could be accomplished at the level of adult resting metabolism due partly

to embryonic heat production and nest insulation. Our study, as well as previous studies on incubating penguins (Brown 1984; Groscolas 1988), albatrosses (Grant & Whittow 1983; Brown & Adams 1984; Pettit et al. 1988) and petrels (Grant & Whittow 1983), supports King's (1973) contention that the metabolic rate of a bird at rest can supply all the heat required for incubation, at least in some species.

Energy expenditure during incubation depends in part on nest attentiveness (Vleck 1981). Many smaller species of birds in particular have limited resistance to starvation and are obliged to forage regularly during incubation. The energy cost of rewarming the eggs increases with increased time away from the nest and lower ambient temperature (Gabrielsen & Steen 1979; Biebach 1986; Tøien et al. 1986). This extra energy cost is avoided when the incubation is shared by both parents. In contrast, many larger birds incubate for weeks without eating. Mehlum (1991b, this volume) found that female Eiders left the nest for an average of 4–5 min every second day, and they always covered the eggs with down before leaving. Consequently, egg temperature decreased less than 1°C during their absence time. Thus Eiders normally experience a low egg rewarming cost during incubation.

The mean ambient temperature measurement in Ny-Ålesund in June was 2.1°C which indicates that Eiders incubate at temperatures below the thermoneutral zone of non-incubating birds much of the time. Several of the non-incubating Eiders used in the metabolism measurements still had remnants of a brood patch. This probably resulted in an overestimation of the lower critical temperature as the down-lined nest would prevent considerable heat loss from the brood patch. The lower critical temperature of Eiders in winter is –6°C (Jenssen et al. 1989) or considerably lower than the 7°C measured in the present study. Microclimatic influences such as solar radiation have a positive effect on heat balance. Behavioural changes may also reduce heat loss, e.g. the lowest IMR values were obtained at low ambient temperatures when the bird put its bill under the wing feathers.

According to studies by Le Maho (1983) fasting penguins and geese go through three different periods during long-term fasting: a rapid adaptation period, a long period of economy, and finally a critical period. In geese the adaptation

period is characterized by a rapid reduction in specific metabolic rate, the economy period by a slow decrease in body weight and RMR but with no decrease in specific RMR, and the critical period by drop in body mass which was not accompanied with a change in RMR (Le Maho et al. 1981; Le Maho 1983). Our measurements of body weight and IMR indicate that the period of adaptation and economy are also present in incubating Eiders. Unfortunately we do not have metabolic measurements from the beginning of incubation, but Le Maho et al. (1981) in their studies of geese suggest that the main reduction in metabolic rate appears at this time. While we found a slight (7.5%) difference between specific IMR and RMR in Eiders, and a 20–25% difference when subtracting for the eggs, there was a 17% difference between starved and normal geese (Le Maho 1983).

Measurements of thyroxine (T_4) and triiodothyronine (T_3) in Eiders indicated that while the level of T_4 was stable throughout the incubation period, there was a small but significant increase in T_3 . This increase in the T_3 level contrasts with results from corresponding studies on chickens and penguins (May 1978; Cherel et al. 1988) which showed that the T_3 level was depressed after food deprivation. The thyroid hormones are involved in controlling heat production, and we suggest that the levels of these hormones are kept high in incubating Eiders because of heat requirements associated with the incubating eggs. Measurements of body temperature support this theory, for while body temperature in starved geese decreased from 40.1°C to 39.3°C (Le Maho et al. 1981), female Eiders showed a body temperature of 40.1°C up until day 20 of incubation.

Eiders show body weight reductions in the vicinity of 45% during breeding (Milne 1963, 1976; Cantin et al. 1974; Korschgen 1977). The present study showed a 44.4% decrease in body weight from the start of egg-laying until hatching and a 35.6% decrease during incubation. Our metabolic measurements gave a respiratory quotient value of 0.70, indicating that fat was the major fuel during incubation fasting in Eiders. Parker & Holm (1990) calculated from body composition analysis that lipid accounted for 91.8% of the total energy expenditure during incubation in Eiders. Le Maho et al. (1981) found a 39% reduction in body weight after 40 days of fasting in geese, and that lipid accounted for 95% of the energy expended.

Lasiewski & Dawson (1967) provided an allometric equation for basal metabolic rate (BMR) in non-passerines based on body mass. Aschoff & Pohl (1970) made a similar equation which in addition accounted for the influence of diurnal rhythm on BMR. Our IMR and RMR measurements (of birds in resting or β -phase and within the thermoneutral zone) were 130–149% of those predicted from these equations. RMR values obtained in this study, RMR measurements of arctic seabirds (Gabrielsen et al. 1988) as well as Prinzinger & Hansler's (1980) metabolic study of 24 different non-passerine birds in which 11 species were Anseriformes, reveal RMR values above the values predicted from these equations.

According to Aschoff & Pohl (1970) there is a 20–25% difference in metabolism in non-passerine birds during their active (α) versus their resting place (β) phase. Our RMR measurements of Svalbard Eiders were 23% higher than RMR values reported from central Norway in winter acclimatized birds (in resting phase) (Jenssen et al. 1989). The body temperature in summer acclimatized Eiders is 0.5–1.0°C higher than in winter birds (Jenssen et al. 1989). Summer acclimatized Willow Ptarmigan (*Lagopus lagopus*) and Rock Ptarmigan (*Lagopus mutus*) are also reported to have a higher metabolic rate than winter birds (Mortensen & Blix 1986).

Disappearance of a diurnal resting phase in arctic birds during the summer has been described in ptarmigan and seabirds (West 1968; Stokkan et al. 1986; Gabrielsen et al. 1988). In temperate areas there is a distinct day/night variance in light intensity. This is accompanied by a clear variation in RMR and body temperature (T_B). In contrast, diurnal phases in RMR and T_B seem to fade away under continual light conditions of the arctic summer. It therefore seems inappropriate to talk about active/resting phases (Aschoff & Pohl 1970) during arctic summers. When comparing measured with predicted metabolic rates it is important that experimental conditions are standardized.

Metabolism of non-incubating Eiders increased as ambient temperature decreased in the usual homeothermic linear fashion. Thermal conductance was very close to the allometric values calculated for birds of similar body size. When using Herreid & Kessel's (1967) equation for dead birds (dry conductance), we obtained values 131% greater than those predicted, while Aschoff's (1981) equation (α -phase) gave 90% of

the predicted value. When compensating for respiratory heat loss, which according to Drent & Stonehouse (1971) is estimated to be 12%, a better agreement with Aschoff's (1981) than Herreid & Kessel's (1967) equation was obtained. Compared to other summer acclimatized arctic birds such as the Raven (*Corvus corax*) (Schwan & Williams 1978) and Ptarmigan (West 1968; Mortensen & Blix 1986), the TC value in Eiders was similar. The TC in winter acclimatized Eiders (Jenssen et al. 1989) was 25% lower than our measurements. A reduced summer insulation is also described in the Brent Goose (*Branta bernicla*) (Irving et al. 1955), Wild Turkeys (*Meleagris gallopavo*) (Gray & Prince 1988) and in Ptarmigan (Mortensen & Blix 1986). It is most likely through the naked brood patch that incubating birds lose most heat, which is probably the main reason for the higher TC and LCT measured in summer acclimatized Eiders.

Studies of water content in starved geese have shown that while the extracellular fluid volume was maintained throughout fast, there was an increase after 21 days of fasting. (Le Maho et al. 1981). Studies from body composition of Eiders performed by Parker & Holm (1990) showed that water content increased from 51 to 63% from egg-laying until hatching. It may be argued that this increase was due to depletion of body fat, relative to protein, but our studies of water turnover rates at the end of incubation suggested that Eiders also increase water consumption at this time. A water influx rate of 90 ml/day and a metabolic water production of 20 ml/day would give a water intake of 70 ml/day. Edema associated with starvation is well-known in mammals (Keys et al. 1950). Birds may drink to maintain a steady body mass when approaching a critical weight level (Stage III, as pointed out by Le Maho et al. 1981). This stage is characterized by increased protein utilization as fat reserves disappear and by as rapid drop in body weight. It has also been suggested that drinking at the end of incubation may lead to an underestimation of DEE when calculations are based only on weight loss (Groscolas 1988). According to Groscolas (1988), DEE in penguins should only be determined in the middle part of the starvation period in order to avoid the final period of protein catabolism. Caution should therefore be exercised when using weight loss to calculate DEE in starved birds.

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Summer distribution and population size of the King Eider *Somateria spectabilis* in Svalbard

PÅL PRESTRUD



Prestrud, P. 1991: Summer distribution and population size of the King Eider *Somateria spectabilis* in Svalbard. *Norsk Polarinstitutt Skrifter* 195, 63–68.

Registrations of King Eiders were made throughout Svalbard in the period 1982–1985. In addition, records of casual observations of King Eiders in the period 1970–1985 were collected in a fauna database. The most important breeding grounds were found between Bellsund and Isfjorden. Moulting takes place along the western coast of Spitsbergen in July–August, and large flocks are found at the outlet of Isfjorden, in Bellsund, and between Hornsund and Sørkapp, at this time of the year. The minimum and maximum population size in August is estimated at about 2,500 and 4,000–5,000 individuals respectively.

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Introduction

The King Eider *Somateria spectabilis* has a virtually circumpolar distribution and hardly breeds outside the arctic region (Cramp & Simmons 1977).

Løvenskiold (1964) summarizes all the observations of the King Eider in Svalbard up to 1960 and classifies it as a scattered breeder mainly found along the western coast of Spitsbergen.

Norderhaug (1977) collected data on the King Eider on expeditions to Svalbard during the period 1965–1970. He gives nearly the same figures on breeding distribution as Løvenskiold.

Neither Løvenskiold (1964) nor Norderhaug (1977) has made any systematical surveys to map the breeding distribution or to estimate the population size of the King Eider in Svalbard. Since 1970 new information has been obtained, and systematical surveys were carried out in the 1980's by the present author and others. This paper summarizes these observations and surveys.

Materials and Methods

Animal observations throughout Svalbard during the last 15–20 years have been reported in a standard format devised by the Norwegian Polar Research Institute and compiled in a fauna database. A total of about 120 single observations of the King Eider have been reported and entered into the database in the period 1970–1985. These observations combined with observations made

and compiled during the following surveys provide the basis data for this paper:

1. Routine inspection trips carried out by the Governor's office in the period 1982–1985. Animal observations including observations of King Eiders were collected.
2. Surveys of the breeding distribution of the Common Eider *Somateria mollissima* in the period 1982–1984 (Prestrud & Mehlum 1991, this volume). The occurrence of King Eiders was also registered. All the small islands, and about 95% of all the islets along the western and northern coasts of Spitsbergen between Sørkapp and Gråhuken, were visited. Several of the islets along the eastern coast were also visited during the survey.
3. Aerial surveys carried out in the period 1982–1985 where King Eiders were also registered. These surveys included:
 - Irregular fauna registrations by the Governor's helicopter during routine inspection trips over the entirety of Svalbard.
 - Systematic censuses of the Common Eider carried out by both the Governor's Office and the Norwegian Polar Research Institute along the western and northern coast of Spitsbergen in June/July and August 1984 (Karlsen & Mehlum 1986).
 - Surveys of polar bears by the Governor's Office along the eastern coast of Svalbard in July–September.
4. Surveys of the expected, most important breeding areas (Nordenskiöldkysten and

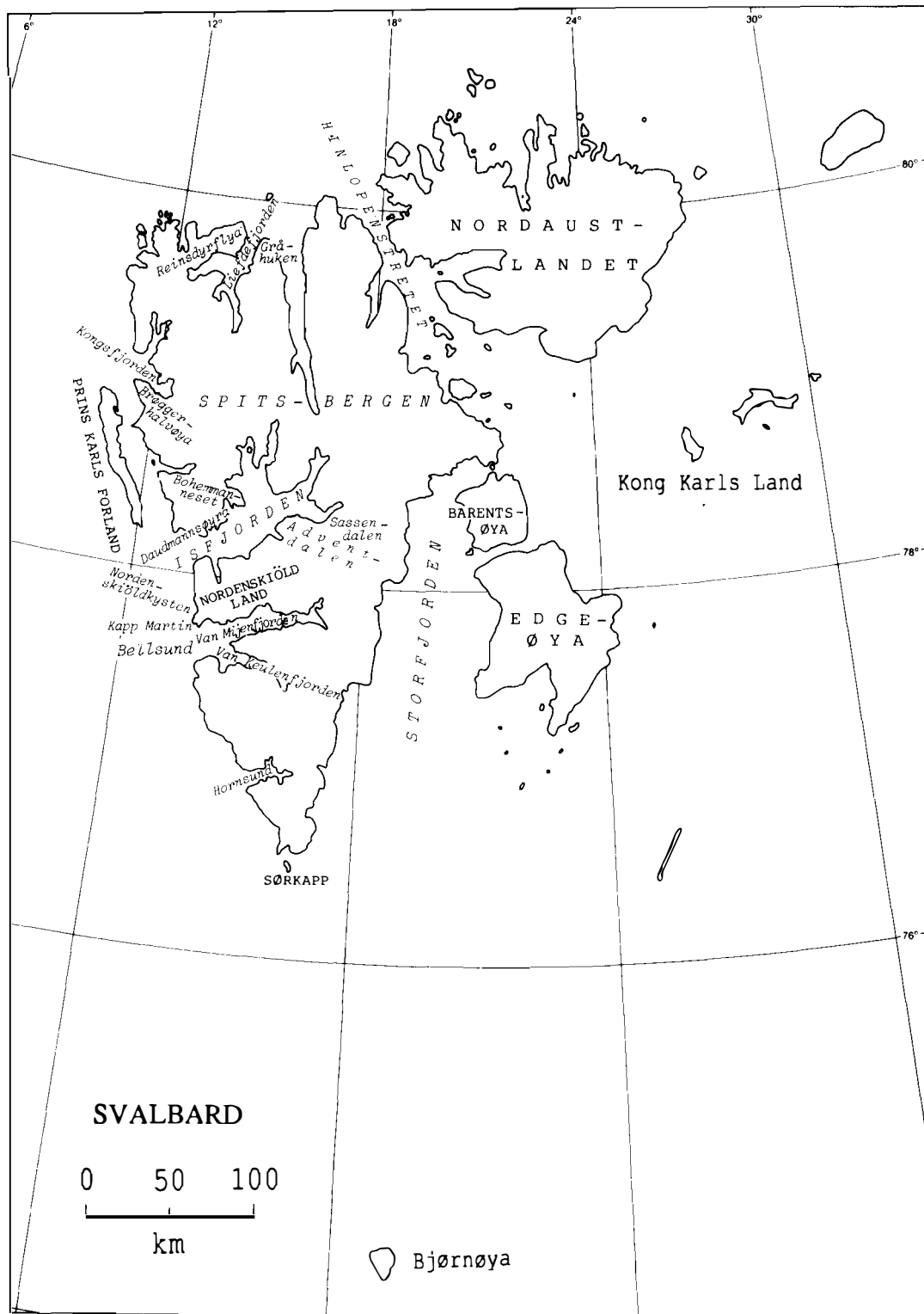


Fig. 1. Geographical references used in the summarizing of observation data.

Daudmannsøyra) carried out on foot in 1982, 1984 and 1985. Adventdalen and Sassendalen, typical parts of the inner fjord zone in Svalbard, were systematically surveyed for breeding King Eiders in the period 1983–1988.

5. Surveys of seabirds (including King Eiders) carried out by helicopter and rubberboats in connection with an Environmental Impact Assessment in the southern part of Storfjorden and along the southwestern coast of Spitsbergen (Bakken & Mehlum 1988; Knutsen et al. 1988).

All aerial surveys were carried out by Bell 212, Bell 206 or Écureuil AS–350 helicopters. Flock sizes with rough estimates of minimum and maximum numbers of birds in the flocks were made by experienced observers.

Results

Bjørnøya

About 10 single observations of King Eiders were reported from Bjørnøya during the 1970–1985 period. In July–August of 1980, 1986 and 1987, less than 10 King Eiders were observed around the island each year. Larger flocks (max. 250 inds.) were observed in May. The King Eider was never observed breeding on Bjørnøya.

The Sørkapp-Hornsund coast

Single individuals and smaller flocks (max. 50 inds.) were observed along the Sørkapp-Hornsund coast in June and July. Throughout August and in September, larger flocks of several hundred individuals were seen. Knutsen et al. (1988) observed 2,500 inds. in three flocks during a survey in September 1987. There were no indications of the King Eider breeding in this area.

Hornsund

There were no reported observations of King Eiders from Hornsund in the study period.

The Hornsund-Bellsund coast

The King Eider was observed along the northern part of the Hornsund-Bellsund coast, but never in large numbers. In July 1983 a flock of 25–30 males was observed in Dunderbukta. Except for this observation, only single birds or pairs were reported.

Van Keulenfjorden and Van Mijenfjorden

Only two observations were reported in this area, both in 1980, near the Sveagruva in the inmost part of Van Mijenfjorden. 4 males and 1 female were recorded.

Bellsund and Nordenskiöldkysten

Most of the observations of King Eiders reported from Svalbard in the period 1970–1985 are from the Bellsund/Nordenskiöldkysten area. In June/July 1975, 1982 and 1984 the whole area was surveyed. During the summer, flocks of different sizes (maximum 180 inds.) were distributed along the coast, especially around Lågneset-Kapp Martin-Van Muyden bukta, Orustosen and Kapp Linné. The total population recorded on the sea in July fluctuated from 180 to 350 individuals from year to year.

Several observations of breeding King Eiders were also made from this area. In 1975, 10–15 nests were found, and some females with ducklings were seen on the sea. In June 1982, parts of the area were surveyed on foot. Based on observations of males and females in small ponds, the assumed number of breeding pairs in the area covered was between 20 and 25. The most important breeding areas are at Kapp Linné (2–6 pairs) and between Orustosen and Lågneset-Vårsolbukta. The total breeding population in this latter area is estimated at 60–80 pairs, based on the assumption that the density of breeding pairs is uniform in the area.

Isfjorden

The King Eider was found dispersed throughout the Isfjorden area. In Adventfjorden, records are available from several years back. Here 5–15 males are seen each summer (June–first part of July). An estimated 3–6 pairs breed each year in small ponds at the outlet of Adventdalen. In Sassenfjorden the King Eider is not as common as in Adventfjorden. One or two pairs breed each year in Sassendalen. The King Eider has also been observed breeding in Grøndalen, and pairs and small flocks are recorded each year along the coast between Grønfjorden and Sassenfjorden. The King Eider assumedly also breeds in Colesdalen, but only in limited numbers.

Very few observations of the King Eider have been reported from the northern part of Isfjorden, but it is supposed that they breed here in small numbers.

Daudmannsøyra and Forlandssundet

The largest number of King Eiders in Svalbard is recorded along the coastline between Alkhorneret and Eidembukta (Daudmannsøyra). The area was surveyed by foot in July/August 1975 and in August 1985, and the King Eider population was estimated at 2,000 individuals in 1975 and 1,350 individuals in 1985. Aerial surveys in July 1984 gave an estimate of 400–550 individuals. Several other observations of large flocks (200–600 ind.) are reported from this area during the summer months 1970–1985.

Larger flocks (60–200 inds.) are also commonly observed in Forlandssundet north of Daudmannsøyra and along the southeastern coast of Prins Karls Forland.

King Eiders have been found breeding both on Daudmannsøyra and on Forlandssletta. Based on observations of single individuals or pairs in small ponds, 10–15 pairs were found breeding on Daudmannsøyra during a survey on foot in June 1984. Only a small part of this large coastal plain was surveyed, and the total breeding population may be close to 100 pairs if the breeding density is uniform over the entire area.

The western and northern coast of Prins Karls Forland

The King Eider has only been seen occasionally in this area and never in large numbers.

Engelskbukta and the Kongsfjorden area

In Engelskbukta and along the southwestern coast of Brøggerhalvøya, flocks of King Eiders have been observed several times. In July 1974, a flock constituting 450 individuals was observed in Engelskbukta, and during the summers 1977–1979 flocks constituting 30–80 inds. were seen along the southeastern coast of Brøggerhalvøya.

In the Kongsfjorden area small flocks of 3–10 males are occasionally observed during the summer, but never in large numbers. During the summer of 1984, altogether 17 males were observed in this area.

The King Eider has not been observed breeding in the Engelskbukta/Kongsfjorden area.

The northwestern part of Spitsbergen

No observations were reported from this area in the period 1970–1985.

The northern coast of Spitsbergen

Only a few observations were reported from this area. 13 males were seen at Andøyane in Liefdefjorden in July 1982. Along the coastline of Reinsdyrflya, 80 King Eiders were observed in June/July 1984. Some observations of single individuals or small flocks (3–6 ind.) have been reported from this latter area.

Hinlopen, Nordaustlandet, Kong Karls Land

No observations were reported from this area in the period 1970–1985. In 1979, Jepsen (1984) carried out an aerial survey of the Common Eider by helicopter in this area without reporting any observations of King Eiders.

Storfjorden, Barentsøya, Edgeøya

Only few observations were reported from this area. 200 individuals were observed in Agardhbukta in 1977, 5 individuals were observed at Barentsøya in 1977, and 8 individuals at Edgeøya in 1974. In August 1989 two females with broods were observed on ponds in Russebukta, Edgeøya.

Discussion

The King Eider is not nearly as numerous as the Common Eider in Svalbard (Prestrud & Mehlum 1991, this volume). In accordance with Løvenskiold (1954, 1964) and Norderhaug (1977), the main distribution was found to be between Sørkapp and Kongsfjorden. Both authors stated that the coastline between Sørkapp and Hornsund is an important moulting area where ducks congregate from the middle of July. The reports from the period 1970–1985 suggest that the King Eider arrives at this area in large numbers throughout August. During aerial surveys in July 1984, flocks of King Eiders were not observed along this coastline at all. Bakken & Mehlum (1988) carried out detailed surveys with a helicopter on 10 and 26 July 1987, and with a rubber boat during the same period. They observed only 6 King Eiders. In September the same year, Knutsen et al. (1988) observed 2,500 King Eiders in three flocks between Stormbukta and Hornsund. Løvenskiold (1954) made observations of large flocks between Sørkappøya and Hornsund from the middle of July. This difference in observations between the early 1950's

and 1980's might be due to a shift in the timing in the arrival of flocks before the end of July, or an indication of a decrease in the population size.

In June and July large flocks of King Eiders tend to congregate along Nordenskiöldysten and Daudmannsøyra. During the period 1970–1985 the number of King Eiders in these areas fluctuated between 250–450 individuals in June and 1,350–2,000 individuals in July. At this time of the year flocks are also seen yearly in Forlandsundet, Engelskbukta and on Brøggerhalvøya. These important moulting and feeding areas are marked in Fig. 2.

It seems reasonable to assume that the flocks of post-breeding King Eiders observed between Bellsund and Kongsfjorden in June/July move southward and congregate between Sørkapp and Hornsund in August and September before migration begins.

It is unlikely that King Eiders congregate each year in large numbers in other areas of Svalbard since no such congregation of flocks has been reported by either of the following:

- the many trained biologists (from the Governor's Office, the Norwegian Polar Research Institute and others) who have worked throughout Svalbard during the last years compiling reports on general fauna observations,
- systematic surveys carried out from helicopters, boats or on foot which have covered most of the Svalbard coastlines.

In addition, Løvenskiold (1964) summarized all the information available before 1960, and large flocks of King Eiders had not been observed in areas other than those already mentioned.

The post-breeding gatherings of King Eiders are mainly composed of males. They offer a unique opportunity for estimating the population size in the same way as for Common Eider populations. The areas where the King Eiders gather during moulting and feeding before migration are vital to the population and should be safeguarded from detrimental human impacts during this period.

Based on numbers of King Eiders along the western coast of Spitsbergen between Sørkapp and Kongsfjorden in June, July, and the first part of August, the minimum population size in Svalbard in the autumn (August–September) is estimated at 2,500 individuals. An estimate of the maximum population size is still pure

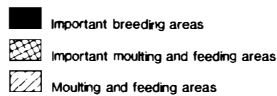
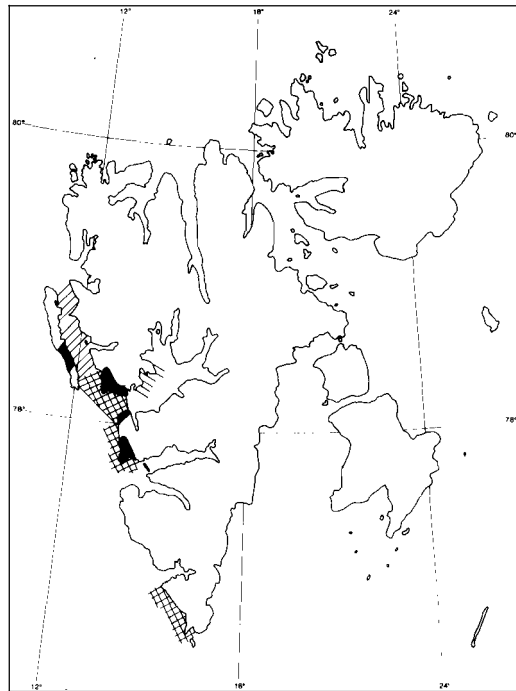


Fig. 2. Known breeding, moulting and feeding areas of the King Eider in Svalbard.

speculation. Very few females with ducklings are reported. This is believed to be due to the non-specialist's difficulties in differentiating between the King Eider and the Common Eider female. If a large part of the expected very small population of females with ducklings is dispersed along the entire western coast of Spitsbergen during the summer months, this population would be very difficult to census. The tendency in reports that estimate the number of females in proportion to the number of males in flocks is that males predominate. Based on the assumption that there is a 1:1 relationship between the sexes in the population, this suggests that the population might be 500–1,000 individuals larger than the minimum estimate; furthermore, several small flocks and single individuals are not registered. With this background, the maximum population size is estimated at around 4,500–5,000 individuals in August.

In this study breeding King Eiders have

been reported from Nordenskiöldkysten, Daudmannsøyra, Forlandssletta, and in the valleys south of Isfjorden. Løvenskiöld (1964) reports several observations of breeding King Eiders along the entire coast between Hornsund and Kongsfjorden. The King Eider probably breeds dispersed along the entire western coast of Spitsbergen, but the important breeding areas are undoubtedly those mentioned in this study (Fig. 2). The species has also been found breeding in the Storfjorden area (Løvenskiöld 1964, one record from Edgeøya; this study). Reinsdyrflyta is probably also a breeding area, since the habitat is excellent and a relatively large number of males have been observed during the breeding period.

In 1968, Norderhaug (1977) carried out a survey on foot along the coastal plain between Kapp Linné and Kapp Martin. He estimated the breeding population of King Eiders at 80–100 pairs. This is well in agreement with the estimated 60–80 pairs in this study, based on an equivalent survey on foot in 1982 and a survey on foot at Kapp Martin in 1984.

Both Løvenskiöld (1964) and Norderhaug (1977) state Bohemanneset at the northern part of Isfjorden to be both an important breeding and moulting area. In this study, no observations have been reported from this area, yet one cannot disregard this as an important area for the King Eider since systematic surveys have not been carried out here and few observers have worked here.

In this study the King Eider has not been found breeding on small islands or islets where its near relative, the Common Eider, breeds in large numbers. According to Løvenskiöld (1964), there have been few observations of King Eiders breeding in this habitat. The general breeding habitat in Svalbard is found on large tundra plains dotted with small ponds (typical for the outer coast of Spitsbergen) and in the large, broad valleys on Nordenskiöld Land, in central

Svalbard. Here the King Eider breeds dispersed and solitarily. The nests are found in close conjunction with small ponds or streams.

A dispersed breeder such as the King Eider is less exposed to unfavourable human impacts than Common Eiders in their colonies. During the moulting season, however, King Eiders congregate in large flocks in restricted areas along the western coast of Spitsbergen where ship-traffic is frequent. During this period the population is especially vulnerable to oil pollution. This applies in particular to the outlet of Isfjorden where a large part of the population is gathered when ship-traffic is at its greatest, especially regarding small supporting tankers travelling to settlements in the area.

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