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Evidence of Population Decline in Common Eiders Breeding in Western Greenland

FLEMMING RAVN MERKEL[1]

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ABSTRACT. In the Arctic, there is great concern for several eider populations, including the northern common eider (*Somateria mollissima borealis*) breeding in Canada and Greenland. In 1998–2001, extensive ground surveys were conducted on 937 potential nesting islands in West Greenland, covering most of the districts of Ilulissat, Uummannaq, and Upernavik (69˚15′ N to 74˚05′ N). On 216 islands within 106 eider colonies, 4097 ± 468 active nests were identified. In 15 colonies where comparable and well-documented surveys were conducted approximately 40 years ago, the study shows a population decline of 81% (from 3361 to 624 nests). A rough comparison shows that of 51 eider colonies surveyed in 1920, 1960, or 1965, 71% either were gone or had declined in breeding numbers when resurveyed in 1998–2001. At the colony level, the 1998–2001 surveys revealed large year-to-year variations in nesting numbers. The reason for the overall decline is not clear. However, there is circumstantial evidence that harvest of common eiders in West Greenland is a key factor. The results urgently call for more cautious management of the northern common eider population.

Key words: northern common eider, *Somateria mollissima borealis*, West Greenland, breeding population, population decline, harvest

RÉSUMÉ. On se préoccupe beaucoup dans l'Arctique de plusieurs populations d'eiders, y compris l'eider à duvet (*Somateria mollissima borealis*) qui se reproduit au Canada et au Groenland. De 1998 à 2001, on a procédé à de vastes relevés au sol sur 937 îles susceptibles d'abriter des nids dans l'ouest du Groenland, une zone qui recouvrait la plupart des districts d'Ilulissat, d'Uummannaq et d'Upernavik (69° 15' de latit. N. à 74° 05' de latit. N.) Sur 216 îles situées à l'intérieur de 106 colonies d'eiders, on a identifié 4097 ± 468 nids actifs. Dans 15 colonies où des relevés comparables et bien documentés ont été effectués il y a 40 ans, l'étude révèle une baisse de la population de 81 % (soit de 3361 à 624 nids). Une première comparaison montre que des 51 colonies d'eiders étudiées en 1920, 1960 ou 1965, 71 % avaient soit disparu, soit enregistré une baisse du nombre de paires lors des nouveaux relevés effectués entre 1998 et 2001. Au niveau de la colonie, ces derniers relevés montraient d'importantes variations interannuelles dans le nombre de nids. La raison de la baisse globale n'est pas très claire, mais certains indices prouvent que le prélèvement de l'eider à duvet dans l'ouest du Groenland est un facteur clé. Les résultats appellent à une plus grande prudence dans la gestion de la population de l'eider à duvet, et ce, au plus vite.

Mots clés: eider à duvet, *Somateria mollissima borealis,* ouest du Groenland, population d'oiseaux nicheurs, baisse de la population, prélèvement

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INTRODUCTION

The northern common eider *Somateria mollissima borealis* breeds along the west coast of Greenland and in eastern Canada and is one of several seabird populations shared between Canada and Greenland (Salomonsen, 1967, 1990; Abraham and Finney, 1986; Reed and Erskine, 1986; Boertmann, 1994). All common eiders from western Greenland and the majority of the Canadian breeding population winter in the open water area of Southwest Greenland (Salomonsen, 1967; Lyngs, 2003), and recent counts estimated 460 000 wintering birds (Merkel et al., 2002a). The rest of the Canadian breeding population winters in the Maritime Provinces of Canada and is estimated at approximately 160 000 birds (Gilchrist et al., 2001).

Like most seabirds, the common eider has deferred sexual maturity, low annual recruitment rates to breeding age, relatively low rates of reproduction, and variable annual rates of nonbreeding by adults (Palmer, 1976; Coulson, 1984). Population stability relies on high adult annual survival rates (generally > 85%) and thus is sensitive to even small increases in adult mortality due to harvesting, severe winter conditions, or diseases (Flint et al., 2000; Goudie et al., 2000).

The common eider is harvested in both Canada and Greenland (Denlinger and Wohl, 2001). Harvest levels are especially high in Greenland, with reported annual bag totals between 55 000 and 70 000 eiders (Department of Fishing and Hunting, Greenland Home Rule). Other seabird populations experience high harvests in West Greenland

[1] Greenland Institute of Natural Resources, P.O. Box 570, DK-3900, Nuuk, Greenland; merkel@natur.gl

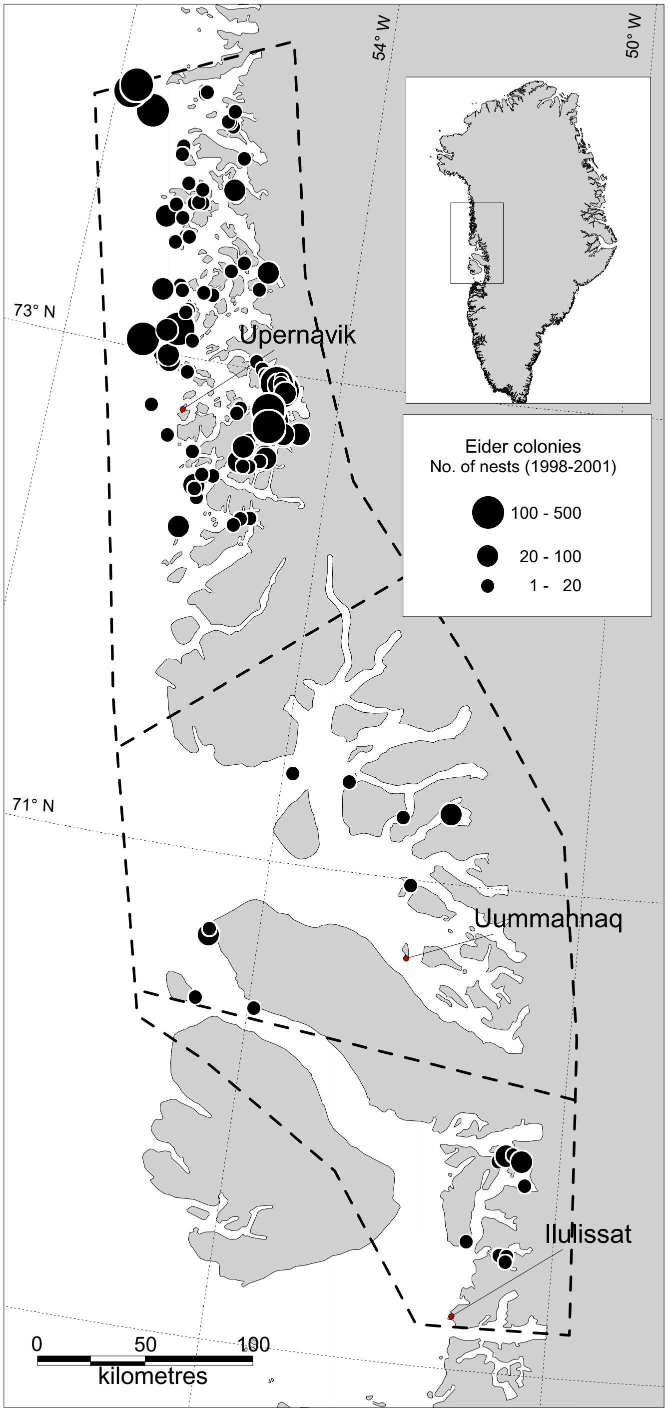

FIG. 1. Map showing the study area in West Greenland surveyed in 1998–2001. The broken lines show delimitations between districts, and the black dots show the current distribution of eider colonies.

that have been linked to declining population trends for the thick-billed murre *Uria lomvia* (Kampp et al., 1994; Gardarson, 1995; Natturufrædistofnun Islands, 2000), and king eider *Somateria spectabilis* (Gratto-Trevor et al., 1998; Mosbech and Boertmann, 1999). Great concern over a similar scenario for northern common eider has led managers to call for intensified survey efforts and improved conservation cooperation between Arctic countries (CAFF, 1997; Gilchrist and McCormick, 2001).

Quantitative information about breeding numbers in Greenland has been scarce since the 1960s and only recent efforts have generated accurate information. A 1997 survey of one minor area in mid-west Greenland (Kangaatsiaq) showed a dramatic decline of approximately 80% since the 1960s (Frich et al., 1998), while a simultaneous survey in Northwest Greenland (Avanersuaq) indicated a stable breeding population (Christensen and Falk, 2001).

To fill in the incomplete picture of the common eider situation in West Greenland, I initiated surveys in other districts of West Greenland (Upernavik, Uummannaq, and Ilulissat), where significant breeding populations were expected still to exist. The overall objective of this study was to improve the management basis for this species. Specifically, I aimed to provide extensive information on current breeding numbers to establish a baseline for future monitoring work and produce population estimates of the total breeding population within this central part of West Greenland. A number of colonies were resurveyed in two or three consecutive years to generate information about year-to-year fluctuations. Finally, I compared recent and historical survey data to examine population change over time.

METHODS

Survey Area and Period

Eider ground surveys were conducted in central and northern parts of West Greenland (Fig. 1), from Ilulissat (69˚15′N) in the south to Nuussuaq (74˚05′N) in the north. The surveys were carried out during incubation in 1998–2001. In 1998 (4–7 July), the effort was concentrated within the southern Upernavik district; in 1999 (8–19 July), in the northern Upernavik district; and in 2000 (22 June–6 July), within the districts of Ilulissat and Uummannaq, as well as in northern Upernavik (19–22 July). In 2001 (27 June–9 July), effort was dedicated to recounts of colonies throughout the survey area. Information about previously monitored eider colonies in the study area was obtained from the Greenland seabird colony database, which compiles all available data on colonial seabird populations in Greenland (Boertmann et al., 1996).

Survey Methods

From prior knowledge about common eider nesting habitats in Greenland (Boertmann et al., 1996), small islands (less than approximately 2 km^2) were considered suitable eider breeding sites and were inspected. Exceptions were islands used for sledge dogs during the summer period and islands situated very close to cities or settlements. Four eider colonies known from historical surveys were not visited because of dangerous ice conditions en route. Four minor areas in Southern Upernavik were excluded because information from Inuit people indicated that they were not breeding areas (for detailed maps and routes see Merkel, 2002). This information was collected as part of a local knowledge survey about eiders in the districts of Ilulissat, Uummannaq, and Upernavik, in which three Inuit were interviewed from each city or settlement. As part of the interview protocol, Inuit were asked to identify colonies and quantify nesting numbers within their home range area (F. Merkel and S. Nielsen, unpubl. data). The accuracy of this information was assessed by inspecting identified colonies, as well as a sample of islands within declared nonbreeding areas. Only in southern Upernavik was this method used to speed up the surveys. Elsewhere in the study area, small islands were less numerous and they were all visited.

An eider colony was defined as one island, or a cluster of islands, at which one or more active eider nests had been recorded. The boundaries of colonies (if more than one island) were decided in each case. Individual islands were kept as separate colonies if available maps (1:50 000) made it possible to relocate those islands. Otherwise, they were combined into a single colony. In many cases, colonies had been defined during previous surveys. Most nesting islands were easy to identify because females flushed from their nests as we approached the island, or as we passed by the island inspecting it visually from the sea. Such islands were subsequently examined on foot. If no evidence of nesting eiders was observed during the course of a boat tour around the island, we assumed that no eiders were breeding there. This method is not common practice for common eider ground surveys; however, the technique proved to be efficient and safe in this study area. At regular intervals, we verified the flush technique by inspecting on foot islands that had been declared unoccupied by the "flush criterion" (on average every five islands). In two such cases, a single nest was found.

Breeding numbers were assessed by means of nest counts. One to four observers examined each island, depending on its size. To avoid double counting, observers walked only a short distance apart from each other, using communication and natural landscape features to separate the search effort. When counting the nests, we distinguished between 1) old nest cups; 2) nests lined merely with plant material, which were interpreted as prospected, abandoned, or occupied by a pre-laying female; 3) nests containing plant material and eggs, representing females during early laying; 4) nests containing only down with the eggs missing; 5) nests containing down and eggs that were incubating; 6) nests containing chicks; and 7) nests containing fresh egg membranes, indicating that chicks had hatched and left the nest. Clutch size was recorded for all nests containing eggs or chicks. Only incubating nests were used to calculate average clutch size.

Historical Information

Historical information on common eider breeding abundance is scarce for most parts of western Greenland. Historical data for the Ilulissat, Uummannaq, and Upernavik districts exist mainly from two periods, 1920 and 1960–65 (Bertelsen, 1921; Joensen and Preuss, 1972), and these data are, to some extent, comparable with the data from our survey. The 1920 survey covered the entire Uummannaq district; however, eider nesting numbers were only roughly estimated from the sea (Bertelsen, 1921) and are not useful for colony-by-colony comparisons. The 1960–65 surveys covered only selected breeding areas in the Ilulissat and Upernavik districts, but most colonies were carefully inspected, and the methods and the timing of the 1960–65 surveys are well documented (Joensen and Preuss, 1972) and directly comparable with the 1998–2001 survey.

Data Analysis

The nest categories 2–7 were considered as representing the number of active nests. For a colony-by-colony comparison with the 1960–65 surveys, category 2 nests were not included because these were not reported in that study (Joensen and Preuss, 1972). During 1998–2001, a number of colonies were surveyed in more than one year. To estimate the total breeding population within the study area, I used the mean number of nests for colonies that were resurveyed once or twice in subsequent years. For comparison with historical survey data, the maximum number of nests counted in each colony in the period 1998–2001 was used.

The Statistica software package (ver. 5.5) from StatSoft Inc. was used for all analyses (www.statsoft.com). An $\alpha = 0.05$ was used throughout. To detect differences in mean clutch size between districts, an unpaired t-test was used. Only incubated clutches containing fewer than eight eggs per nest were included in comparisons between districts, as more than eight eggs per nest were considered a result of nest-parasitism, i.e., egg dumping (Cramp, 1977).

Differences in nesting numbers for colonies that were counted and recounted within the 1998–2001 survey period were tested with a paired t-test. A Wilcoxon Matched Pairs test was used to detect changes between this survey and historical ones, as the distribution of differences in nesting numbers was far from normal. Confidence intervals (95%) were then based on estimated medians. In addition, I analyzed the square roots (to deal with a skewed dataset) of nest count numbers from old and recent survey periods for variance components (ANOVA) to determine which variable—year, period (old or recent), or colony—contributed the most to change in eider nesting numbers. For instance, I wished to determine whether natural year-to-year variation in nesting numbers could explain large differences detected between old and recent survey periods.

To quantify confidence limits (95%) of the current breeding population estimate, I conducted a variance components analysis for 106 colonies that were surveyed once or more in the period 1998–2001. The variance (S^2) was calculated as the sum of the variance component from the year-to-year effect (S_Y^2) and the error (unexplained) term (S_E^2) as:

TABLE 1. Summary statistics for common eiders nesting in the districts of Ilulissat, Uummannaq, and Upernavik in West Greenland, 1998–2001. Mean numbers are used for colonies that were resurveyed once or twice in subsequent years during that period.

	Ilulissat	Uummannaq	Upernavik	Total
Years of surveys	2000, 2001	2000, 2001	1998–2001	1998–2001
Dates of surveys	23–27 June	27 June–7 July	1–22 July	23 June–22 July
No. of eider nests	120	138	3839	4097
No. of islands surveyed	52	100	785	937
No. of islands with nests	15 (28.8%)	11 (11.0%)	182 (23.2%)	208 (22.2%)
No. of colonies	9	8	89	106
No. of nests per colony (range)	13.3 (1–73)	17.2 (1–77)	43.1 (1–598)	38.6 (1–598)
No. of nests per island (range)	8.0 (0–73)	12.5 (0–77)	21.1 (0–597)	19.7 (0–597)
No. of nesting islands per colony (range)	1.7 (1–5)	1.4 (1–2)	2.3 (1–25)	2.0 (1–25)
Percent of nests in status:				
– 2 (Prospected, abandoned or pre-laying)	43.8	25.4	3.8	5.8
– 3 (Laying)	5.7	1.5	1.0	1.2
– 4 (Previously incubated – eggs now missing)	23.7	21.4	17.4	17.7
– 5 (Incubating)	26.8	51.7	75.4	73.0
– 6 (Hatching)	0.0	0.0	1.8	1.7
– 7 (Hatched)	0.0	0.0	0.6	0.6
Mean clutch size ± SD (sample size)[1]	3.08 ± 1.28 (61)	3.61 ± 1.29 (129)	3.57 ± 1.23 (5235)	3.56 ± 1.23 (5425)
Mean clutch size ± SD (sample size)[2]	3.08 ± 1.28 (61)	3.96 ± 1.72 (140)	3.61 ± 1.30 (5278)	3.61 ± 1.31 (5479)

[1] Incubated nests with fewer than 8 eggs/nest (more than 8 eggs is considered egg dumping).

[2] All incubated nests.

$$S^2_{E+Y} = \frac{SS_E + SS_Y}{df_E + df_Y}$$

where *SS* is the sum of squares, and *df* is degrees of freedom. The standard error (SE) used in the computation of 95% confidence limits for the total breeding population estimate was calculated as

$$SE = \sqrt{S^2_{E+Y} \cdot \sum_{i=1}^{m} 1/n_i}$$

where *n* is the number of times a colony was surveyed, and *m* is the number of colonies included.

An a posteriori power analysis was used to calculate the magnitude of population change (%) that one could expect to be able to detect at a future survey with a given effort. The appropriate formula is

$$change(\%) \geq \sqrt{\frac{n_1 + n_2}{n_1 n_2}} \cdot cv \cdot (t_{\alpha/2} + t_{1-p})$$

where n_1 is the number of times (years) that the colonies were surveyed during the initial survey period, (1998–2001) and n_2 is the number of times (years) they would be surveyed in a given future survey period. *CV* is the coefficient of variation based on the total number of active nests, *p* is the certainty to detect the calculated population change with a given α level. The $t_{a/2}$ and t_{1-p} are one-tailed test values from a t-distribution with $n_1 + n_2 - 2$ degrees of freedom (Falk and Kampp, 1997).

RESULTS

The 1998–2001 Surveys

No more than 29% of all surveyed islands in any district had eiders nesting on them, and in the Uummannaq district only 11% were occupied (Table 1). The Upernavik district had the highest number of small islands; approximately 85% of all the surveyed islands. Also, the mean number of nests found per colony was highest in the Upernavik district (Table 1). On average, an eider colony consisted of two nesting islands. Altogether, 106 colonies were identified, with a total breeding population of 4097 ± 468 (95% CI) active nests. When excluding category 2 nests, for which the status is not clear, the breeding population was calculated to be 3859 ± 473 active nests (104 colonies). As many as 94% of the nests were found in the Upernavik district, while only 3% were located at each of the Uummannaq and Ilulissat district sites. The mean number of nests on each island increased progressively towards the most northern district (Upernavik), and ranged from 8 to 21 nests per island. No island larger than 1.5 km^2 had eiders nesting. Within the Upernavik district, colonies were most frequently encountered in the innermost fjord systems in the southern region and at the outermost archipelago in the northern region (Fig. 1).

Clutch size of incubated clutches (< 8 egg/nest) was significantly lower in the Ilulissat district than in the Uummannaq and Upernavik districts (t-test: t = 2.64; 3.09, $p = 0.009$; 0.002). This may be explained by the observation that laying was less completed in Ilulissat (Table 1). Clutch size did not differ between the districts of Uummannaq and Upernavik (t = 0.39, $p = 0.69$). The majority of nests were found during the incubation period; however, for a considerable proportion of the nests (17.7%), all eggs were missing at the time of the survey. This conclusion was based on nests that were fully loaded with down of the season, which does not occur until egg laying is almost completed (Cooch, 1965; G. Robertson, pers. comm. 2002). Only a few clutches were hatched at the time of the survey (Table 1), and these were confined

TABLE 2. Year-to-year variation in common eider nesting numbers (cat. 2–7 nests) for 49 colonies surveyed twice and 22 colonies surveyed three times in the period 1998–2001.

Colony[1]	1998	1999	2000	2001
69024			18	9
69117			14	21
69145			1	1
69147			57	73
70009			4	6
70024			4	4
70030			56	24
70031			10	3
70129			1	0
71017			77	72
71021			1	5
72028	14		52	9
72040	48		13	2
72102			23	55
72109		401	598	505
72111	13		14	0
72112	1		0	0
72127	24		56	46
72128	15		0	21
72129	4		4	0
72149		75	88	80
72154		2	10	6
72157		87	82	104
72161			50	7
73003			1	6
73006		7	2	5
73020		311	335	328
73036		11	14	1
73038			77	69
73045		8	3	0
73072			26	11
73076			185	196
73082		55	62	76
73084		13	11	6
73085		1	0	0
73086		2	1	0
73088		1	1	0
73096		5	4	4
73097		10	0	1
73098			2	1
73099			3	5
73100			10	27
73101			7	0
73102			10	0
74003			111	145
74032			7	0
74033			6	19
74034			2	10
74035			7	14
Total			2120	1977

[1] The colony code refers to the Greenland seabird colony database (Boertmann et al., 1996).

to areas with high nesting density in the Upernavik district. The earliest known hatch date was 8 July (1998 and 2001), while the latest date of a first hatching was 13 July (1999).

Year-to-Year Variation

From colonies that were surveyed in two or three subsequent years (1998–2001), it was evident that natural year-to-year variation in breeding numbers was high (Table 2). For small colonies (< 20 nests), the change could easily be ±100%, while larger colonies (< 20 nests) usually did not change more than ±50%. Changes in nesting numbers from one year to the next in individual colonies tended to go in different directions, but when summarized for a number of colonies, most of the variation was removed. For example, at 49 colonies surveyed both in 2000 and 2001, the total number of nesting eiders changed only from 2120 to 1977 nests (7% ± 13% (95% CI)), and any difference could not be detected (paired t-test: t = 1.03, $p = 0.31$). A power analysis revealed that if we were to repeat the survey of 49 colonies in two consecutive years, we could expect to detect only a population change greater than 27% ($p = 80\%$, $\alpha = 5\%$). Alternatively, 22 colonies surveyed three years in a row would not do any better. Only a population change of 31% ($p = 80\%$, $\alpha = 5\%$) or greater would be detected.

Old Versus Recent Surveys

Both a comparison of the number of breeding colonies found in old and recent surveys (Table 3) and a colony-by-colony comparison based on nest counts (Table 4) showed a drastic decline in breeding abundance. Among colonies surveyed during this study, 51 colonies were known from previous surveys. Of these, 36 colonies (71%) either did not exist anymore in 1998–2001 (n = 22) or had a reduced number of nesting eiders (n = 14). At 15 colonies, eiders were still nesting, but historical information is too vague to draw conclusions about population trend. The proportion of deserted colonies was notably higher within the Uummannaq district than in the two other districts for which historical data were collected 40–45 years later (76% vs. 20%). The more detailed comparison from the Upernavik and Ilulissat districts (Table 4) shows a drastic decline in the number of nesting eiders from 1960–65 until now. The number of nests declined from 3361 nests to 624 nests (81%) over a period of approximately 40 years, corresponding to an annual decline of 4% for the 15 colonies monitored (Table 4). According to a Wilcoxon matched pair test, an estimated median decline of 121 nests (95% CI: 48–236) was significantly larger than zero ($N = 15$, $T_- = 0$, $T_+ = 120$, $p = 0.001$). No colony had more nesting eiders than had been previously recorded there; however, the magnitude of the reduction varied considerably from one colony to another (range: 28%–100%). According to the ANOVA tests that quantify variance components due to changes between periods (1960–65 vs. 1998–2001) and changes within periods, a year-to-year variation during the 1960s that corresponds to the magnitude detected during 1998–2001 could not explain the change in nesting numbers observed from 1960–65 to 1998–2001. Variation between periods was significantly larger than variation within periods ($F_{1;3} = 294.8$; $p < 0.001$), as was variation due to interactions between year and colony size ($F_{1;71} = 481.1$; $p < 0.001$).

TABLE 3. Simplified breeding population trends for a number of colonies in the Upernavik, Uummannaq, and Ilulissat districts visited in 1920 (nests estimated) or in 1960–65 (nests counted) and recounted in 1998–2001. The table does not include all colonies surveyed in 1998–2001, but only those known from previous surveys.

District	No. of colonies surveyed in 1920 or in 1960–65	No. of colonies resurveyed in 1998–2001	No. of colonies abandoned	No. of colonies reduced in nesting numbers	No. of colonies with uncertain population trend
Upernavik	25	25	5	9	11
Uummannaq	25	21	16	1	4
Ilulissat	5	5	1	4	0
Total	55	51	22	14	15

DISCUSSION

Accuracy of the 1998–2001 Survey

Survey Technique: Identification of colonies and counting of nests introduce uncertainty, as colonies or nests (or both) can be missed. This source of error was not quantified, but is considered low for this survey because 1) colonies were easily identified because breeding birds were very alert, and some always flushed off the nests when we approached by boat; 2) areas not surveyed in Upernavik were independently identified as nonbreeding areas by at least two local people; 3) reliability of local knowledge included was verified within selected areas; and 4) eider nests in the colonies generally had a clustered distribution, and clusters were easily predicted on the basis of vegetation and exposure to wind and sun. Occasionally, the common eider breeds solitarily in West Greenland (Boertmann et al., 1996), and a few solitary nests were also discovered during this survey. It is likely, however, that most such nests were overlooked.

Uncertainties exist about the status of "category 2" nests (nests lined merely with plant material). Some of these nests may represent laying females that had the first one or two eggs depredated, or late breeders about to lay the first egg. This interpretation would agree with the observations that category 2 nests were more common in Ilulissat, where the proportion of category 3 nests (laying for sure) was also higher than elsewhere (Table 1). Furthermore, on several occasions females took off from category 2 nests. The remaining nests may represent nests that were abandoned at an early stage (before incubation), or they may be nests that were only prospected prior to laying. The latter should not be included as active nests. Occasionally, one got the impression that abandonment was the reason, as in one colony (69024) where only one incubating female corresponded to 17 prospected or abandoned nests, and nearby nesting alternatives were at least 15 km away. In most cases, however, category 2 nests were few and alternative nesting sites were close by, so there was no way to distinguish between prospected and abandoned nests.

All things considered, the overall count of active nests (categories 2–7) probably still represents a conservative estimate because of overlooked nests. In total, category 2 nests accounted for 5.8% of the active nests (Table 1), and at least some of them are likely to represent behaviour other than that of females prospecting for nests.

Year-to-year Variation: From this study, it is clear that without regular monitoring, year-to-year variation in the number of nesting eiders can be a major hindrance to producing a meaningful estimate of breeding population. Within this study area, the variation at the colony level was high, taking into account that eiders are usually considered highly philopatric with respect to their nesting sites (Cooch, 1965; Reed, 1975; Swennen, 1990). A possible explanation for the large year-to-year changes among different colonies is interannual movements of eiders between nearby breeding sites—sites that, although we define them as separate breeding colonies, eiders might consider as just one breeding unit. Studies in Scotland and Alaska have shown that eiders experiencing poor breeding success on one island tended to nest on an alternative nearby island the following year (Milne, 1974; Schamel, 1977). Within a 10 km^2 fjord bay area in Svalbard, Mehlum (1991) found substantial local redistribution of breeding birds, apparently related to variable snow and ice conditions early in the breeding season. The study indicated that eiders moved up to 5 km from one breeding season to the next. This suggests that the eiders are only as philopatric as local conditions ultimately permit.

In case of very unfavourable breeding conditions, eiders may not breed at all. Coulson (1984) and Mehlum (1991) reported on large fluctuations in total breeding numbers due to such extensive nonbreeding. Coulson (1984) cited a shortage of nesting sites, and Mehlum (1991) found the breeding propensity was reduced because of late ice breakup. Available information does not support a similar explanation for the population decline in West Greenland. Apparently, the current breeding population is only a fraction of its previous numbers (see below), yet according to NOAA satellite photos and local information, the sea ice breakup was similar in all years. First hatch dates that differ by only five days among years support this similarity. Furthermore, available colony-specific clutch size data from Upernavik (colony 73001, 73003, 74001-3; Table 4) show that clutch size was slightly higher during this survey (3.40 ± 1.15 (SD) eggs/nest) compared to 1965 (3.20 ± 1.02; t-test: $t = -3.59$, $p < 0.001$). This does not indicate more favourable breeding conditions

TABLE 4. Breeding population trends for a number of colonies in the districts of Ilulissat and Upernavik based on surveys conducted in 1960–65 (Joensen and Preuss, 1972) and in 1998–2001 (cat. 3–7 nests). Only colonies that were surveyed by means of nest-counts in both cases are included.

Colony[1]	No. of islands	No. of nests 1960–65	No. of nests 1998–2001	Deviation (days) between old and recent survey	Percent Reduction
69024	1	1075	1–2	3–7	98[2]
69081	2	36	2	6	94
69084	1	220	1	6	99
69085	2	27	0	6	100
69117	6	82	8–9	6–10	89[2]
72028	9	75	4–51	15–18	32[2]
73001	30	229	164	1	28
73002	6	215	0	3	100
73003	1	146	0–6	0–12	96[2]
73004	1	20	0	3	100
73005	3	72	0	4	100
73006	1	11	2–7	1–13	36[2]
74001	1	88	12	9	86
74002	1	522	226	9	57
74003	1	543	111–144	4–9	73[2]
Total	66	3361	624		81

[1] The colony code refers to the Greenland seabird colony database (Boertmann et al., 1996).

[2] The colony was surveyed 2–3 times in the period 1998–2001. The comparison between old and recent surveys is based on the highest number obtained in 1998–2001.

in 1965. The overall mean clutch size of 3.56 ± 1.23 observed in 1998–2001 appears intermediate compared to findings on Baffin and Ellesmere Islands (3.12–3.44; see Prach et al., 1986) and elsewhere in West Greenland (3.74–3.81; Frich et al., 1998; Christensen and Falk, 2001). Periodic nonbreeding may also arise from variability in body condition or in the number and species of predators present on the nesting ground (Quakenbush and Suydam, 1999). Information on these conditions is not available here. However, had nonbreeding been more common within this survey period, compared to the prior one, we would not expect to find larger clutch sizes. Females in good body condition tend to produce larger clutches (Milne, 1976; Erikstad et al., 1993).

Reasons for Eider Population Decline

Historical Reasoning: Using calculations based on the production of bird-skin carpets and clothes, the annual harvest at the turn of the nineteenth century was estimated to be a minimum of 150 000 eiders (Müller, 1906). Probably the common eider in West Greenland had already experienced a major decline by then (Müller, 1906; Krabbe, 1907; Bistrup, 1925; Salomonsen, 1967; Vibe, 1967), and harvest was thought by most to be the main cause. Vibe (1967) argued instead that the reason was climatic; however, his argument was based on questionable indirect information about common eider population trends in West Greenland (Merkel, 2002).

Climate: Common eiders depend on open water around the nesting site for a period of time in order to breed successfully (to have access to nesting sites themselves and to discourage access by arctic foxes), and therefore would have optimal breeding conditions during periods with a relatively warm climate (Goudie et al., 2000). The time of the 1960–65 surveys (Upernavik and Ilulissat) did in fact represent the final stage of a 40-year period of warm climate, with a mean sea surface temperature 0.5–1.0˚C higher than it is today. In contrast, the time of the Uummannaq survey (1920) represented the end of a cold climate period in West Greenland, with temperatures lower than today's (Buch, 2001). This general information indicates, at most, that gradual overall climate change cannot satisfactorily explain a general eider population decline in all three districts surveyed. Huge die-offs of common eiders (*S. m. sedentaria*), caused by adverse winter weather events, have been reported from Canada (Robertson and Gilchrist, 1998). Such events, which are not a function of overall climatic trends, are believed to be one of the key factors responsible for a major decline of the common eider population in Hudson Bay. Similar die-offs have not been reported from West Greenland; however, that does not exclude the possibility that winter mortality of eiders in Southwest Greenland is significantly influenced by adverse climatic events. High adult female survival is thought to be important in maintaining populations with the life strategy of eiders (i.e., late sexual maturity, low recruitment, low annual productivity, etc.) (Flint et al., 2000; Goudie et al., 2000).

Harvest: Harvest may be a threat to the common eider population. A computer model that simulates population dynamics of the northern common eider population in Greenland and Canada indicates that the reported harvest of 55 000–70 000 eiders per year in Greenland is not sustainable, given the known number of eider ducks wintering there (estimated at 460 000), and estimates that harvest must be reduced by at least 40% to stop projected population declines (Gilchrist et al., 2001). Also, recent studies indicate that bycatch of eiders in gill nets can be a major problem in winter and spring, especially in the lumpsucker (*Cyclopterus lumpus*) fishery. In March and April in 2000 and 2001, bycatch in gill nets accounted for 52% of all the eiders brought to the local market in Nuuk, Southwest Greenland (F. Merkel, unpubl. data).

In general, the winter and spring harvest period in Southwest Greenland (October – May) has contributed the most to the harvest. Close to 90% of all eiders harvested in western Greenland are taken during this period **(**Piniarneq, 1993 – 2002**)**. Excessive winter harvest mortality could affect breeding numbers on a wide geographical scale. Farther south in West Greenland, at a remote and inaccessible fjord location near Kangaatsiaq (67˚40′ N), Frich et al. (1998) found that the local breeding population had been reduced by 73% to 83% since 1965. Only the breeding population in the most northern region of West Greenland seems to be stable (Christensen and Falk, 2001). Recoveries of banded birds indicate that these birds mainly winter in the northern part of Southwest Greenland, as far north as the ice allows (Lyngs, 2003), and according to the harvest records, hunting is less extensive there. The effect of the winter harvest is diminished because so many of the birds harvested (more than half the harvest in Nuuk) are juveniles (Frich and Falk, 1997; F. Merkel, unpubl. data). Furthermore, hunting pressure during winter on the West Greenland breeding population is diluted because approximately 90% of the common eiders wintering in Southwest Greenland breed in the eastern Canadian Arctic (Merkel et al., 2002a). In April and May, when the Canadian breeders start migrating to their breeding areas, a greater proportion of the eiders harvested would be Greenland breeders.

Potential threats during the breeding season (June–August) include a relatively small hunt (ca. 3200 eiders, partly illegal), egging, and predation. Overall, 18% of nests were found empty. Gull predation could account for at least one-fifth of these, judging by the number of eggshells left in or nearby the colonies. No evidence of fox predation was found. It is possible, though, that some colonies were abandoned during laying or early incubation because of foxes. Fox predation on eider eggs usually leads to colony extirpation (Quinlan and Lehnhausen, 1982; Robertson, 1995). Egging has not been allowed since 1977, but it is recognized still to occur to some extent in West Greenland. Egging was also observed on a few occasions during this study. In view of the large proportion of empty nests registered, it is tempting to suggest that egging is still common practice in this part of West Greenland. Egging is usually done during early incubation to avoid eggs with advanced embryo development. Early incubation is also the period when eiders are most vulnerable (in terms of nesting success) to disturbance (Bolduc and Guillemette, 2003).

Management Considerations

At this point, it is not clear what has caused the common eider population decline in West Greenland. However, available information indicates that harvest needs to be considered as a likely key factor in the reduction. If the winter and spring harvest in Southwest Greenland indeed is highly unsustainable, as indicated by recent modelling (Gilchrist et al., 2001), then there is reason to believe that the Canadian breeding population of northern common eider has suffered a decline similar to that in West Greenland. Most Canadian birds spend the fall, winter, and spring in Southwest Greenland (Merkel et al., 2002a, b). Recent trend information is needed from eastern Canadian breeding grounds. For the West Greenland breeding population, uncertainty remains for a few colonies far to the north and for the breeding population in Southwest Greenland. Priority should be given to surveying these areas to complete a recent update for all of West Greenland. Estimating the unsurveyed areas in West Greenland, the total breeding population is probably no more than 12 000 – 15 000 breeding pairs (Merkel, 2002).

Recent national and international focus on wise management of Arctic eider populations (CAFF, 1997; Gilchrist, 1999; Gilchrist et al., 1999; Gilchrist and McCormick, 2001; Merkel and Christensen, 1999) has encouraged restrictions on the harvest. From January 2002, the winter season was shortened by four months, and spring hunting is no longer allowed. At this point, however, some politicians want to revert to former regulations because of pressure from hunting organizations. If the 2002 regulations are fully implemented, harvest levels are expected to decline significantly. From this point on, breeding colonies should be monitored more regularly to see if they do show signs of recovery. Retrospectively, such monitoring could help us to assess the causal link between recent harvest levels and declining population trends.

Future monitoring, however, will have to take into consideration expected annual variations. The power analyses clearly showed that large-scale year-to-year fluctuations in nesting numbers restrict the possibility of detecting certain small-scale population changes—information that is needed to assess the impact of conservation initiatives. To increase the chance of detecting small-scale population trends, we need a long-term program of annual surveys covering 30 – 50 colonies that are distributed in a number of well-defined subunits, which will account for both extensive non-breeding and local interannual movements.

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REFERENCES

ABRAHAM, K.F., and FINNEY, G.H. 1986. Eiders of the eastern Canadian Arctic. In: Reed, A., ed. Eider ducks in Canada. Canadian Wildlife Service Report Series No. 47. 55–73.

BERTELSEN, A. 1921. Fuglene i Umánaq Distrikt. Meddelelser om Grønland 62:139–214.

BISTRUP, A. 1925. Ederfuglenes saga i Grønland. Dansk Ornitologisk Forenings Tidsskrift 23:43–54.

BOERTMANN, D. 1994. An annotated checklist to the birds of Greenland. Meddelelser om Grønland, Bioscience 38. 63 p.

BOERTMANN, D., MOSBECH, A., FALK, K., and KAMPP, K. 1996. Seabird colonies in western Greenland. Technical Report No. 170. Copenhagen: National Environmental Research Institute (NERI). 98 p.

BOLDUC, F., and GUILLEMETTE, M. 2003. Human disturbance and nesting success of common eiders: Interaction between visitors and gulls. Biological Conservation 110:77–83.

BUCH, E. 2001. The ocean environment. In: Born, E., and Böcher, J., eds. The ecology of Greenland. Nuuk: Ilinniusiorfik. 111–122.

CAFF (CONSERVATION OF ARCTIC FLORA AND FAUNA). 1997. Circumpolar Eider Conservation Strategy and Action Plan. http://www.grida.no/caff. 16 p.

CHRISTENSEN, K.D., and FALK, K. 2001. Status of the common eider breeding in the municipality of Avanersuaq (Thule), northwest Greenland. Polar Research 20(1):109–114.

COOCH, F.G. 1965. Breeding biology and management of the northern eider (*Somateria mollissima*) in the Cape Dorset area, Northwest Territories. Wildlife Management Bulletin Series 2, No. 10. Canadian Wildlife Service. 68 p.

COULSON, J.C. 1984. The population dynamics of the eider duck *Somateria mollissima* and evidence of extensive non-breeding by adult ducks. Ibis 126:525–543.

CRAMP, S., ed. 1977. The birds of the western Palearctic, Vol. I. Oxford: Oxford University Press. 722 p.

DENLINGER, L., and WOHL, K. 2001. Seabird harvest regimes in the Circumpolar Nations. Conservation of Arctic Flora and Fauna (CAFF) Technical Report No. 9. Akureyri, Iceland: CAFF International Secretariat, Circumpolar Seabird Working Group (CSWG). 52 p.

ERIKSTAD, K.E., BUSTNES, J.O., and MOUM, T. 1993. Clutch-size determination in precocial birds: A study of the common eider. Auk 110(3):623–628.

FALK, K., and KAMPP, K. 1997. A manual for monitoring thick-billed murre populations in Greenland. Technical Report No. 7. Nuuk: Greenland Institute of Natural Resources. 90 p.

FLINT, P.L., PETERSEN, M.R., DAU, C.P., HINES, J.E., and NICHOLS, J.D. 2000. Annual survival and site fidelity of Steller's eiders moulting along the Alaska Peninsula. Journal of Wildlife Management 64(1):261–268.

FRICH, A.S., and FALK, K. 1997. Jagtindsats og ederfuglefangst ved Nuuk. Technical Report No. 5. Nuuk: Greenland Institute of Natural Resources. 33 p.

FRICH, A.S., CHRISTENSEN, K.D., and FALK, K. 1998. Ederfugle-optællinger i Kangaatsiaq og Avanersuaq 1997 (Common eider ground surveys in Kangaatsiaq and Avanersuaq 1997). Technical Report No. 10. Nuuk: Greenland Institute of Natural Resources. 33 p.

GARDARSON, A. 1995. Svartfugl i islenskun fuglabjörgum (English summary: Numbers and distribution of common murre *Uria aalga*, thick-billed murre *U. lomvia* and razorbill *Alca torda* in Iceland). Bliki 16:47–65.

GILCHRIST, H.G. 1999. Canadian Implementation of the CAFF Eider Conservation and Action Plan. Unpubl. report, Canadian Wildlife Service. Available from the National Wildlife Research Centre, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3, Canada. 26 p.

GILCHRIST, H.G., and McCORMICK, K. 2001. Northern Common Eider Cooperative Management Strategy and Action Plan. Unpubl. report, Canadian Wildlife Service. Available from the National Wildlife Research Centre, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3, Canada. 20 p.

GILCHRIST, H.G., MERKEL, F.R., GILLILAND, S., and SAVARD, J.-P. 1999. Identifying research priorities of king and common eider duck populations shared by Canada and Greenland (Results from a strategic planning meeting). Unpubl. report, Canadian Wildlife Service and Greenland Institute of Natural Resources. Available from the National Wildlife Research Centre, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3, Canada. 20 p.

GILCHRIST, H.G., GILLILAND, S., ROCKWELL, R., SAVARD, J.-P., ROBERTSON, G.J., and MERKEL, F.R. 2001. Population dynamics of the northern common eider in Canada and Greenland: Results of a computer simulation model. Unpubl. report, Canadian Wildlife Service. Available from the National Wildlife Research Centre, Carleton University, 1125 Colonel By Drive, Ottawa, Ontario K1A 0H3, Canada.

GOUDIE, R.I., ROBERTSON, G.J., and REED, A. 2000. Common eider (*Somateria mollissima*). In: Poole, A., and Gill, F., eds. The Birds of North America, No. 546. Philadelphia: The Birds of North America, Inc. 31 p.

GRATTO-TREVOR, C.L., JOHNSTON, V.H., and PEPPER, S.T. 1998. Changes in shorebird and eider abundance in the Rasmussen Lowlands, NWT. Wilson Bulletin 110(3):316–325.

JOENSEN, A.H., and PREUSS, N.O. 1972. Report on the ornithological expedition to Northwest Greenland 1965. Meddelelser om Grønland 191(5). 58 p.

KAMPP, K., NETTLESHIP, D.N., and EVANS, P.G.H. 1994. Thick-billed murres of Greenland: Status and prospects. In: Nettleship, D.N., Burger, J., and Gochfeld, M., eds. Seabirds on

Islands: Threats, case-studies and action plans. Birdlife Conservation Series No. 1. Cambridge: Birdlife International. 133–154.

KRABBE, T.N. 1907. Om de grønlandske ederfugle. Dansk Ornitologisk Forenings Tidsskrift 1:98–112.

LYNGS, P. 2003. Migration and winter ranges of birds in Greenland: An analysis of ringing recoveries. Dansk Ornithologisk Forenings Tidsskrift 97(1). 167 p.

MEHLUM, F. 1991. Breeding population size of the common eider *Somateria mollissima* in Kongsfjorden, Svalbard, 1981–1987. Norsk Polarinstitut Skrifter 195:21–29.

MERKEL, F.R. 2002. Ederfugleoptællinger i Ilulissat, Uummannaq og Upernavik kommune, 1998-2001 (English summary: Common eider ground surveys in western Greenland (1998–2001), covering the districts of Ilulissat, Uummannaq and Upernavik.) Technical Report No. 43. Nuuk: Greenland Institute of Natural Resources. 80 p.

MERKEL, F.R., and CHRISTENSEN, T. 1999. Conservation Strategy and Action Plan for Eiders in Greenland. Unpubl. report, Greenland Institute of Natural Resources & Department of Environment and Nature, Greenland Home Rule. Available from the Greenland Institute of Natural Resources, P.O. Box 570, DK-3900 Nuuk, Greenland. 11 p.

MERKEL, F.R., MOSBECH, A., BOERTMANN, D.M., and GRØNDAHL, L. 2002a. Winter seabird distribution and abundance off south-western Greenland, 1999. Polar Research 21(1):17–36.

MERKEL, F.R., MOSBECH, A., SONNE-HANSEN, C., and FLAGSTAD, A. 2002b. Satellite tracking of common eiders wintering around Nuuk, Southwest Greenland, 2000–2001. Progress Report. Nuuk: Greenland Institute of Natural Resources. 20 p.

MILNE, H. 1974. Breeding numbers and reproductive rate of eiders at the Sands of Forvie National Nature Reserve, Scotland. Ibis 116:135–152.

———. 1976. Body weights and carcass composition of the common eider. Wildfowl 27:115–122.

MOSBECH, A., and BOERTMANN, D. 1999. Distribution, abundance and reaction to aerial surveys of post-breeding king eiders (*Somateria spectabilis*) in western Greenland. Arctic 52(2):188–203.

MÜLLER, R. 1906. Vildtet og jagten i Sydgrønland. Hovedkomm. for Norge: Oslo: H. Aschehoug.

NATTURUFRÆDISTOFNUN ISLANDS. 2000. Válisti 2. Fuglar. (English summary: Red list of Iceland (2). Birds). Compiled by: Alfheidur Ingadottir, Kristinn H. Skarphedinsson & Ævar Petersen. Reykjavik: Natturufrædistofnun Islands. 103 p.

PALMER, R.S. 1976. Handbook of North American birds. New Haven and London: Yale University Press. 560 p.

PINIARNEQ. 1993–2002. Hunting statistics for 1993–2002 for Greenland. Nuuk: Department of Hunting and Fisheries, Greenland Home Rule.

PRACH, R.W., SMITH, A.R., and DZUBIN, A. 1986. Nesting of the common eider near the Hell Gate-Cardigan Strait polynya, 1980-1981. In: Reed, A., ed. Eider ducks in Canada. Report Series No. 47. Ottawa: Canadian Wildlife Service. 127–135.

QUAKENBUSH, L., and SUYDAM, R. 1999. Periodic nonbreeding of Steller's eider near Barrow, Alaska, with speculations on possible causes. In: Goudie, R.I., Petersen, M.R., and Robertson, G.J., eds. Behaviour and ecology of sea ducks. Occasional Paper No. 100. Ottawa: Canadian Wildlife Service. 34–40.

QUINLAN, S.E., and LEHNHAUSEN, W.A. 1982. Arctic fox, *Alopex lagopus*, predation on nesting common eiders, *Somateria mollissima*, at Icy Cape, Alaska. The Canadian Field-Naturalist 94(4):462–466.

REED, A. 1975. Migration, homing, and mortality of breeding female eiders *Somateria mollissima dresseri* of the St. Lawrence estuary, Quebec. Ornis Scandinavica 6:41–47.

REED, A., and ERSKINE, A.J. 1986. Populations of the common eider in eastern North America. In: Reed, A., ed. Eider ducks in Canada. Canadian Wildlife Service Report Series No. 47. 156–162.

ROBERTSON, G.J. 1995. Factors affecting nest site selection and nesting success in the common eider *Somateria mollissima*. Ibis 137:109–115.

ROBERTSON, G.J., and GILCHRIST, H.G. 1998. Evidence of population declines among common eiders breeding in the Belcher Islands, Northwest Territories. Arctic 51(4):378–385.

SALOMONSEN, F. 1967. Fuglene på Grønland (The birds of Greenland). Copenhagen: Rhodos. 340 p.

———. 1990. Grønlands fauna (The fauna of Greenland). 2nd ed. Copenhagen: Gyldendal. 464 p.

SCHAMEL, D. 1977. Breeding of the common eider (*Somateria mollissima*) on the Beaufort Sea coast of Alaska. Condor 79: 478–485.

SWENNEN, C. 1990. Dispersal and migratory movements of eiders *Somateria mollissima* breeding in the Netherlands. Ornis Scandinavica 21:17–27.

VIBE, C. 1967. Arctic animals in relation to climatic fluctuations. Meddelelser om Grønland 170. 227 p.