Richard H. Kerbes

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Number 81
Canadian Wildlife Service

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Cover photo: Nesting Ross' Geese and Lesser Snow Geese at Karrak Lake, NWT. (M. Robert McLandress)

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Abstract

I used large-format aerial photography combined with ground-truth surveys to estimate the total numbers of Ross' Geese *Anser rossii* and Lesser Snow Geese *Anser caerulescens caerulescens* (hereafter also called Snow Geese or Snows) nesting in June in the Queen Maud Gulf Migratory Bird Sanctuary (MBS) in the central Canadian Arctic. In 1982, 41 colonies had 196 500 nesting birds, 46% of them Ross' Geese; in 1988, 57 colonies had 467 000 nesting birds, 40% of them Ross' Geese. Comparison with previous surveys of nesting birds in 1965–67 and 1976 shows that both species have increased in number. The rate of increase is lower for Ross' Geese than for Snow Geese. Over the period between 1965 and 1988, the average annual finite rates of increase were 7.7% for Ross' Geese and 15.4% for Snows.

The rapid increase in the number of Snow Geese seems to be due in part to immigration from colonies in the eastern Canadian Arctic. The percentage of blue-phase Snow Geese among total Snow Geese in the Queen Maud Gulf MBS increased from 5% in 1965 to almost 20% in 1988. The latter percentage is similar to the blue-phase percentage observed in Snow Goose colonies on the west coast of Hudson Bay.

Most of the increase in both Ross' and Snow goose numbers has occurred among birds nesting on mainland, or lakeshore, as opposed to birds nesting on the traditional islands in lakes. The proportion of total birds nesting on mainland increased from 0% in 1965 to 23% in 1976, 55% in 1982, and 75% in 1988. The four largest colonies have supported an increasing proportion of the total number of birds, amounting to 92% in 1982 and 91% in 1988. However, the small colonies continue to persist and increase in number, although many were not occupied during each of the survey years. In total, 66 different colonies were recorded from 1965 to 1988.

Most (an estimated 95%) of the world's population of Ross' Geese nest in the Queen Maud Gulf region, with smaller numbers nesting in the Snow Goose colonies of the eastern and western Canadian Arctic. The Central Valley of California is the main wintering ground for Ross' Geese, although the proportion wintering there may be declining. Many Ross' Geese winter in New Mexico and the north-central highlands of Mexico. Smaller, but increasing, numbers winter in Texas and Louisiana.

The Queen Maud Gulf region now supports one of the largest breeding populations of Snow Geese. Most winter in New Mexico, northern Mexico, Texas, and Louisiana, with a small portion (those from the western part of the Queen Maud Gulf MBS) wintering in California.

Management concerns include the potential threats of genetic swamping of the Ross' Goose by the Snow Goose and of overpopulation of both species with consequent destruction of summer habitat. The latter factor is related to concerns for other species of geese and mammals that use the same habitat as Ross' and Snow geese. Most of the nesting and summer habitats are within the Queen Maud Gulf MBS.

Investigations are needed on habitat conditions and the current size of the Ross' Goose and Snow Goose populations in the Queen Maud Gulf region. Also, management of these geese needs information on the current rate of Snow Goose emigration from the eastern Canadian Arctic and the size of nesting populations in that region. Continental management of Ross' and Snow geese should be based on breeding populations, rather than on combinations of populations on the wintering grounds.

Résumé

J'ai utilisé des photographies aériennes grand format et réalisé au sol des relevés de contrôle pour estimer les effectifs totaux d'Oies de Ross *Anser rossii* et de Petites Oies des neiges *Anser caerulescens caerulescens*, appelées *Snow Geese* ou *Snows* dans le présent rapport, qui nichent en juin dans le refuge d'oiseaux migrateurs (ROM) du Golfe-de-la- Reine-Maud, lequel se trouve dans la région centrale de l'Arctique canadien. En 1982, on a dénombré 41 colonies comptant en tout 196 500 oiseaux nicheurs, dont 46 % étaient des Oies de Ross; en 1988, on a dénombré 57 colonies comptant 467 000 oiseaux nicheurs, dont 40 % étaient des Oies de Ross. Il ressort de ces relevés d'oiseaux nicheurs et de ceux effectués dans la période 1965–1967 et en 1976 que les effectifs des deux espèces se sont accrus d'un relevé à l'autre. Le taux d'accroissement des effectifs de l'Oie de Ross est inférieur à celui des effectifs de la Petite Oie des neiges : pour la période allant de 1965 à 1988, les taux finis annuels moyens d'accroissement des populations ont été de 7,7 % dans le cas de l'Oie de Ross et de 15,4 % dans le cas de la Petite Oie des neiges.

L'accroissement rapide des effectifs de la Petite Oie des neiges semble en partie attribuable à l'immigration d'oiseaux provenant de colonies de l'est de l'Arctique canadien. La proportion d'oies de la forme bleue chez les Petites Oies des neiges du golfe de la Reine-Maud est passée de 5 %, en 1965, à presque 20 %, en 1988. Ce dernier pourcentage est similaire à celui observé dans les colonies de Petites Oies des neiges de la côte ouest de la baie d'Hudson.

Tant dans le cas de l'Oie de Ross que dans celui de la Petite Oie des neiges, c'est le nombre d'oiseaux nichant sur la terre ferme ou en bordure des lacs, plutôt que celui des oiseaux nichant sur les îles lacustres habituelles, qui a le plus augmenté. La proportion d'oiseaux nichant sur la terre ferme était nulle en 1965, puis est passée à 23 % de l'ensemble des oiseaux nicheurs en 1976, à 55 % en 1982 et enfin à 75 % en 1988. Les quatre colonies les plus importantes ont abrité une proportion croissante de l'ensemble des oiseaux; cette proportion était de 92 % en 1982, et de 91 % en 1988. Toutefois, les petites colonies continuent d'exister et leur nombre s'accroît, même si bon nombre d'entre elles n'étaient pas présentes durant les années de relevés. On a signalé en tout 66 colonies différentes durant la période 1965–1988.

La plus grande partie de la population mondiale d'Oies de Ross, soit environ 95 %, nichent dans la région du golfe de la Reine-Maud, et un petit nombre, dans les colonies de Petites Oies des neiges de l'est et de l'ouest de l'Arctique canadien. La plus grande proportion des Oies de Ross hivernent dans la Central Valley, en Californie, mais il se pourrait que cette proportion soit actuellement à la baisse. De nombreuses Oies de Ross hivernent au Nouveau-Mexique et dans le centre-nord des hautes terres du Mexique. Des effectifs plus petits, quoique de plus en plus nombreux, hivernent au Texas et en Louisiane.

La région du golfe de la Reine-Maud abrite actuellement l'une des plus importantes populations nicheuses de Petites Oies des neiges. La plupart des oies de cette population hivernent au Nouveau-Mexique, dans le nord du Mexique, au Texas et en Louisiane, et une faible proportion (oies de la partie ouest du ROM du Golfe-de-la-Reine-Maud) hivernent en Californie.

En ce qui concerne la gestion de ces populations d'Oies de Ross et de Petites Oies des neiges, on craint notamment qu'il y ait dilution du patrimoine génétique de l'Oie de Ross dans la population de Petites Oies des neiges, et surpopulation des deux espèces, ce qui entraînerait une destruction de l'habitat d'estivage. Ce dernier aspect concerne également d'autres espèces d'oies ainsi que certains mammifères qui vivent dans le même habitat que les Oies de Ross et les Petites Oies des neiges. La plus grande partie des habitats de nidification et d'estivage se trouvent dans le ROM du Golfe-de-la-Reine-Maud.

On devra effectuer des recherches pour déterminer les conditions d'habitat et la taille des populations d'Oies de Ross et de Petites Oies des neiges dans la région du golfe de la Reine-Maud. La gestion de ces oies devra s'appuyer sur des informations relatives au taux actuel d'émigration de Petites Oies des neiges provenant de l'est de l'Arctique canadien, ainsi qu'à la taille des populations nicheuses dans cette région. Enfin, la gestion des deux espèces à l'échelle du continent devra être fondée sur les populations nicheuses plutôt que sur les groupes de populations qui se forment dans les lieux d'hivernage.

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1.0 Introduction

The Queen Maud Gulf Migratory Bird Sanctuary (MBS) in the central Canadian Arctic (Fig. 1) is the breeding ground for most of the world's population of Ross' Geese *Anser rossii* (Ryder 1969; Prevett and MacInnes 1972). Although its numbers have increased greatly in recent decades, Ross' Goose remains one of the least numerous species of geese in North America. Lesser Snow Geese *Anser caerulescens caerulescens* (hereafter also called Snow Geese or Snows), among the most abundant of geese, nest primarily in the eastern and western Canadian Arctic (Kerbes 1975, 1986) but also nest in association with Ross' Geese in the central Canadian Arctic (Ryder 1969; Kerbes et al. 1983). Here I report on June surveys using aerial photography to determine the numbers and geographical distribution of Ross' Geese and Snow Geese nesting in the Queen Maud Gulf MBS in 1982 and 1988. I relate these results to earlier records and to the summer habitat of the geese and their southern distribution.

2.0 Previous investigations

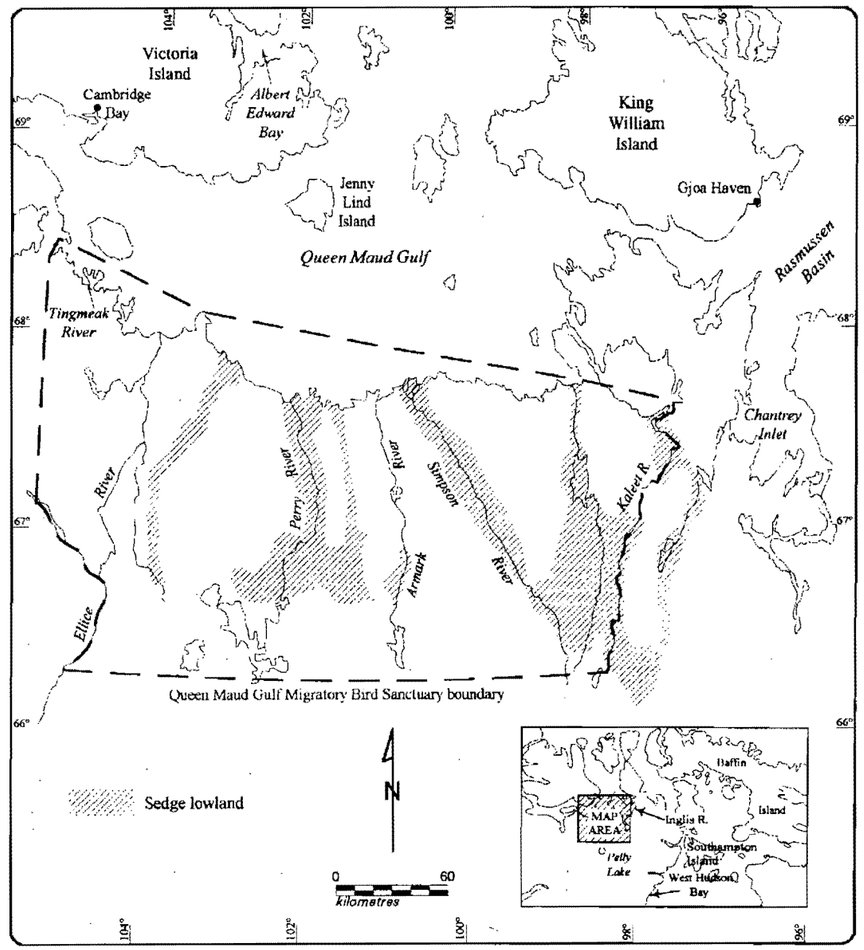
The following adds to, and clarifies, historical reviews by Hanson et al. (1956) and Ryder (1967).

The whereabouts of the breeding grounds of the Ross' Goose was one of North America's last great ornithological mysteries (Taverner 1940). Samuel Hearne (1795) was the first European to describe the Ross' Goose. In 1770–72, while travelling on foot across the interior between Fort Prince of Wales (Churchill) and the Coppermine River with Chipewyan guides, he saw, hunted, and ate the "Horned Wavey." The species was not described officially until 90 years later, when Cassin (1861) named it after Bernard Rogan Ross of the Hudson's Bay Company, who had sent him specimens taken during migration. The nesting grounds of the Ross' Goose remained unknown for another 80 years.

As it turned out, the elusive small goose was nesting within the ancestral territory of the Kogmuit, a small tribe of Inuit who lived on the shores of Queen Maud Gulf (Fig. 1) and traded at the Hudson's Bay Company post at Perry River. The Kogmuit knew the Ross' Goose well and, in 1938, offered to guide Angus Gavin to a nesting colony. Gavin, a young fur trader fluent in the Inuit language, had been alerted to the search for Ross' Geese by his superiors in the Company. In June of both 1938 and 1939, the Kogmuit guided Gavin to two small nesting colonies of Ross' Geese, approximately 20 km inland from the Perry River post (Gavin 1947). Specimens were collected in both years but were subsequently lost before reaching outside authorities (A. Gavin, pers. commun.).

Meanwhile, Charles E. Gillham of the United States Biological Survey had been investigating waterfowl in the Mackenzie Delta area. Acting on the Inuit reports that he had earlier received from Gavin, Gillham attempted to reach Perry River by chartered float plane in both 1938 and 1939, in pursuit of the Ross' Goose. However, he was prevented from reaching the area in both years. In 1938, drifting sea ice at Perry River prevented a landing. In 1939, Gillham's flight was cancelled unexpectedly because of the sudden death of a close friend of his pilot, Wop May (the famous Canadian World War I fighter ace and bush pilot). May offered to make the flight after the funeral, but it would have been too late to record geese on nests (Gillham 1947). Finally, in 1940, with John J. Lynch (pers. commun.), Gillham planned another charter to Perry River, but lack of funds — personal as well as from his employer — cancelled

Figure 1
Queen Maud Gulf region, showing the boundary of the Migratory Bird Sanctuary, the approximate extent of continuous sedge lowland habitat areas, and places mentioned in the text



the trip again. As Gillham (1947) said, "it wasn't in the cards" for him to "discover" the Ross' Goose.

On 1 July 1940, Gavin and E. Donovan, with Kogmuit guides, reached the nesting colony of Ross' Geese at Discovery Lake. They collected skins and eggs and took photographs of nesting Ross' Geese, all of which successfully reached the National Museum of Canada to officially document the nesting grounds (Taverner 1940).

In 1949, Harold Hanson (later to become famous for Canada Goose *Branta canadensis* taxonomy), Peter Scott (founder of the Severn Wildfowl Trust in Britain in 1946), and Paul Queneau (a geologist, later president of the International Nickel Company of Canada) conducted biological and geographical investigations in the Perry River region. They confirmed the Kogmuit report of another Ross' Goose colony at Arlone Lake, where they collected data on nesting birds. They also did a visual survey of part of the Queen Maud Gulf area from an aircraft at the conclusion of their study (Hanson et al. 1956).

Biological investigations were not resumed until 1960, when Barry (1960) flew extensive surveys of the area. Efforts led by Barry and F.G. Cooch (pers. commun.) resulted in the establishment of the federal Queen Maud Gulf MBS in 1961, to protect the nesting grounds of the Ross' Goose. MacInnes (1964) neckbanded Ross' Geese in the Perry River area in 1962. Ryder (1967) documented the breeding biology of Ross' Geese at Arlone Lake in 1963 and 1964. In 1964, Lumsden (1964) conducted an aerial survey of geese in the region. From 1965 to 1967, Ryder (1969, 1971a) flew visual surveys of the Queen Maud Gulf MBS, documenting Karrak Lake and 34 other colonies of Ross' and Snow geese, which were additional to those at Discovery and Arlone lakes. As most (>90%) of his estimates of actual numbers of nesting birds were obtained in 1965, hereafter I may refer to his results as being from 1965. Ryder (1972) studied the biology and nest spacing of Ross' Geese at Karrak Lake from 1966 to 1968.

Visual aerial surveys of waterfowl in the region were conducted in 1971 by Kuyt et al. (1971) and again in 1972 by E. Kuyt and C. Schroeder (pers. commun.). In 1976, McLandress (1983b) studied nesting Ross' and Snow geese at Karrak Lake and Kerbes et al. (1983) used aerial photography and ground-truthing to estimate the numbers of nesting Ross' and Snow geese in 30 colonies of the Queen Maud Gulf MBS.

In addition to my 1982 and 1988 inventories of nesting Ross' and Snow geese reported here, recent studies include my aerial surveys of summer distribution of those birds in 1981 and 1989; neckbanding of Ross' Geese, Snow Geese, Greater White-fronted Geese *Anser albifrons*, and Canada Geese from 1989 to 1993 (Kerbes 1991; R. Alisauskas, pers. commun.); studies of nesting and brood dispersal of Ross' and Snow geese in 1991 and 1992 (R. Alisauskas and S. Slattery, pers. commun.); visual aerial transect surveys of nesting geese in 1990–92 (Alisauskas and Boyd, in press); and habitat mapping from satellite imagery in 1991 and 1992 (A. Didiuk, pers. commun.).

3.0 Methods

In 1982 and 1988, as in 1976 (Kerbes et al. 1983), I used aerial photography to determine total numbers of nesting Ross' and Snow geese, with concurrent ground-truth surveys to estimate the numbers of each species in the Queen Maud Gulf colonies. All previously known colony sites, as well as most of the potential sites, were surveyed each year. Potential sites were defined as shallow lakes with islands suitable for nesting (Ryder 1969), which I identified from examination of Landsat satellite imagery (Kerbes 1978). Snow Geese include white-phase and blue-phase birds (Delacour and Mayr 1945). For analysis, I considered the Ross' Goose to have only a white phase. Blue-phase Ross' and Ross' × blue-phase Snow hybrids exist (McLandress and McLandress 1979), but they are exceedingly rare (< 0.1%). Nesting areas on colonies were defined as *islands* (surrounded by water during incubation in June) or as *mainland* (on the shore of lakes, occasionally rivers). Nesting areas of the three largest colonies — colonies 3, 9, and 10 — extended inland for several kilometres. These three, plus certain smaller colonies, constituted *key* colonies, at which both air photo and ground surveys were conducted.

3.1 Obtaining and analyzing aerial photographs

I obtained sample photo coverage of the large colonies and total coverage of most small colonies during the incubation period of the geese. We used a Twin Otter aircraft and a Wild RC-10 (23-cm format) camera with a 153-mm lens and Kodak Plus-X film. Images of the geese were counted from the original negatives on a light table with a binocular microscope. Birds distributed in pairs or singles on the ground were classified as nesting; those in flocks or in flight were classified as nonbreeders (Kerbes 1975; Reed et al. 1987). Ross' Geese and white-phase Snows were counted from photos taken at altitudes of between 305 and 760 m (scale 1:2000 to 1:5000). Colour ratios of blue-phase Snows to total Ross' and Snow geese were taken from photos of scale 1:2000 in 1982 and from visual counts by ground observers in 1988.

3.2 Ground-truth surveys

A crew of three observers and a pilot with a Bell 206B helicopter, based at the mouth of Perry River, conducted ground observations to estimate the species and colour ratios of the nesting geese. The helicopter deployed the ground crew to each of the major and some of the minor colonies. Disturbance to nesting birds was minimized by landing in low wet areas with no nests nearby. Observers then classified nests as Ross' or Snow goose nests as they walked along sample transects that crossed the major habitat types in that area of the colony. Habitat type — that is, moss, mixed, or rock (Kerbes et al. 1983) — species, and clutch size were recorded for each sample nest.

Nests were classified to species using egg measurement criteria established by R. McLandress (pers. commun.) at Karrak Lake in 1976 for differentiating between Ross' and Snow goose nests. Each nest was identified by measurement of an "intermediate-laid" egg of the clutch (i.e., neither the largest nor the smallest and showing an intermediate amount of staining), as follows:

1) Breadth of egg ≤50 mm = Ross', or
2) Breadth of egg >53 mm = Snow, or
3) Breadth of egg >50 but ≤53 mm, then:
   a) Length of egg ≤76 mm = Ross', or
   b) Length of egg >76 mm = Snow.

In 1988, the ground crew measured the eggs of "known" species when parents at the nest could be verified. They estimated the proportion of blue-phase Snow Geese among total geese from sample counts of nesting birds.

While flying in the helicopter past small colonies, the crew visually estimated the number of nesting birds and obtained small-format (35-mm) photographs. Those observations and photos, taken obliquely from far enough away to avoid disturbing the geese, provided a supplement and backup to the 23-cm vertical air photos.

3.3 Data analyses

Air photos and ground work provided three types of data:

1) counts of Ross' and white-phase Snow geese from air photos at the large colonies and most of the small colonies (some small colonies were estimated visually from the photo aircraft or the helicopter);
2) air photo counts of samples of nesting birds, for an estimate of the proportion of blue-phase Snows among total geese; and
3) ground sampling of nests for an estimate of the proportion of Ross' Geese among total geese (1982 and 1988), and sample counts of nesting birds for an estimate of the proportion of blue-phase Snows among total geese (1988).

The major and some of the minor colonies were covered by all three surveys. For these key colonies, the numbers, species, and colour composition, with standard errors, were calculated as in Kerbes (1975) and Kerbes et al. (1983). To estimate the goose composition in other colonies where colour ratios, but not Ross' ratios, were obtained, we assumed that the proportion of blue-phase Snow Geese among all Snow Geese at other colonies was equal to the mean value for the key colonies. In colonies where neither colour nor Ross' ratio was obtained, we assumed that the proportion of Ross' Geese among Ross' and Snow geese was the same as the mean value for all other colonies. These extrapolations were done for west and east portions of the Queen Maud Gulf MBS, divided by the Armark River.

Because ground surveys were not conducted on some of the minor colonies, standard errors were not calculated for Ross' or Snow goose populations at those locations. For those colonies, I subjectively estimated an error factor equivalent to a statistical calculation. That variance was then incorporated into the calculation of standard error for the estimates of total Ross' and Snow geese in all colonies.

4.0 Results and discussion

In 1982, 41 colonies had 196 500 nesting birds, 46% of them Ross' Geese; in 1988, 57 colonies had 467 000 nesting birds, 40% of them Ross' Geese (Tables 1 and 2, Fig. 2, Appendices 1 and 2).

In 1982, aerial photographs were obtained on 21–23 June and ground-truth samples on 25–28 June; in 1988, aerial photographs were obtained on 17–18 June and ground-truth samples on 16–20 June. Ground-truth surveys sampled 6147 nests in 1982 and 8060 in 1988 for estimating the proportion of Ross' Geese among total geese. For estimating the proportion of blue-phase Snows among total geese, ground counts sampled 2231 birds in 1982 and 7162 in 1988.

Figures 3 to 6 show the major colonies, with islands and mainland areas occupied by nesting birds. Appendix 3 shows the smaller colonies, with areas occupied by nesting birds.

4.1 Population increases from 1965 to 1988

The total number of nesting Ross' and Snow geese increased over 10-fold from 1965 to 1988 (Table 1, Fig. 7). The Ross' Geese increased at a slower rate than the Snows: the percentage of total birds estimated to be Ross' Geese declined from 77% in 1965 to 58% in 1976, 46% in 1982, and 40% in 1988 (Table 2). The average annual finite rates of increase over the 23-year period from 1965 to 1988 were 7.7% for Ross' Geese and 15.4% for Snows. That sustained high rate for Snow Geese seems to exceed any realistic internal rate of increase. McLaren and McLaren (1982) provided evidence of the movement of some Snow Geese from the west coast of Hudson Bay in the eastern Arctic to Rasmussen Basin just east of Queen Maud Gulf from 1975 to 1977. As noted previously by Kerbes et al. (1983), much of the increase in numbers of Snow Geese in the Queen Maud Gulf MBS most likely has been due to immigration from the large Snow Goose colonies of the eastern Canadian Arctic (see discussion of colour ratios below).

Table 1
Numbers of Ross' Geese and Lesser Snow Geese nesting in the Queen Maud Gulf MBS, June 1982 and 1988

	No. of nesting birds (±2 SE in %)					
	1982			1988		
Colony No.	Ross'	Snow	Total	Ross'	Snow	Total
3	55 137 (±17%)	50 446 (±20%)	105 583 (±13%)	71 230 (±25%)	141 590 (±15%)	212 820 (±9%)
9	10 799 (±53%)	25 594 (±28%)	36 393 (±25%)	22 129 (±63%)	53 081 (±28%)	75 209 (±9%)
10	16 123 (±37%)	18 258 (±34%)	34 381 (±25%)	72 525 (±27%)	39 282 (±42%)	111 807 (±18%)
46	1 622 [a]	931 [a]	2 553 [a]	4 138 (±55%)	18 598 (±13%)	22 736 (±2%)
All others	7 071 [a]	10 489 [a]	17 560 [a]	17 964 [a]	26 438 [a]	44 402 [a]
Total	90 752 (±14%)[a]	105 718 (±13%)[a]	196 470 (±10%)[a]	187 986 (±16%)[a]	278 989 (±12%)[a]	466 974 (±7%)[a]

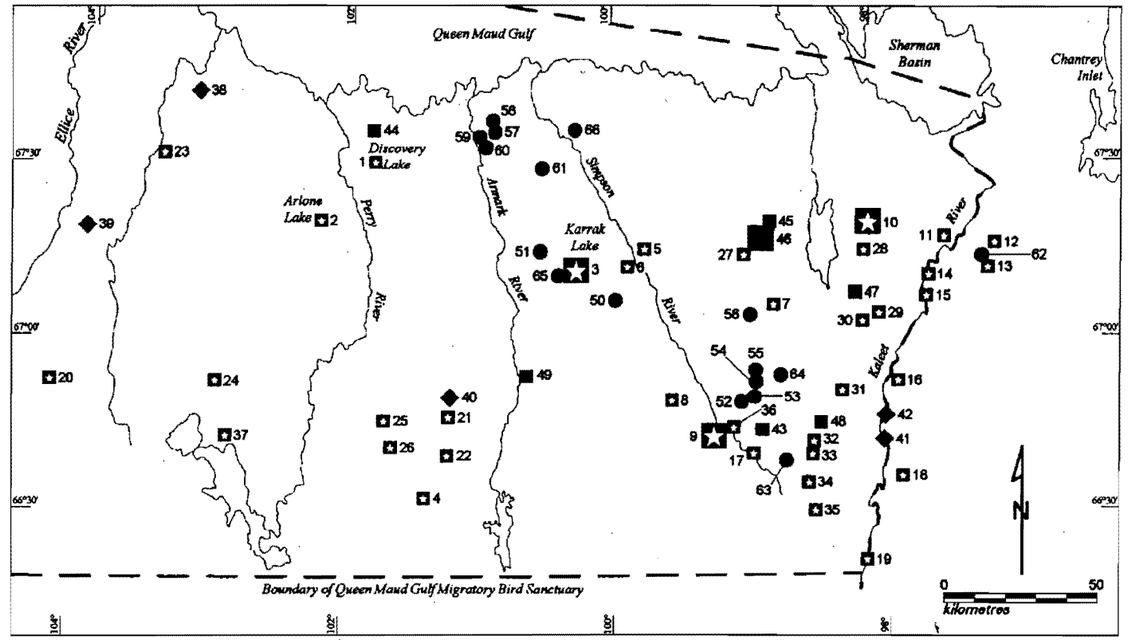
[a] The 95% confidence interval (±2 SE in %) was estimated as explained in Appendices 1 and 2.

Table 2
Inventories of Ross' Geese and Lesser Snow Geese nesting in the Queen Maud Gulf MBS, by visual survey (1965–67) and by aerial photography with ground truthing (1976, 1982, and 1988)

	1965–67[a]	1976[b]	1982[c]	1988[c]
No. of occupied colonies	37	30	41	57
Total no. of nesting birds (Ross' plus Snows)	44 300	133 700	196 500	467 000
Total no. of Ross' Geese (Percentage of total geese)	34 000 (77%)	77 300 (58%)	90 800 (46%)	188 000[e] (40%)
Total no. of Snow Geese	10 300	56 400	105 700	279 000[e]
Percentage of blue-phase among Snow Geese	5%	14.9%	8.0%[d]	19.6%
Percentage of total geese per colony:				
Colony 3	39%	41%	54%	46%
Colony 9	14%	11%	19%	16%
Colony 10	13%	20%	17%	24%
Colony 46	0%	0%	1%	5%
All other colonies	34%	28%	9%	9%
Percentage of total geese nesting on islands[f]	100%	77%	45%	25%

[a] From Ryder (1969), with extrapolation as in Kerbes et al. (1983).
[b] From Kerbes et al. (1983).
[c] This report.
[d] Percentage of blue-phase Snow Geese probably underestimated, hence total number of Snow Geese and total number of geese probably higher than total here (see text).
[e] Percentage of Ross' Geese among total geese possibly overestimated (see text).
[f] Mainland nesting occurred on colonies 3, 9, and 10 (1976, 1982, and 1988) and on colonies 36 and 46 (1988).

Figure 2
Colonies of Ross' and Lesser Snow geese in the Queen Maud Gulf MBS, 1965–88. Larger symbols indicate major colonies.



4.2 Colour ratios

Among Snow Geese in the Queen Maud Gulf MBS, Ryder (1971a) estimated that 5% were blue phase in 1965–67. Blues had increased to 14.9% in 1976 (Kerbes et al. 1983) and to 19.6% in 1988 (Table 2). Samples of Snow Geese captured for neckbanding in the Queen Maud Gulf MBS in 1989, 1990, 1991, and 1992 averaged 18.7% blue (n = 4174 adult-plumaged birds; R. Kerbes and R. Alisauskas, unpubl. data). The increase in percentage of blue phase and in total numbers of Snow Geese in the Queen Maud Gulf MBS from 1965 to 1988 was most likely due to immigration of Snow Geese from the eastern Canadian Arctic. "Donor" colonies there, at McConnell River, La Pérouse Bay, and Southampton Island, have varied in composition from 16% to 30% blue phase since 1973 (Kerbes 1975; Reed et al. 1987; Kerbes et al. 1990; F. Cooke and D. Lank, pers. commun.).

Further evidence of immigration was expected from the recapture, in the Queen Maud Gulf MBS, of Snow Geese banded in colonies of the eastern Canadian Arctic. During neckbanding operations in the Queen Maud Gulf MBS in 1989 and 1990, I recaptured a total of 15 Snow Geese banded previously on the west coast of Hudson Bay (R. Kerbes, unpubl. data). All but one were males, consistent with the expected exchange among colonies in which a pair established on the wintering grounds returns to the female's home colony (Cooke et al. 1975). As movement of females would indicate immigration (Geramita and Cooke 1982) and therefore growth for the new colony, it was surprising that only males were recaptured.

In the Queen Maud Gulf MBS, Snow Goose colonies west of Armark River have contained fewer blues than colonies east of the river. In 1988, the west had 5.0% blue and the east had 19.9% (Appendix 2). Snow Goose colonies in the west part of the Queen Maud Gulf MBS have always included fewer blue-phase Snows than colonies in the east (Barry 1960; Appendices 1 and 2). Probably there has been much less emigration of eastern Canadian Arctic Snow Geese to the western area. Dzubin (1979) suggested that Snow Geese from colonies of both the western Canadian Arctic, which have only a trace of blue phase (Kerbes et al. 1983), and the eastern Arctic had emigrated to the Queen Maud Gulf MBS. Given the relatively small numbers of Snow Geese in the western part of the Queen Maud Gulf MBS, such emigration from the western Arctic apparently has not added much to numbers there.

The frequency of the very rare blue-phase Ross' Goose may be increasing. In California, during winter 1976–77, McLandress and McLandress (1979) counted three blue-phase Ross' hybrids among 38 825 Ross' Geese examined. In the spring of 1991, M. Schwitters (pers. commun.) counted eight blue-phase Ross' (possibly some were hybrids) among 14 000 Ross' at Freezeout Lake, Montana. In July 1992, W.B. Sturgeon Jr. (pers. commun.) saw two blue-phase Ross' among 15 000 Ross' Geese nesting at Karrak Lake and found a brood of blue-phase Ross' goslings. During neckbanding operations from 1989 to 1992 in the Queen Maud Gulf MBS, one blue-phase Ross' was recorded among 2948 adult-plumaged Ross' Geese captured (R. Kerbes and R. Alisauskas, unpubl. data).

4.3 Mainland nesting

Ryder (1969) reported that Ross' and Snow geese nested exclusively on islands at all colonies in 1965. In 1976, Kerbes et al. (1983) found 23% of total geese nesting on mainland areas. They suggested, as did McLandress (1983b), that Snow Geese had pioneered mainland nesting, being better able than Ross' Geese to defend their nests and themselves against predation by Arctic fox *Alopex lagopus*. Foxes, being reluctant to swim, rarely visit the nesting islands when they are surrounded by open water.

Snow Geese defending their nests from Arctic fox could provide protection for Ross' Geese nesting nearby. By following Snow Geese to nesting habitat on the mainland, the Ross' Geese escaped the physical restrictions imposed by nesting only on islands, given that there are a limited number of lakes with suitable islands (Ryder 1969).

The expansion of mainland nesting has continued since 1976 (Figs. 3–6, 8). The proportion of total geese nesting on mainland rose from 23% in 1976 to 55% in 1982 and to 75% in 1988 (Table 2). Most of the increase in total numbers since 1965 has been among mainland-nesting birds. Mainland nesting occurred almost entirely at the major colonies (colonies 3, 9, 10, and 46). The many smaller colonies remained island nesting, with a few minor exceptions.

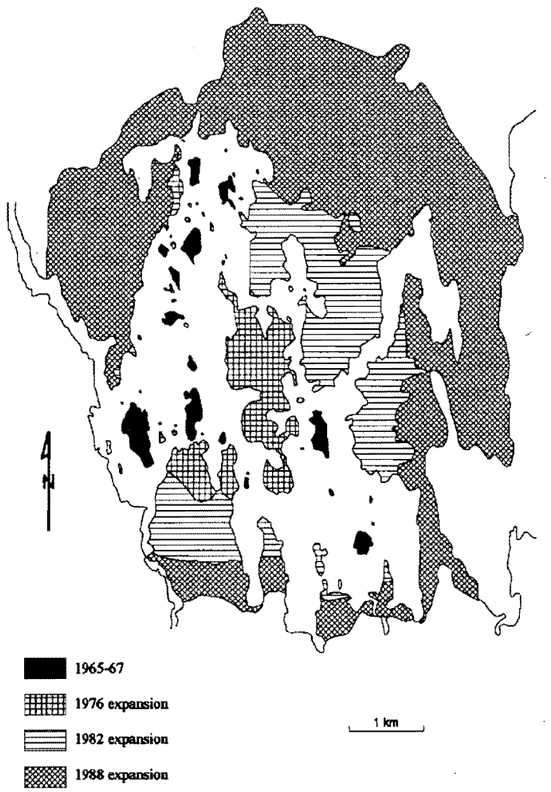
4.4 Distribution of Ross' and Snow geese among colonies

Sixty-six different colonies of Ross' and Snow geese were documented in the Queen Maud Gulf MBS region from 1965 to 1988 (Table 3, Fig. 2). Since 1965, major colonies have supported most of the total geese (Table 2, Fig. 9). Karrak Lake (Colony 3) has been the largest colony, with up to half of the total geese. The four major colonies had an increasing proportion of the total birds, from 66% in 1965 to 72% in 1976, to 92% in 1982 and 91% in 1988 (Tables 2 and 3). Nevertheless, small colonies continued to persist and proliferate, although many were not occupied during each of the survey years (Table 3). The number of small colonies increased as the total number of geese in the Queen Maud Gulf MBS increased. Recorded "new" small colonies increased from five in 1976 to seven in 1982 and to 17 in 1988. During visual aerial surveys in 1990 and 1991, which sampled about 20% of the area of the sanctuary, Alisauskas and Boyd (in press) saw 26 additional "new" colonies.

Discovery Lake (Colony 1) was one of three small lakes near the mouth of Perry River where Ross' Geese were first reported to be nesting (Gavin 1947). It is quite likely that Colony 44 is another of those three lakes. Colony 1 was not occupied when visited in 1949 by Hanson et al. (1956), and they suggested that hunting by local Inuit had eliminated that colony. However, it was occupied again in 1965, when Ryder (1969) found 12 nesting birds.

Although now among the smaller colonies of the Queen Maud Gulf MBS, Arlone Lake (Colony 2) is the largest of the "western" colonies. It probably represents the "ancestral" stock of Ross' and Snow geese in the western part of the Queen Maud Gulf MBS. In 1990, during a helicopter flight, I observed and photographed what is most likely an ancient stone goose catching corral, near Perry

Figure 3
Karrak Lake (Colony 3), showing area occupied by nesting Ross' and Lesser Snow geese, 1965–67, with expansion recorded in 1976, 1982, and 1988



River, about 25 km north of Arlone Lake. Its presence indicates that prehistoric Eskimo hunted geese there.

Although Karrak Lake (Colony 3) was not documented as the major colony until 1965 (Ryder 1969), there is no doubt that it has been present and important for a very long time. Ancient stone meat caches and a stone goose catching corral found by G. Beyersbergen and M.R. McLandress (pers. commun.) at Karrak Lake in 1976 show that prehistoric Eskimo caught geese there. During their flight on 27 July 1949, Hanson et al. (1956) recorded 200 nonbreeding Ross' Geese at Colony 3 and the lake on its east side, which they called "Kangowan Lakes." Those birds represented the largest concentration of Ross' or Snow geese that they saw outside the Arlone Lake (Colony 2) area in 1949. In 1965, J.P. Ryder (pers. commun.), realizing the lake had been erroneously named Kangowan, for what Hanson et al. (1956) thought was the Inuit name for Ross' Geese, renamed it Karrak Lake, the correct Inuit name for the species.

Along with the other major colonies, Colony 9 has expanded rapidly since 1965. By 1988, its mainland nesting area had reached the shore of its neighbouring colony to the east, Colony 36 (Fig. 4). Although I have retained reference to Colony 36 separately (Tables 2 and 3), it could now be considered part of Colony 9.

Figure 4
Colonies 9 and 36, showing area occupied by nesting Ross' and Lesser Snow geese in 1976, with expansion recorded in 1982 and 1988 (which in effect has made Colony 36 part of Colony 9; see text)

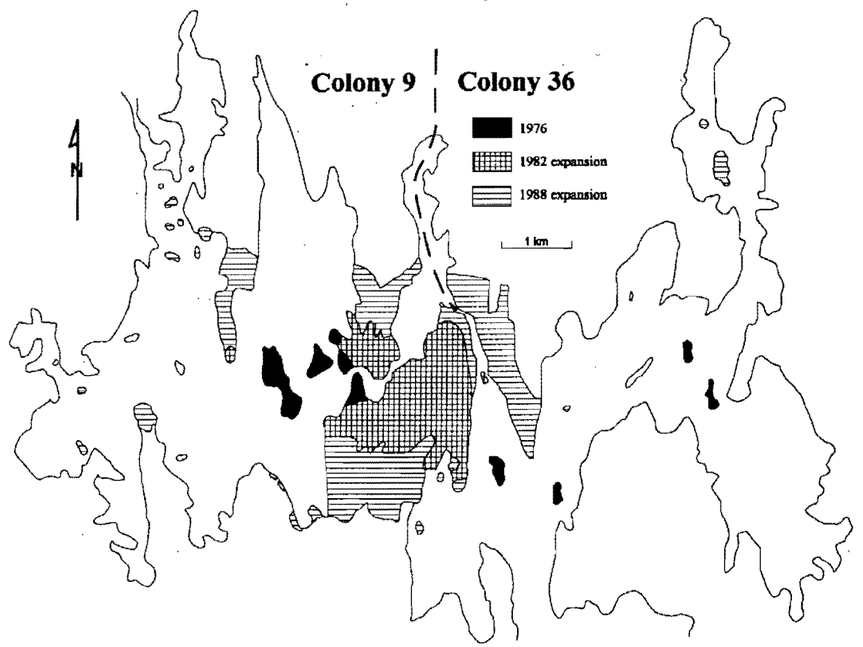


Figure 5
Colony 10, showing area occupied by nesting Ross' and Lesser Snow geese in 1976, with expansion recorded in 1982 and 1988

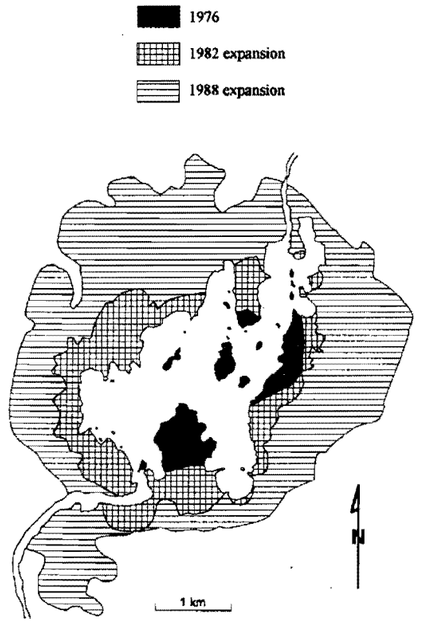


Figure 6
Colony 46, showing area occupied by nesting Ross' and Lesser Snow geese in 1982, with expansion recorded in 1988

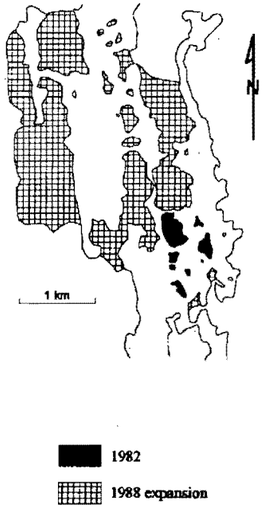


Figure 7
Growth in numbers of nesting Ross' Geese and Lesser Snow Geese, Queen Maud Gulf MBS, 1965–88

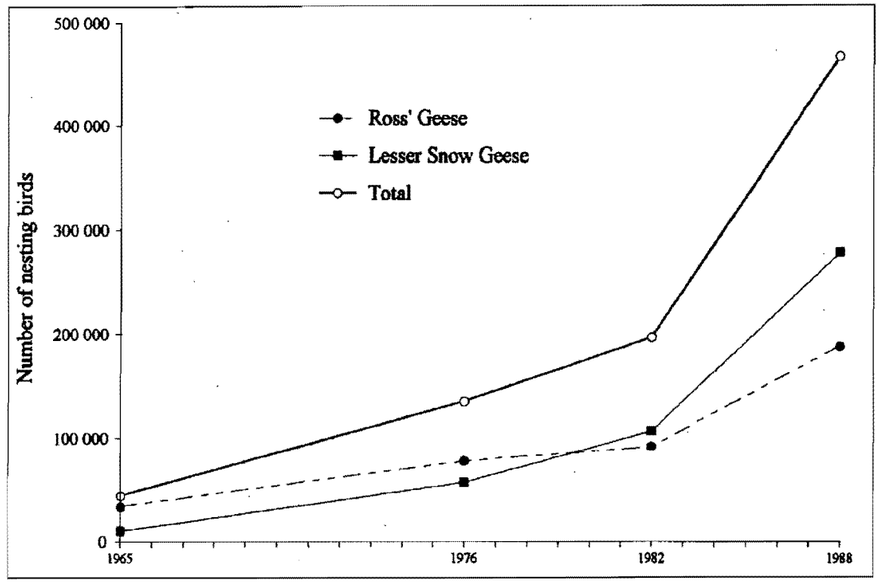


Figure 8
Island and mainland distribution of nesting Ross' Geese and Lesser Snow Geese, colonies 3, 9, 10, and 46, 1965, 1976, 1982, and 1988

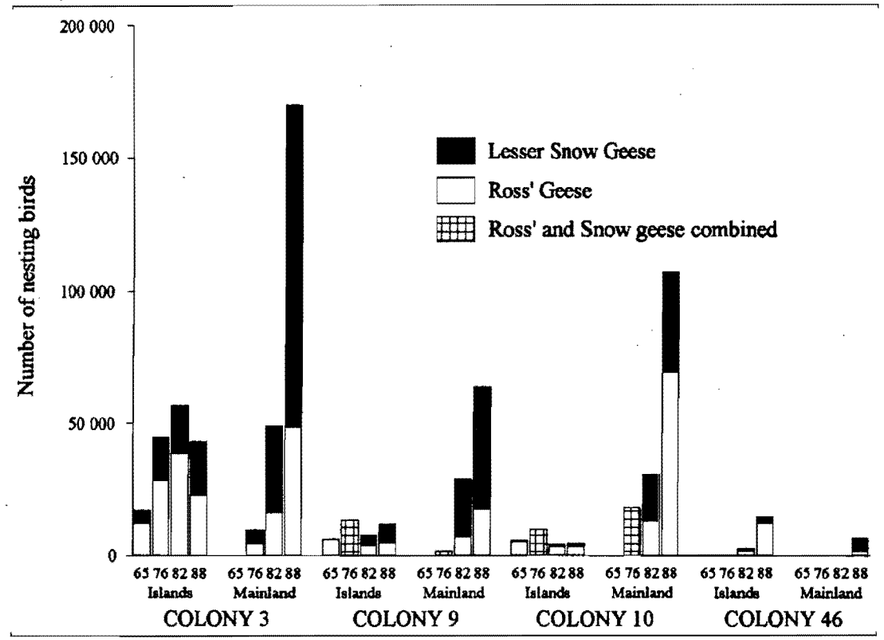


Table 3
Estimated number of nesting Ross' and Lesser Snow geese, Queen Maud Gulf MBS, June 1965–67, 1976, 1982, and 1988

	No. of nesting birds (% Ross')							
Colony No.	1965–67[a]		1976[b]		1982		1988	
1	12	(100%)	569	(58%)	203	(50%)	897	(75%)
2	2 000	(75%)	5 667	(78%)	4 938	(51%)	5 591	(44%)
3	17 060	(70%)	54 537	(60%)	105 583	(52%)	212 820	(33%)
4	180	(17%)	n[c]		92	(0%)	407	(48%)
5	100	(60%)	n		n		2	(0%)
6	230	(87%)	n		388	(64%)	706	(41%)
7	54	(93%)	n		n		n	
8	3 800	(68%)	4 172	(39%)	835	(62%)	2 683	(42%)
9	6 200	(97%)	15 082	(24%)	36 393	(30%)	75 209	(29%)
10	5 600	(89%)	27 115	(77%)	34 381	(47%)	111 807	(65%)
11	40	(100%)	n		35	(63%)	n	
12	85	(71%)	38	(58%)	n		23	(41%)
13	360	(83%)	428	(58%)	464	(36%)	59	(41%)
14	60	(100%)	418	(58%)	19	(100%)	67	(41%)
15	1 500	(80%)	1 497	(47%)	681	(14%)	6 580	(41%)
16	40	(100%)	n		37	(5%)	123	(41%)
17	30	(67%)	626	(58%)	34	(0%)	212	(41%)
18	200	(100%)	1 256	(58%)	2 810	(9%)	6 637	(8%)
19	450	(83%)	427	(58%)	9	(100%)	902	(41%)
20	50	(100%)	534	(58%)	80	(43%)	172	(48%)
21	190	(74%)	28	(58%)	554	(0%)	16	(50%)
22	125	(80%)	n		n		n	
23	*[c]		826	(58%)	594	(53%)	2 115	(48%)
24	*		164	(58%)	258	(43%)	432	(48%)
25	*		213	(58%)	126	(0%)	366	(48%)
26	*		n		12	(42%)	n	
27	*		4 760	(38%)	828	(64%)	1 521	(41%)
28	*		n		n		178	(41%)
29	*		7 324	(64%)	1 284	(51%)	1 085	(41%)
30	*		593	(58%)	254	(0%)	383	(41%)
31	*		n		88	(64%)	127	(41%)
32	*		n		16	(63%)	n	
33	*		n		n		n	
34	*		107	(58%)	58	(64%)	2	(0%)
35	*		427	(58%)	n		n	
36	150	(38%)	4 241	(47%)	1 334	(55%)	5 224	(63%)
37	80	(40%)	142	(58%)	247	(0%)	2	(0%)
38	u[c]		427	(58%)	196	(48%)	n	
39	u		51	(58%)	127	(27%)	95	(48%)
40	u		1 519	(0%)	98	(0%)	765	(48%)
41	u		295	(58%)	n		n	
42	u		213	(58%)	40	(0%)	67	(41%)
43	u		u		102	(64%)	28	(41%)
44	u		u		37	(43%)	491	(48%)
45	u		u		306	(64%)	523	(41%)
46	u		u		2 553	(64%)	22 736	(18%)
47	u		u		123	(63%)	17	(41%)
48	u		u		133	(63%)	429	(41%)
49	u		u		120	(64%)	37	(41%)
50	u		u		u		1 003	(41%)
51	u		u		u		683	(41%)
52	u		u		u		68	(41%)
53	u		u		u		32	(41%)
54	u		u		u		261	(41%)
55	u		u		u		492	(41%)
56	u		u		u		235	(41%)
57	u		u		u		541	(41%)
58	u		u		u		141	(41%)
59	u		u		u		54	(41%)
60	u		u		u		301	(41%)

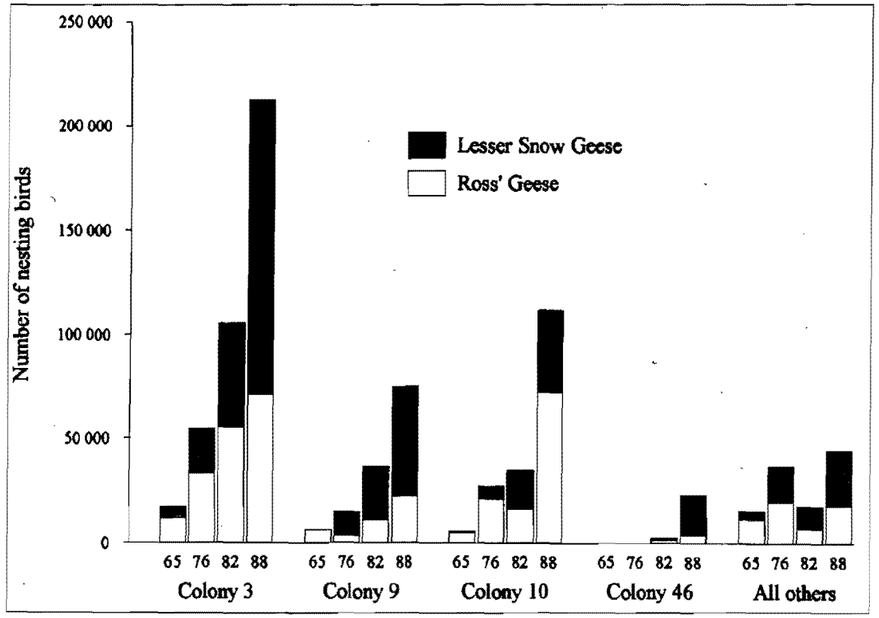
continued

Table 3 (*continued*)
Estimated number of nesting Ross' and Lesser Snow geese, Queen Maud Gulf MBS, June 1965–67, 1976, 1982, and 1988

Colony No.	No. of nesting birds (% Ross') 1965–67[a]		1976[b]		1982		1988	
61	u		u		u	441	(41%)	
62	u		u		u	416	(41%)	
63	u		u		u	257	(41%)	
64	u		u		u	14	(41%)	
65	u		u		u	148	(41%)	
66	u		u		u	342	(41%)	
Total	44 300	(77%)	133 696	(58%)	196 470	(46%)	466 975	(40%)

[a] From Ryder (1969); total as extrapolated in Kerbes et al. (1983).
[b] From Kerbes et al. (1983).
[c] * = Colony occupied by nesting birds, but numbers not estimated.
n = Nil nesting birds present.
u = Status unknown, presume not occupied.

Figure 9
Numbers of Ross' Geese and Lesser Snow Geese nesting in colonies 3, 9, 10, and 46, compared with all other colonies, Queen Maud Gulf MBS, 1965, 1976, 1982, and 1988



Colony 10 has shown the fastest rate of expansion in numbers and occupied area of the three largest colonies, possibly because of its very high percentage of mainland nesting (Figs. 5 and 8). In 1988, 96% of the total number of birds at Colony 10 were on mainland, compared with 84% at Colony 9 and 80% at Colony 3 (Appendix 2).

Colony 46 was first recorded in 1982, although it may have existed before that. Its rate of increase, 10-fold in the six years from 1982 to 1988, is the fastest recorded for a single colony.

4.5 Management concerns

4.5.1 Importance of the Queen Maud Gulf MBS

Most, probably 95% or more, of the world's population of Ross' Geese nest in the Queen Maud Gulf MBS. A few Ross' Geese have been found nesting at Snow Goose colonies of Southampton Island and West Hudson Bay (MacInnes and Cooch 1963), La Pérouse Bay (Ryder and Cooke 1973), Cape Henrietta Maria (Prevett and Johnson 1977), Banks Island (Manning et al. 1956; Barry 1960; R. Bromley, pers. commun.), and Sagavanirktok River, Alaska (Johnson and Troy 1987). Nonbreeding Ross' Geese have also been recorded on Wrangel Island, Russia (V.V. Baranyuk, pers. commun.), and on Baffin Island in 1992 (F.D. Caswell, pers. commun.). However, no one has presented any evidence that those colonies in total support more than a few percent of the total Ross' Goose population.

Prevett and MacInnes (1972) and Frederick and Johnson (1983) suggested that an increase in the proportion and number of Ross' Geese on migration and wintering grounds in central North America represented an increase in numbers of Ross' Geese nesting in Snow Goose colonies of the eastern Canadian Arctic. However, legband recoveries from the 1960s (Melinchuk and Ryder 1980) and recent monitoring of neckbanded Ross' Geese (Kerbes 1991) show that, although most move to California, New Mexico, and north-central Mexico, some Ross' Geese from the Queen Maud Gulf MBS also migrate to central North America.

The extrapolated total Ross' Goose population that departed from the Queen Maud Gulf MBS in 1988 was approximately 470 000 birds, assuming that 40% were adult breeders and the remainder were nonbreeders and young-of-the-year. In 1988–89, Silveira (1989) estimated that there were 235 000 Ross' Geese on the major Ross' Goose wintering grounds in California. During that period, approximately 15 000 Ross' Geese were estimated to be wintering in New Mexico and the northern highlands of Mexico (R. Drewein, B. Turner, and J. Taylor, pers. commun.). The number of Ross' Geese wintering in the Central and Mississippi flyways has been increasing (Frederick and Johnson 1983), but the current total number is unknown. In winter of 1991–92, Harpole et al. (1993) estimated that there were over 27 000 Ross' Geese in the rice-prairie region of Texas alone. Although it seems that only half the Ross' Geese may be wintering in California, it is quite possible that numbers there were underestimated. Silveira's (1989) estimate was based on his ground sampling of species composition applied to visual aerial counts (of unknown accuracy) of total numbers of Ross' and Snow geese.

The Ross' Goose has made a dramatic recovery, from as low as 2000 total population in the early 1950s (Lloyd 1952) to 188 000 nesting adults in 1988. Market hunting in the late 1800s probably wrought a steep reduction in the Ross' Goose population (see McLandress 1979). After protective measures were taken in the early 1900s, the species may have recovered sooner than was officially recorded, as a result of the difficulties of taking census on the wintering grounds (MacInnes 1964; Dzubin 1965).

The south shore of Queen Maud Gulf is the essential breeding ground for Ross' Geese, and it has become increasingly important for Snow Geese as well. Its 1988 population of 279 000 nesting Snow Geese ranked among the world's major concentrations. The latest available numbers of nesting birds at the other major Snow Goose nesting regions are as follows: Great Plain of the Koukdjuak on Baffin Island, 455 000 in 1979 (Reed et al. 1987); Southampton Island, 233 000 in 1979 (Reed et al. 1987); West Hudson Bay, 436 000 in 1985 (Kerbes et al. 1990), down to 198 000 in 1990 (R. Kerbes, unpubl. data); Cape Henrietta Maria, 109 000 in 1979 (P. Angehrn and K. Ross, pers. commun.); western Canadian Arctic, 205 000 in 1987 (R. Kerbes, unpubl. data); and Wrangel Island, 63 000 in 1979 and 47 000 in 1992 (V.V. Baranyuk, pers. commun.). Only Baffin Island is likely to support more breeding Snow Geese at present than the Queen Maud Gulf MBS.

There are several small colonies of Snow Geese within the central Canadian Arctic in the vicinity of the Queen Maud Gulf MBS (Fig. 1). The largest of those is on Jenny Lind Island, where McCormick and Poston (1988) estimated that there were 54 000 birds in July 1985. I estimated, from aerial photographs and ground-truth surveys, that there were 38 100 Snow Geese and 1100 Ross' Geese nesting there in June 1988. The results of an aerial survey conducted in July 1990 suggested that 25 000 adult Snow and Ross' geese were present (Kay et al. 1993). The number of nesting birds on Jenny Lind Island increased rapidly up to 1985, apparently leading to overpopulation and destruction of feeding habitats.

In the Pelly Lake area, on the Back River immediately south of the Queen Maud Gulf MBS (Fig. 1), McCormick (1989) estimated that there were 9000 and 8000 adult Snow Geese in 1987 and 1988, respectively, on 14 different colonies. He noted that those numbers also included an undetermined small number of Ross' Geese.

East of the Queen Maud Gulf, in the Rasmussen Basin and Chantrey Inlet area (Fig. 1), Allen and Hogg (1978) and McLaren and McLaren (1982) recorded several hundred nesting Snow Geese and several thousand moulting Snow Geese in 1975, 1976, and 1977. The largest of those concentration sites, at Inglis River, had 3500 Snow Geese in 1989 (Bromley and Stenhouse, in press). In 1993, I estimated that there were at least 25 000 Snow Geese in that area.

Bromley and Stenhouse (in press) also recorded 2000 Snow Geese at Tingmeak River, in the western fringe of the Queen Maud Gulf MBS in 1989, 2000 on southeast Victoria Island in 1990, and 700 at Albert Edward Bay on Victoria Island in 1991 (Fig. 1).

4.5.2 Competition and genetic swamping

MacInnes and Cooch (1963) suggested that competition with Snow Geese led to the restricted breeding distribution of Ross' Geese, and Ryder (1971a, 1972) stressed the need for additional study of the relationship between the two to verify if the Ross' Goose might be threatened by the larger Snow Goose. However, population survey results from 1965 to 1988 show that both species have steadily increased in number (Fig. 7). As noted in the discussion of colour ratios above, the more rapid rate of increase in Snow Geese numbers may be due to immigration of birds from colonies of the eastern Canadian Arctic.

Ryder (1967) found that competition with Snow Geese was not affecting the productivity of Ross' Geese at Arlone Lake. McLandress (1983b) reached a similar conclusion from studies at Karrak Lake, noting that Ross' Geese had a high tolerance for crowding and nested close to Snow Geese. He also noted that the two species had different, and possibly mutually beneficial, antipredator behaviour.

In the 1960s, Trauger et al. (1971) documented white geese intermediate between Ross' and Snow geese and estimated that those presumed hybrids accounted for 4.8% of the Ross' Goose population. They warned that the less numerous Ross' Goose might be vulnerable to eventual genetic swamping by the Snow Goose, and they suggested that dump nesting or nest parasitism between species was a possible mechanism facilitating hybridization. During ground-truth operations in 1988, 107 dump nests were recorded among 2148 Ross' and Snow goose nests sampled by A.W. Diamond (pers. commun.), as indicated by nests having one or more eggs of the other species, according to measurement. During summer banding operations from 1989 to 1992, 56 hybrids were found among 2948 Ross' and 4174 Snow adult-plumaged geese captured (R. Kerbes and R. Alisauskas, unpubl. data). Those hybrids amounted to 1.9% of the Ross' Geese, considerably less than the 4.8% estimated by Trauger et al. (1971) in the 1960s. There seems to be little evidence of genetic swamping.

As in earlier studies by Ryder (1971a, 1972) and McLandress (1983b), Ross' Geese had smaller clutches than Snow Geese in the ground-truth samples for 1982 and 1988 (Table 4).

4.5.3 Avian cholera

Ross' and Snow geese are carriers of avian cholera, caused by the bacterium *Pasteurella multocida*. It is the most common fatal disease recorded among these geese, and they can transmit it to other waterfowl (Wobeser 1981). Geese from the Queen Maud Gulf region suffer mortality from this disease mainly while on their wintering grounds in California. Recent studies there indicate that Ross' Geese are less vulnerable than Snow Geese (J. Silviera and G. Mensik, pers. commun.). Outbreaks have also occurred on migration areas and on the breeding grounds of Ross' and Snow geese (Wobeser 1981). In June 1982, several hundred geese died from avian cholera at Karrak Lake (Wobeser et al. 1983).

Environmental factors such as pesticide pollution and habitat deterioration on migration and wintering areas may, through synergistic effects, lead to cholera epizootics (McLandress 1983a; Wobeser 1981).

4.5.4 Habitat for nesting, moulting, and brood rearing

Expansion of nesting on mainland habitats by Snow and Ross' geese has been accompanied by expanding total populations. As most of the newly recorded colonies observed by Alisauskas and Boyd (in press) in 1990 and 1991 were not on "traditional" islands in shallow lakes, they suggested that the most suitable lakes with islands were already occupied. There appear to be no limits to mainland nesting habitat near the major colonies. Those colonies have become similar to the major Snow Goose colonies of the eastern and western Canadian Arctic, which cover extensive areas of mainland tundra.

The Queen Maud Gulf MBS, and adjacent area within 40 km to the east, is a large "oasis" of ponds and sedge lowlands in a largely "desert" central Arctic (Edlund 1982; pers. commun.). Food resources and summer habitat for moulting and brood rearing in the Queen Maud Gulf MBS apparently are not limiting the numbers of geese. If the high rates of increase in goose numbers continue, however, limits to population growth will soon be reached. On the west coast of Hudson Bay, the rapid growth of Snow Geese in the 1960s and 1970s led to destruction of preferred food plants (Kerbes 1982; Kerbes et al. 1990; Cooch et al. 1991) and reduction of population by 1990 (R. Kerbes, unpubl. data).

For a preliminary overview of habitat in the Queen Maud Gulf MBS, I examined Landsat scale 1:1 000 000 imagery to plot the approximate distribution of sedge lowland, the prime summer habitat for Ross' and Snow geese (Fig. 1). A simple analysis of visual counts of geese from summer aerial surveys made by Kuyt et al. (1971) and C. Schroeder (pers. commun.) in 1971 and 1972 and by R. Kerbes (unpubl. data) in 1981 and 1989 showed a significant concentration of Ross' and Snow geese on sedge lowland compared with other habitats (Table 5). The surveys in 1972 and 1981 also showed significantly more geese in eastern, as opposed to western, areas of the sedge lowland (Table 6).

The sedge lowland of Queen Maud Gulf is a favoured summer habitat for muskox *Ovibos moschatus* and barren-ground caribou *Rangifer tarandus groenlandicus*, both of which have also increased in number in recent decades (Gunn et al. 1984). Substantial numbers of Greater White-fronted Geese and Canada Geese also overlap with Ross' and Snow geese on the sedge lowlands, especially in the western part of the sanctuary. R. Alisauskas and H. Boyd (pers. commun.) estimated that over 100 000 Greater White-fronted Geese and more than 80 000 Small Canada Geese *Branta canadensis hutchinsii* were nesting there in 1990–91. Current studies of habitat, the large mammals, and the geese should help to elucidate the relationships of these grazers to their habitat and to each other (A. Gunn, R. Alisauskas, and A. Didiuk, pers. commun.). Destruction of food plants caused by increasing numbers of Ross' and Snow geese, or any of those other species on that habitat, obviously could have negative effects on all species involved.

4.5.5 Human disturbance

The federal Queen Maud Gulf MBS (Fig. 1), covering 6.3 million hectares (24 000 square miles), is the largest bird sanctuary in Canada. It affords protection to migratory birds and their habitats. All the nesting colonies of Ross' and Snow geese, except for a few small ones on, or next to, its eastern border (Fig. 2), lie within the sanctuary.

Table 4
Number of nests of Ross' Geese and Lesser Snow Geese examined during ground-truth surveys, with mean clutch sizes, Queen Maud Gulf MBS, 1982 and 1988

	No. of nests		Mean clutch size (±2 SE)	
Species	1982	1988	1982	1988
Ross'	2767	3456	3.55 ± 0.12	3.15 ± 0.03
Snow	3380	4593	3.82 ± 0.16	3.54 ± 0.03

Table 5
Distribution of adult-plumaged Ross' and white-phase Lesser Snow geese relative to sedge lowland and other habitats, Queen Maud Gulf MBS, July 1971, 1972, 1981, and 1989

	Sedge lowland			Other habitat		
Year	No. of km	No. of birds	No. of birds/km	No. of km	No. of birds	No. of birds/km
1971	236.4	3 947	16.7**	655.2	1 607	2.5**
1972	790.1	10 322	13.1**	1 668.5	11 987	7.2**
1981	259.2	5 259	7.2**	545.0	1 625	3.0**
1989	371.5	4 325	11.6**	834.0	5 800	6.9**

**p = 0.005, significant difference between geese on sedge lowland and other habitat.

Table 6
Distribution of adult-plumaged Ross' and white-phase Lesser Snow geese on eastern and western portions of sedge lowland, Queen Maud Gulf MBS, July 1972 and 1981

	Eastern			Western		
Year	No. of km	No. of birds	No. of birds/km	No. of km	No. of birds	No. of birds/km
1972	164.6	4209	25.6**	152.0	791	5.2**
1981	135.7	3563	26.3**	27.6	4	0.1**

**p = 0.005, significant difference between geese on eastern and western areas.

Most of the sedge lowland summer habitat south of Queen Maud Gulf is in the sanctuary, except for an area about 30 km to the east (Fig. 1). Although subsistence hunting of geese used to occur in the region (Gavin 1947; Hanson et al. 1956), little, if any, now takes place. No Inuit are now living on the south coast of Queen Maud Gulf. Most of their visits are limited to short hunting trips, usually not in summer when geese are present. A few sport hunters of muskox are also taken into the sanctuary by Inuit guides in winter, from Cambridge Bay to the northwestern part, and from Gjoa Haven to the eastern half. The sanctuary is so remote that tourism has been limited to a few canoe trips by southern visitors down the Perry and Simpson rivers.

Alexander et al. (1991) did not recognize any potential conflicts from mining activities in the sanctuary. However, C.N. O'Sullivan (pers. commun.) of Continental Pacific Resources Inc. advised me that there are substantial deposits of nickel and other minerals in the sanctuary.

Recently, the Northern Mineral Policy Review recommended that the sanctuary should be reduced in size, subject to a thorough review of migratory bird resources there (K. McCormick and R. Ferguson, pers. commun.).

4.5.6 Migration and wintering grounds

An international program is under way to update information on distribution, survival, and other factors important to management of Arctic-nesting geese (Kerbes 1991). On Arctic breeding areas, adult birds have been marked with coded plastic neckbands. A network of cooperating observers has been monitoring the marked birds on migration and winter haunts. The program has included the Ross' and Snow geese of the Queen Maud Gulf MBS since 1989. Full results are to be presented elsewhere (R. Kerbes et al., unpubl. data). Some highlights are as follows.

Although they nest in mixed colonies, the two species show very different migration and wintering patterns. Direct resightings of geese neckbanded in 1989 showed that most Ross' Geese follow a migration route through southwestern Saskatchewan, southeastern Alberta, and western Montana to wintering grounds in central California. This had been the pattern shown by recoveries from legbanding done in the 1960s (Melinchuk and Ryder 1980). However, an increased proportion now move through the western Central Flyway to New Mexico and to Chihuahua and Durango in north-central Mexico. Small numbers of neckbanded Ross' Geese were also reported from farther east in the Central and Mississippi flyways (see 4.5.1 above). In contrast, very few Queen Maud Gulf Snow Geese wintered in California, a much larger proportion of their resightings being in the traditional wintering grounds of eastern Arctic Snow Geese in the Central and Mississippi flyways. Because of the diluting effect of the very large eastern Canadian Arctic population of Snow Geese, the resighting rate of neckbanded birds in eastern areas was much lower than in western areas of the wintering grounds.

When the distributions of Ross' and Snow geese from western, central, and eastern sections of the Queen Maud Gulf MBS were compared, Ross' Geese did not show the sectional differences in distribution of the Snow Geese. The neckbanded Snows that wintered in California were almost entirely from the western part of the Queen Maud Gulf MBS, providing further evidence that they are more closely related to western, rather than eastern, Arctic Snow Geese. The differential migration of blue-phase Snow Geese to more eastern areas is also evident from the pattern of neckband observations.

4.5.7 Problems in estimating species and colour ratios

Technical and distributional problems complicate attempts to count the total Ross' population on migration and wintering areas (Dzubin 1965; McLandress 1979; J. Silveira, R. Drewein, and B. Turner, pers. commun.). An inventory of nesting birds in the Queen Maud Gulf MBS with aerial photography and ground-truth surveys remains the most realistic means to obtain an accurate inventory of the total Ross' Goose population (Hanson et al. 1956; Kerbes et al. 1983). However, this method is not without its problems.

Ryder (1971b) and McLandress (1983b) used differences in egg sizes to identify the species incubating study nests. Because both Ross' and Snow geese usually move from their nests well in advance of an approaching investigator, careful observation of undisturbed birds is needed to determine the known species at a given nest. Ryder (1971b) and McLandress (1983b) used known samples of Ross' and Snow goose nests to verify that Ross' and Snow goose eggs could be accurately separated in the hand by an investigator. Samples of eggs of known species were not measured in 1982, as a result of severe limits on time available to do the ground truthing. In 1988, 100 known eggs of Ross' Geese and 108 of Snow Geese were measured.

When classified by the measurement criteria recommended by McLandress (see Methods), those eggs came out as 120 Ross' Geese and 88 Snow Geese. Measurement of that sample therefore apparently over-estimated the number of Ross' by one-fifth, although the difference between known and measured ratios was barely significant, at $p = 0.049$, Pearson chi-square = 3.859 (1 df).

The size of Snow Goose eggs, as shown by studies on the west coast of Hudson Bay (Ankney and Bisset 1976; Ankney 1980; Williams and Cooke, in press) and on Wrangel Island (V.V. Baranyuk, pers. commun.), varies widely, depending on age and condition of female, date of egg laying, phenology of season, and other factors. Williams and Cooke (in press) recorded a variation of 47% in mean egg mass between clutches at La Pérouse Bay. Within the study area at La Pérouse Bay from 1969 to 1986, mean body mass declined by 16% in goslings and by 15% in adults (Cooch et al. 1991).

I present the 1988 results as obtained, without attempting to calculate a correction factor based on the known species sample. Because of the variations among sites and years (Appendix 4), I suggest that simple measurement criteria are not reliable for separating large Ross' Goose eggs from small Snow Goose eggs. Accurate measurement criteria would require an inordinately large and widely distributed sample of known eggs to represent all sites for a given year, which would be totally impracticable.

In future inventories of Ross' and Snow geese, visual ground counts should be used to estimate species ratios of nesting birds. Such counts are practical and logistically feasible, with ground observers using spotting scopes and appropriate sampling procedures. As G.E.J. Smith (pers.

commun.) advised, such direct species identification would be superior to egg measurement, which is an indirect or proxy method. The latter works only if there is a strong and consistent relationship between the species and egg measurements. The data now available do not show such a relationship for Ross' and Snow geese.

Colour ratios, the percentages of blue-phase Snow Geese among total Ross' and Snow geese, were obtained from sample counts from aerial photographs in 1976, when weather conditions were excellent for photography. Ground observations at Colony 3 confirmed that the estimated percentage of blue-phase geese was accurate (Kerbes et al. 1983).

In 1982, we had severe restrictions on time available on both the airplane for photography and the helicopter to support ground truthing. Consequently, aerial photos were obtained under varying amounts and levels of overcast. The images of Ross' Geese and white-phase Snow Geese stood out well and were accurately counted from those photos. However, the sample counts for colour ratio underestimated the frequency of blue-phase Snow Geese, because many of their images were not visible. Proof of this came from a ground-truth sample (total 2231 Ross' and Snow geese) taken from colonies 9, 10, and 15, which had a mean of 10.9% blue among total geese, compared with 4.6% blue as determined from air photo counts at those colonies. This suggests that the 1982 results may have underestimated the number of blue-phase Snow Geese by approximately 50%. The 1982 ground data on percentage of blue-phase Snow Geese among total geese were not obtained on enough colonies to justify their use instead of air photo counts in estimating total populations.

In 1988, similar limits on available time for photo aircraft again made it necessary to obtain photographs under overcast conditions. Fortunately, the ground crew had adequate time to obtain visual counts of nesting birds to estimate colour ratios.

Future inventories should use ground truthing to obtain the estimates of percentages of Ross' Geese and of blue-phase Snow Geese among total geese. Aerial photography should continue to provide total or sample counts of the Ross' plus white-phase Snow geese and, weather permitting, sample counts for the percentage of blue-phase Snow Geese among total geese.

5.0 Recommendations

The dynamic nature of these populations makes it important to carry out another inventory of nesting Ross' and Snow geese in the Queen Maud Gulf region. This inventory must be carried out in 1994 to maintain the six-year interval. The number of colonies, the occupied area of major colonies, and the total number of geese have increased considerably since 1988 (Alisauskas and Boyd, in press). Up-to-date information on habitat conditions and the numbers and distribution of breeding birds will be essential in addressing management concerns related to potential overgrazing of summer habitat, species interactions, and harvest on migration and wintering areas.

Parallel to the need for another inventory on Queen Maud Gulf, the major eastern Canadian Arctic colonies of Snow Geese on Baffin Island, Southampton Island, and Cape Henrietta Maria should also be covered as soon as possible. The latest complete inventory was done on those colonies as long ago as 1979. Visual aerial surveys on the wintering grounds have indicated increasing numbers of Snow Geese in the Central and Mississippi flyways. As a consequence, steps have been taken to increase daily bag limits for sport hunting in those flyways. There is concern that the harvest of both Snow and Ross' geese in those flyways is being increased without good baseline data on the populations (D. Slack and D. Gawlik, pers. commun.). Snow Goose populations can decline rapidly from non- hunting factors such as habitat destruction from over- grazing, as on the west coast of Hudson Bay (Kerbes et al. 1990; Cooch et al. 1991), or a prolonged series of poor nesting seasons, as on Wrangel Island (Bousfield and Syroechkovskiy 1985).

If we are to understand the dynamics of colony size and distribution, the extent of transfers of Snow Geese from colonies in the eastern Canadian Arctic to those of Queen Maud Gulf needs to be verified and its rate measured. We need to find out which birds shift and why. Although it was in the original plan, neckbanding under the recent international study of Snow Geese did not extend to the colonies of the eastern Canadian Arctic. Marking of birds there is needed to detect and measure their movement to more western nesting grounds.

The Arctic Goose Joint Venture, under the North American Waterfowl Management Plan (1991), recognized Midcontinent (eastern Central Flyway and Mississippi Flyway) and Western Central Flyway Snow Goose "populations" for management. That confuses and confounds management of Snow Geese from Queen Maud Gulf, as they winter in both those "population" areas. Clearly, continental management should define "populations" as breeding stocks, not as varying mixtures of stocks on migration and wintering areas.

Appendices

Appendix 1
Estimated numbers of nesting Ross' Geese and Lesser Snow Geese, Queen Maud Gulf MBS, June 1982

Zone[a]/class[b]	Colony No.[c]	No. of nesting birds: Ross'	(±2 SE in %)	Snow	(±2 SE in %)	% blue of Snows	Total no. of geese	(±2 SE in %)
East A	3 Is.	38 921	(±22%)	17 906	(±47%)	6.6	56 827	(±21%)
	Mn.	16 216	(±28%)	32 540	(±16%)	10.8	48 756	(±14%)
	Subtotal	**55 137**	**(±17%)**	**50 446**	**(±20%)**	**9.1**	**105 583**	**(±13%)**
	9 Is.	3 900	(±38%)	3 758	(±40%)	2.8	7 658	(±28%)
	Mn.	6 899	(±81%)	21 836	(±32%)	7.9	28 735	(±31%)
	Subtotal	**10 799**	**(±53%)**	25 594	**(±28%)**	**7.2**	**36 393**	**(±25%)**
	10 Is.	3 335	(±18%)	915	(±54%)	1.3	4 250	(±18%)
	Mn.	12 788	(±47%)	17 343	(±35%)	8.0	30 131	(±28%)
	Subtotal	**16 123**	**(±37%)**	**18 258**	**(±34%)**	7.7	**34 381**	**(±25%)**
	18	261	(±40%)	2 549	(±4%)	5.4	2 810	(±5%)
	29	652	(±18%)	632	(±18%)	5.5	1 284	(±13%)
	15	94	(±69%)	587	(±11%)	4.4	681	(±13%)
	Subtotal	**83 066**	**(±15%)**	**98 066**	**(±14%)**	**8.3**	**181 132**	**(±10%)**
East B	36	738	[d]	596	[d]	5.7	1 334	[d]
	8	519	[d]	316	[d]	5.7	835	[d]
	13	166	[d]	298	[d]	5.6	464	[d]
	30	0	[d]	254	[d]	9.8	254	[d]
	42	0	[d]	40	[d]	12.5	40	[d]
	16	2	[d]	35	[d]	5.7	37	[d]
	17	0	[d]	34	[d]	14.7	34	[d]
	14	19	[d]	0	[d]	0	19	[d]
	19	9	[d]	0	[d]	0	9	[d]
	Subtotal	**1 453**	**(±16%)**	**1 573**	**(±12%)**	**6.4**	**3 026**	**(±10%)**
East C	46	1 622	[d]	931	[d]	5.7	2 553	[d]
	27	526	[d]	302	[d]	5.7	828	[d]
	6	247	[d]	141	[d]	5.7	388	[d]
	45	195	[d]	111	[d]	5.7	306	[d]
	48	84	[d]	49	[d]	5.7	133	[d]
	47	78	[d]	45	[d]	5.7	123	[d]
	49	77	[d]	43	[d]	5.7	120	[d]
	43	65	[d]	37	[d]	5.7	102	[d]
	31	56	[d]	32	[d]	5.7	88	[d]
	34	37	[d]	21	[d]	5.7	58	[d]
	11	22	[d]	13	[d]	5.7	35	[d]
	32	10	[d]	6	[d]	0	16	[d]
	Subtotal	**3 019**	**(±29%)**	**1 731**	**(±29%)**	**5.7**	**4 750**	**(±21%)**
East subtotal		**87 538**	**(±14%)**	**101 370**	**(±14%)**	**8.2**	**188 908**	**(±10%)**
West A	2	2 503	(±40%)	2 435	(±41%)	1.8	4 938	(±29%)
	23	316	(±25%)	278	(±29%)	1.1	594	(±19%)
	1	102	(±34%)	101	(±34%)	15.8	203	(±24%)
	38	94	(±23%)	102	(±22%)	1.0	196	(±16%)
	39	34	(±40%)	93	(±15%)	3.2	127	(±15%)
	Subtotal	**3 049**	**(±33%)**	**3 009**	**(±33%)**	**2.2**	**6 058**	**(±23%)**
West B	21	0	[d]	554	[d]	3.8	554	[d]
	37	0	[d]	247	[d]	2.4	247	[d]
	25	0	[d]	126	[d]	4.0	126	[d]
	40	0	[d]	98	[d]	3.1	98	[d]
	4	0	[d]	92	[d]	20.7	92	[d]
	Subtotal	**0**	–	**1 117**	**(±14%)**	**4.8**	**1 117**	**(±14%)**

continued

Appendix 1 (*continued*)
Estimated numbers of nesting Ross' Geese and Lesser Snow Geese, Queen Maud Gulf MBS, June 1982

Zone[a]/class[b]	Colony No.[c]	No. of nesting birds: Ross'	(±2 SE in %)	Snow	(±2 SE in %)	% blue of Snows	Total no. of geese	(±2 SE in %)
West C	24	110	[d]	148	[d]	2.9	258	[d]
	20	34	[d]	46	[d]	2.9	80	[d]
	44	16	[d]	21	[d]	2.9	37	[d]
	26	5	[d]	7	[d]	2.9	12	[d]
	Subtotal	**165**	**(±35%)**	**222**	**(±35%)**	**2.9**	**387**	**(±25%)**
West subtotal		**3 214**	**(±31%)**	**4 348**	**(±23%)**	**2.9**	**7 562**	**(±19%)**
Grand total		**90 752**	**(±14%)**	**105 718**	**(±13%)**	**8.0**	**196 470**	**(±10%)**

[a] East = East of Armark River; West = West of Armark River.
[b] A = census of Ross' and white Snows, with estimate of % blue of total geese, or census of blues, and estimate of % Ross' of total Ross' and Snows; B =census of Ross' and white Snows, with estimate of % blue of total geese, or census of blues; C =census of Ross' and white Snows.
[c] For colonies 3, 9, and 10: Is. = Island nesting; Mn. = Mainland nesting. All other colonies were island nesting only.
[d] Subjective estimate: (±25%) for B colonies and (±50%) for C colonies, for each of the Ross' and Snow goose estimates. Those variances are incorporated into the calculation of SE for the subtotals and totals.

Appendix 2
Estimated numbers of nesting Ross' Geese and Lesser Snow Geese, Queen Maud Gulf MBS, June 1988

Zone[a]/class[b]	Colony No.[c]	No. of nesting birds: Ross'	(±2 SE in %)	Snow	(±2 SE in %)	% blue of Snows	Total no. of geese	(±2 SE in %)
East A	3 Is.	22 644	(±34%)	20 487	(±38%)	24.9	43 131	(±11%)
	Mn.-hi	34 543	(±42%)	86 100	(±22%)	16.6	120 643	(±15%)
	Mn.-lo	14 043	(±43%)	35 003	(±24%)	16.6	49 046	(±18%)
	Subtotal	**71 230**	**(±25%)**	**141 590**	**(±15%)**	**17.8**	**212 820**	**(±9%)**
	9 Is.	4 796	(±36%)	6 938	(±27%)	20.0	11 733	(±13%)
	Mn.	17 333	(±79%)	46 143	(±31%)	16.3	63 476	(±11%)
	Subtotal	**22 129**	**(±63%)**	**53 081**	**(±28%)**	**16.8**	**75 209**	**(±9%)**
	10 Is.	3 408	(±19%)	1 174	(±23%)	46.3	4 582	(±18%)
	Mn.-hi	27 461	(±42%)	15 141	(±62%)	33.3	42 602	(±30%)
	Mn.-lo	41 656	(±38%)	22 967	(±59%)	33.3	64 623	(±24%)
	Subtotal	**72 525**	**(±27%)**	**39 282**	**(±42%)**	**33.7**	**111 807**	**(±18%)**
	36 Is.	1 539	(±20%)	1 344	(±21%)	25.4	2 883	(±14%)
	Mn.	1 756	(±16%)	585	(±17%)	47.4	2 341	(±16%)
	Subtotal	**3 295**	**(±13%)**	**1 929**	**(±16%)**	**32.0**	**5 224**	**(±11%)**
	46 Is.	2 443	(±94%)	13 807	(±17%)	13.9	16 250	(±3%)
	Mn.	1 695	(±3%)	4 791	(±3%)	16.0	6 486	(±3%)
	Subtotal	**4 138**	**(±55%)**	**18 598**	**(±13%)**	**14.5**	**22 736**	**(±2%)**
	Is. subtotal	**34 830**		**43 750**		**21.3**	**78 579**	
	Mn. subtotal	**138 487**		**210 730**		**19.6**	**349 217**	
	Subtotal 3,9,10,36,46	**173 317**	**(±17%)**	**254 480**	**(±12%)**	**19.9**	**427 796**	**(±7%)**
	8	1 026	(±89%)	1 666	(±55%)	19.6	2 692	(±48%)
	18	531	(±61%)	6 106	(±7%)	17.7	6 637	(±8%)
	Subtotal 8,18	**1 557**	**(±62%)**	**7 772**	**(±13%)**	**18.1**	**9 329**	**(±15%)**
East A subtotal		**174 874**	**(±17%)**	**262 252**	**(±12%)**	**19.9**	**437 125**	**(±7%)**

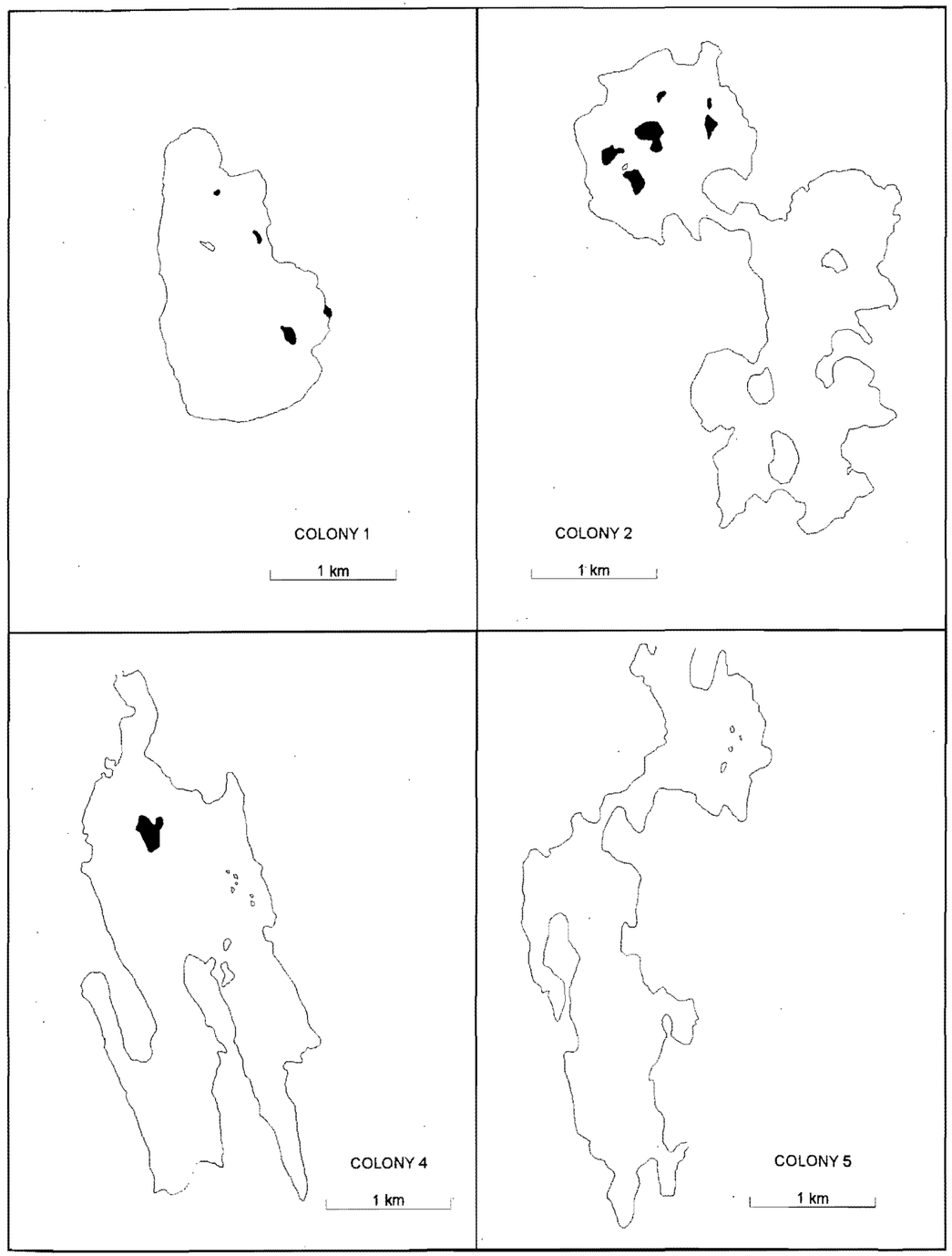
(*continued*)

Appendix 2 (*continued*)
Estimated numbers of nesting Ross' Geese and Lesser Snow Geese, Queen Maud Gulf MBS, June 1988

Zone[a]/class[b]	Colony No.[c]	No. of nesting birds: Ross'	(±2 SE in %)	Snow	(±2 SE in %)	% blue of Snows	Total no. of geese	(±2 SE in %)
East C	5	0	d	2	d	0	2	d
	6	292	d	414	d	20.8	706	d
	12	9	d	14	d	20.8	23	d
	13	25	d	34	d	20.8	59	d
	14	28	d	39	d	20.8	67	d
	15	2 723	d	3 857	d	20.8	6 580	d
	16	51	d	72	d	20.8	123	d
	17	88	d	124	d	20.8	212	d
	19	373	d	529	d	20.8	902	d
	27	630	d	891	d	20.8	1 521	d
	28	74	d	104	d	20.8	178	d
	29	449	d	636	d	20.8	1 085	d
	30	158	d	225	d	20.8	383	d
	31	53	d	74	d	20.8	127	d
	34	0	d	2	d	0	2	d
	42	28	d	39	d	20.8	67	d
	43	12	d	16	d	20.8	28	d
	45	216	d	307	d	20.8	523	d
	47	7	d	10	d	20.8	17	d
	48	178	d	251	d	20.8	429	d
	49	16	d	21	d	20.8	37	d
	50	415	d	588	d	20.8	1 003	d
	51	283	d	400	d	20.8	683	d
	52	28	d	40	d	20.8	68	d
	53	13	d	19	d	20.8	32	d
	54	108	d	153	d	20.8	261	d
	55	204	d	288	d	20.8	492	d
	56	97	d	138	d	20.8	235	d
	57	224	d	317	d	20.8	541	d
	58	58	d	83	d	20.8	141	d
	59	22	d	32	d	20.8	54	d
	60	124	d	177	d	20.8	301	d
	61	182	d	259	d	20.8	441	d
	62	172	d	244	d	20.8	416	d
	63	107	d	150	d	20.8	257	d
	64	6	d	8	d	20.8	14	d
	65	61	d	87	d	20.8	148	d
	66	141	d	201	d	20.8	341	d
East C subtotal		**7 655**	**(±19%)**	**10 845**	**(±19%)**	**20.8**	**18 500**	**(±14%)**
East subtotal		**182 529**	**(±16%)**	**273 097**	**(±12%)**	**19.9**	**455 625**	**(±7%)**
West A	1	670	(±24%)	227	(±70%)	10.1	897	(±25%)
	2	2 449	(±3%)	3 142	(±3%)	4.6	5 591	(±2%)
West A subtotal		**3 119**	**(±6%)**	**3 369**	**(±5%)**	**5.0**	**6 488**	**(±4%)**
West C	4	195	d	212	d	5.0	407	d
	20	83	d	89	d	5.0	172	d
	21	8	d	8	d	5.0	16	d
	23	1 017	d	1 098	d	5.0	2 115	d
	24	208	d	224	d	5.0	432	d
	25	176	d	190	d	5.0	366	d
	37	0	d	2	d	0	2	d
	39	46	d	49	d	5.0	95	d
	40	368	d	397	d	5.0	765	d
	44	236	d	255	d	5.0	491	d
West C subtotal		**2 337**	**(±25%)**	**2 524**	**(±25%)**	**5.0**	**4 861**	**(±18%)**
West subtotal		**5 457**	**(±11%)**	**5 892**	**(±11%)**	**5.0**	**11 349**	**(±8%)**
Grand total		**187 986**	**(±16%)**	**278 989**	**(±12%)**	**19.6**	**466 974**	**(±7%)**

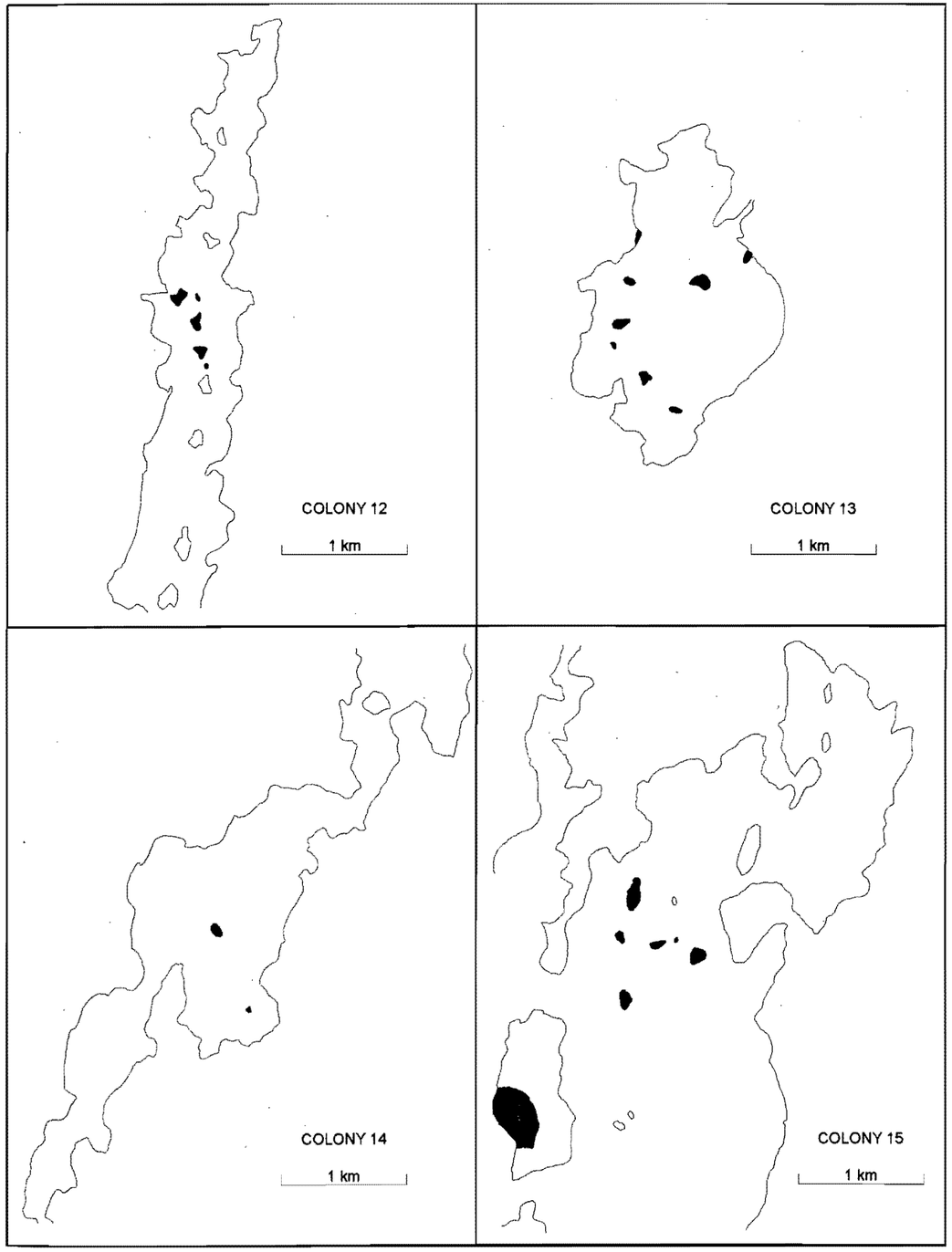
[a] East = East of Armark River; West = West of Armark River.
[b] A = census of Ross' and white Snows, with estimate of % blue of total geese and estimate of % Ross' of total Ross' and Snows; C = Census of Ross' and white Snows.
[c] For colonies 3, 9, 10, 36, and 46: Is. = Island nesting; Mn. = Mainland nesting; Mn.-hi = Mainland nesting high density; Mn.-lo = Mainland nesting low density. All other colonies were island nesting only.
[d] Subjective estimate (±50%) for each of Ross' and Snow goose estimates. Those variances are incorporated into the calculation of SE for the subtotals and totals.

Appendix 3
Maps of small colonies of Ross' and Lesser Snow geese recorded in the Queen Maud Gulf MBS area from 1965 to 1988. Shaded areas were known to have been occupied by nesting birds in one or more survey years. The occupied area on a few colonies was not recorded. Note that the scale on all colonies is consistent, and North is at the top of all figures.

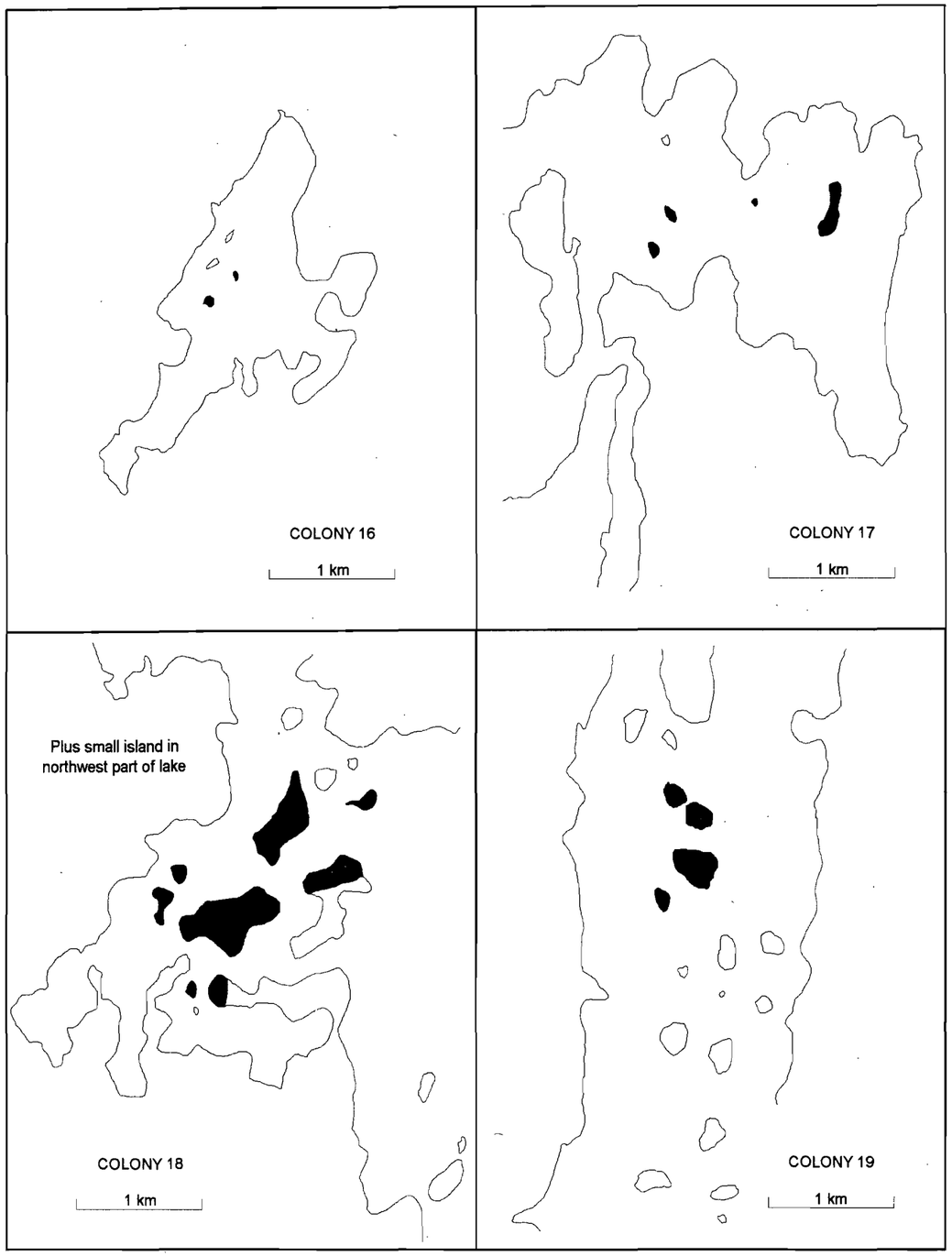


Appendix 3 (*continued*)
Maps of small colonies of Ross' and Lesser Snow geese recorded in the Queen Maud Gulf MBS area from 1965 to 1988. Shaded areas were known to have been occupied by nesting birds in one or more survey years. The occupied area on a few colonies was not recorded. Note that the scale on all colonies is consistent, and North is at the top of all figures.

Appendix 3 (*continued*)
Maps of small colonies of Ross' and Lesser Snow geese recorded in the Queen Maud Gulf MBS area from 1965 to 1988. Shaded areas were known to have been occupied by nesting birds in one or more survey years. The occupied area on a few colonies was not recorded. Note that the scale on all colonies is consistent, and North is at the top of all figures.



Appendix 3 (*continued*)
Maps of small colonies of Ross' and Lesser Snow geese recorded in the Queen Maud Gulf MBS area from 1965 to 1988. Shaded areas were known to have been occupied by nesting birds in one or more survey years. The occupied area on a few colonies was not recorded. Note that the scale on all colonies is consistent, and North is at the top of all figures.



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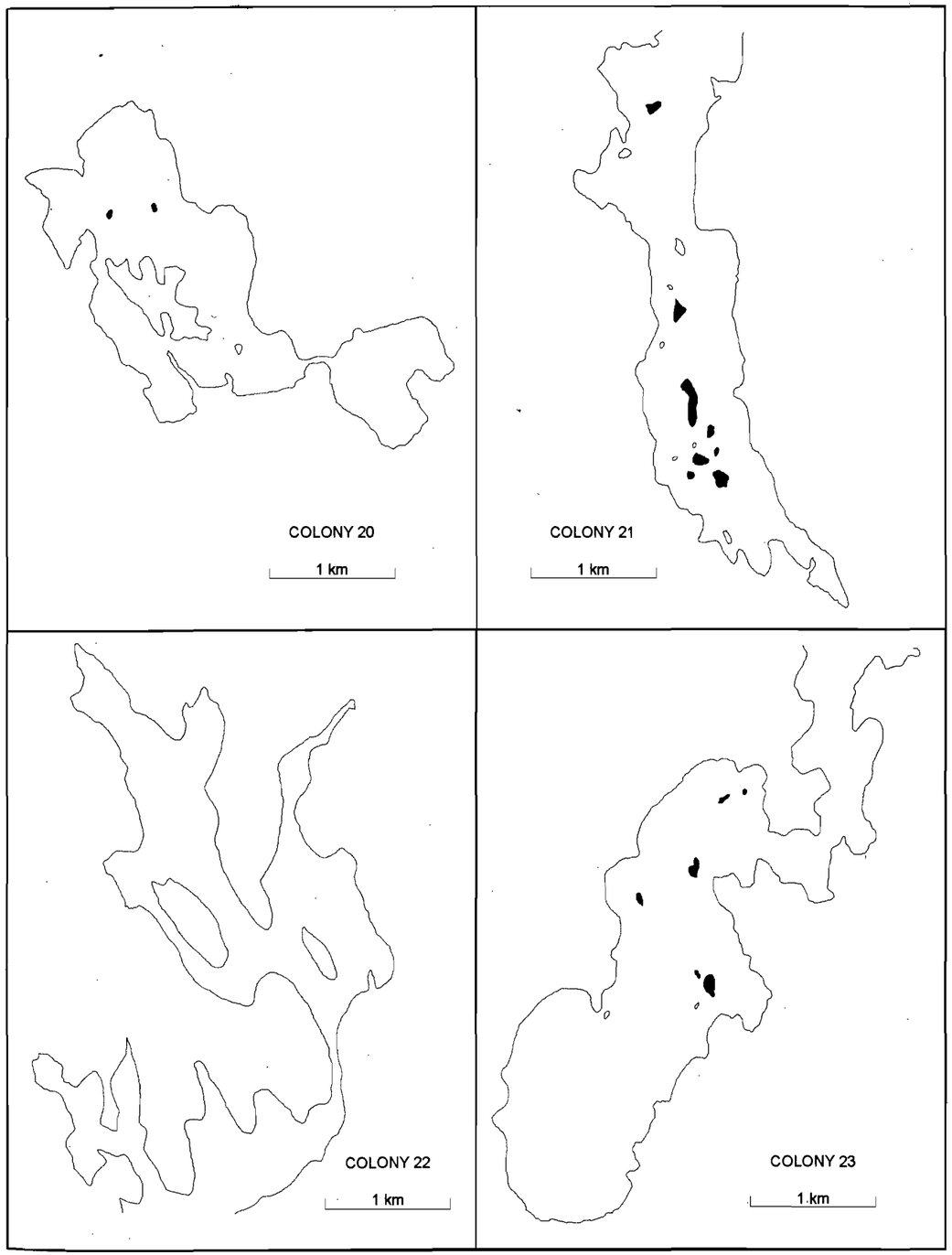

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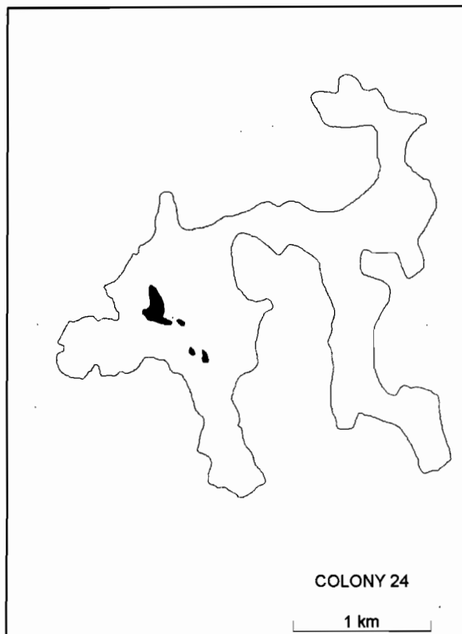

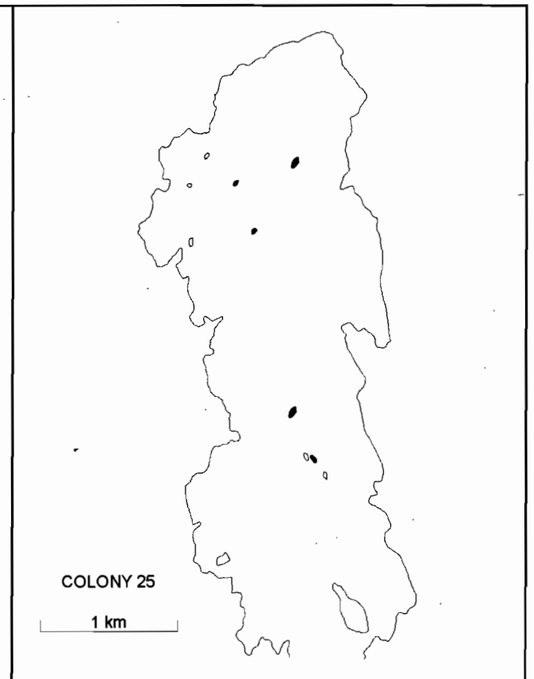

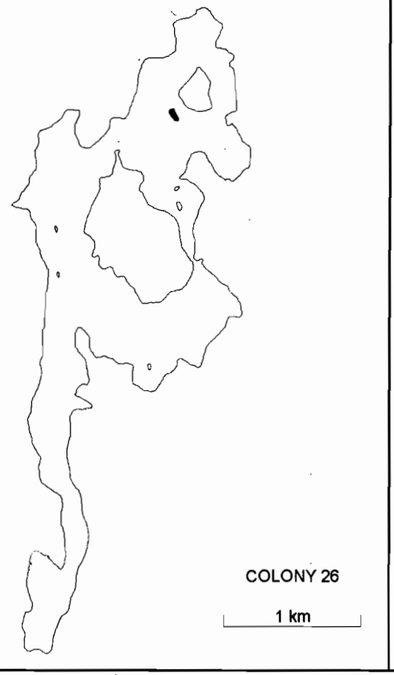

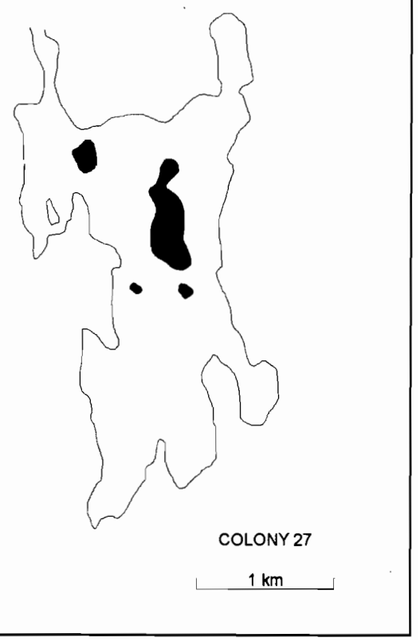

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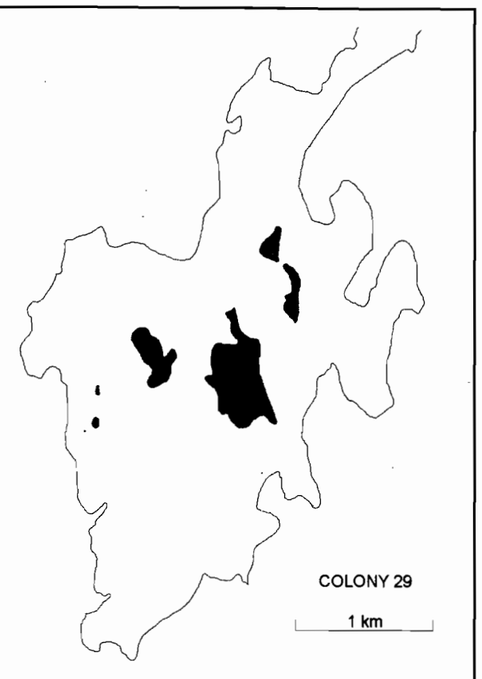

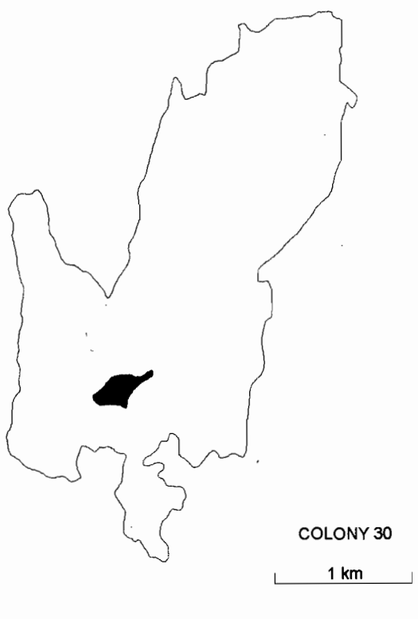

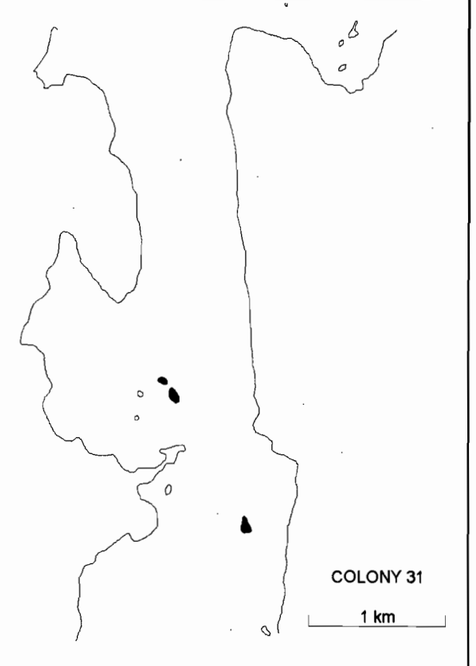

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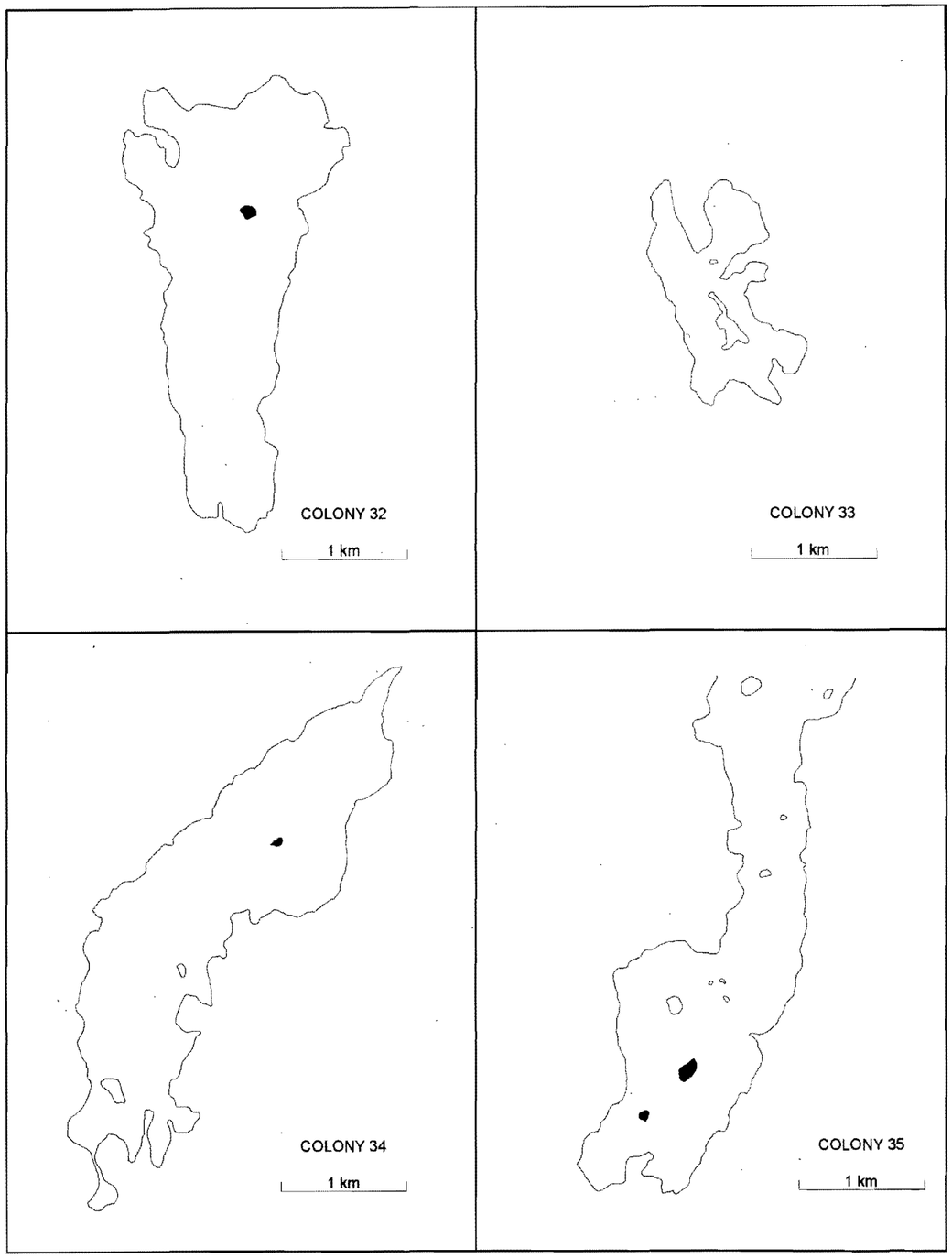

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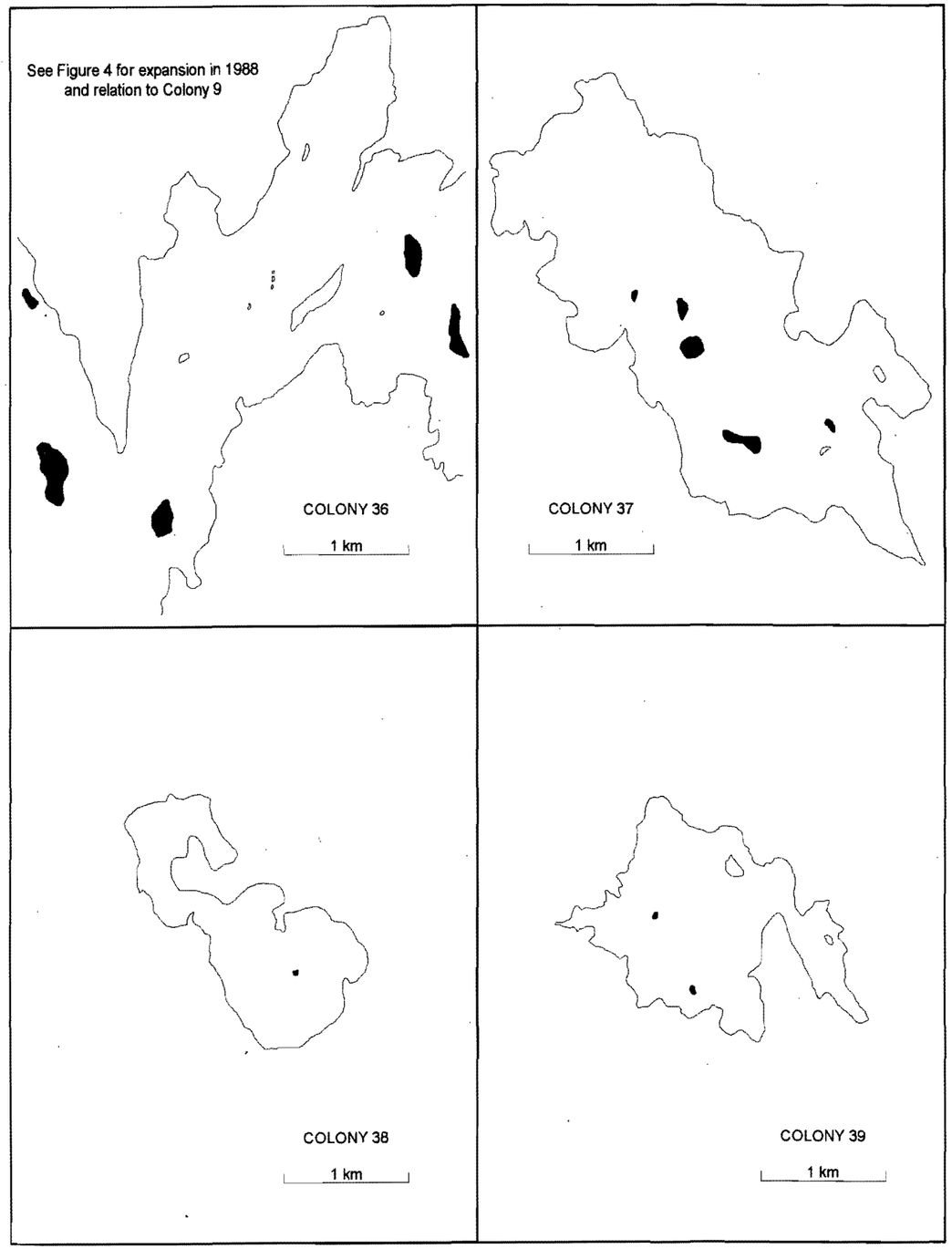

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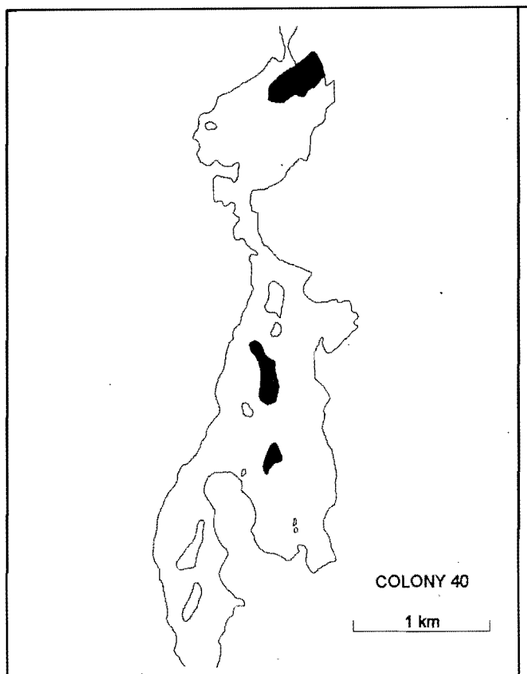

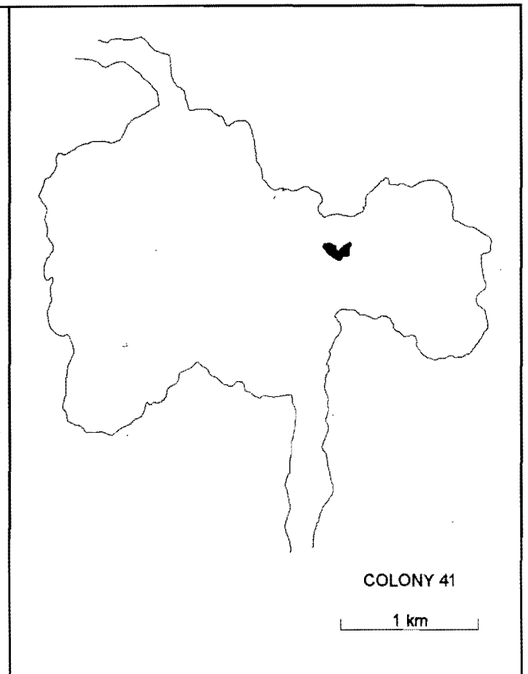

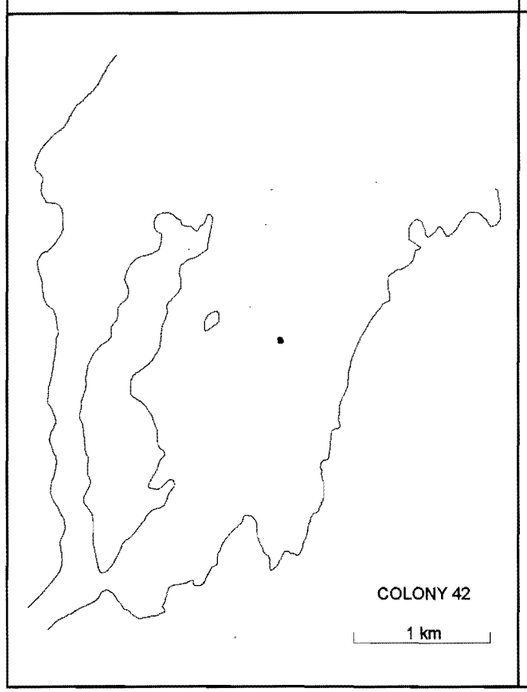

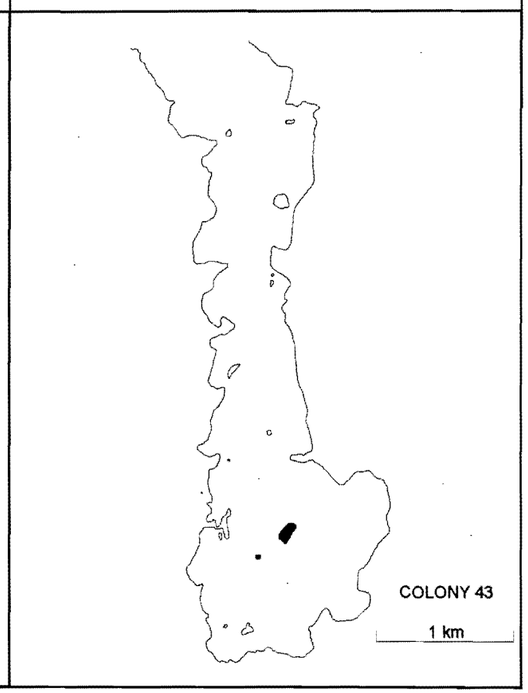

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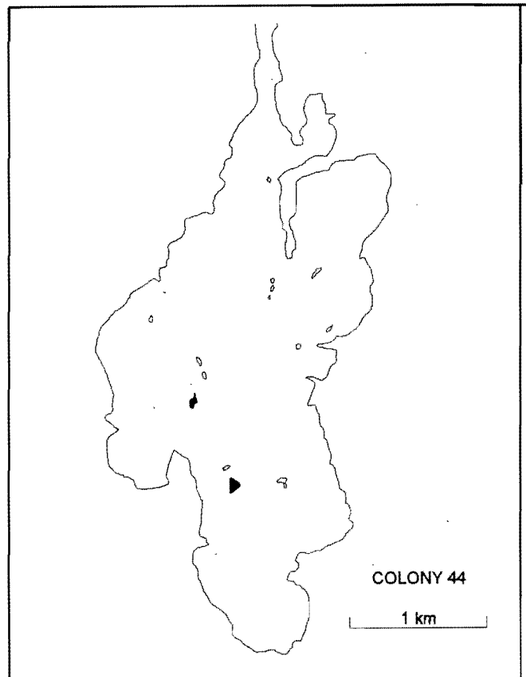

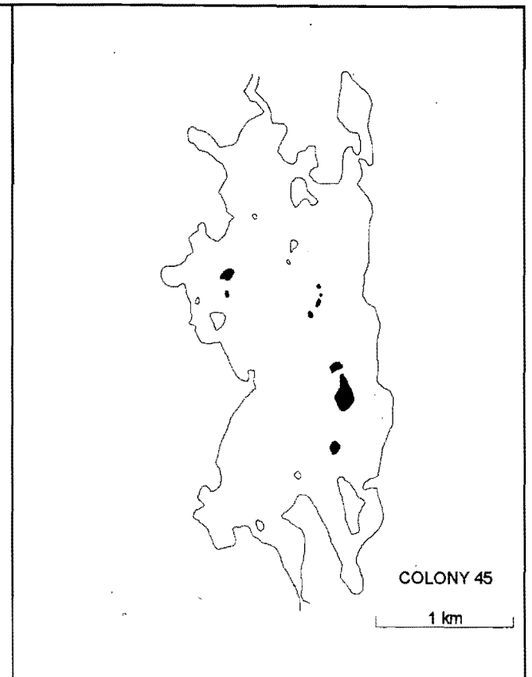

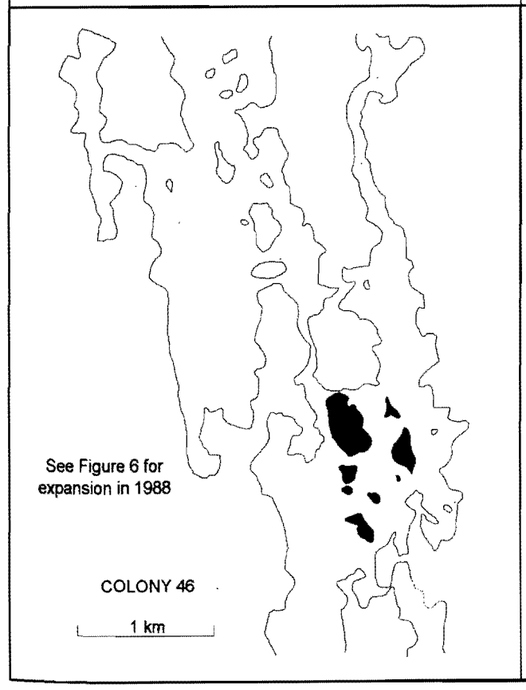

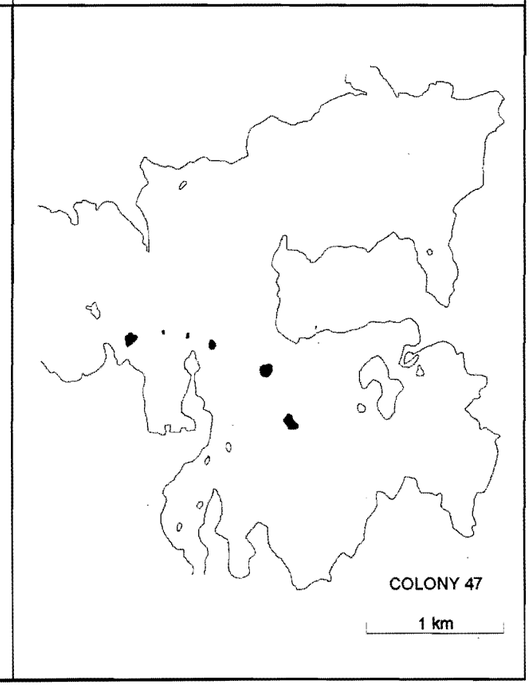

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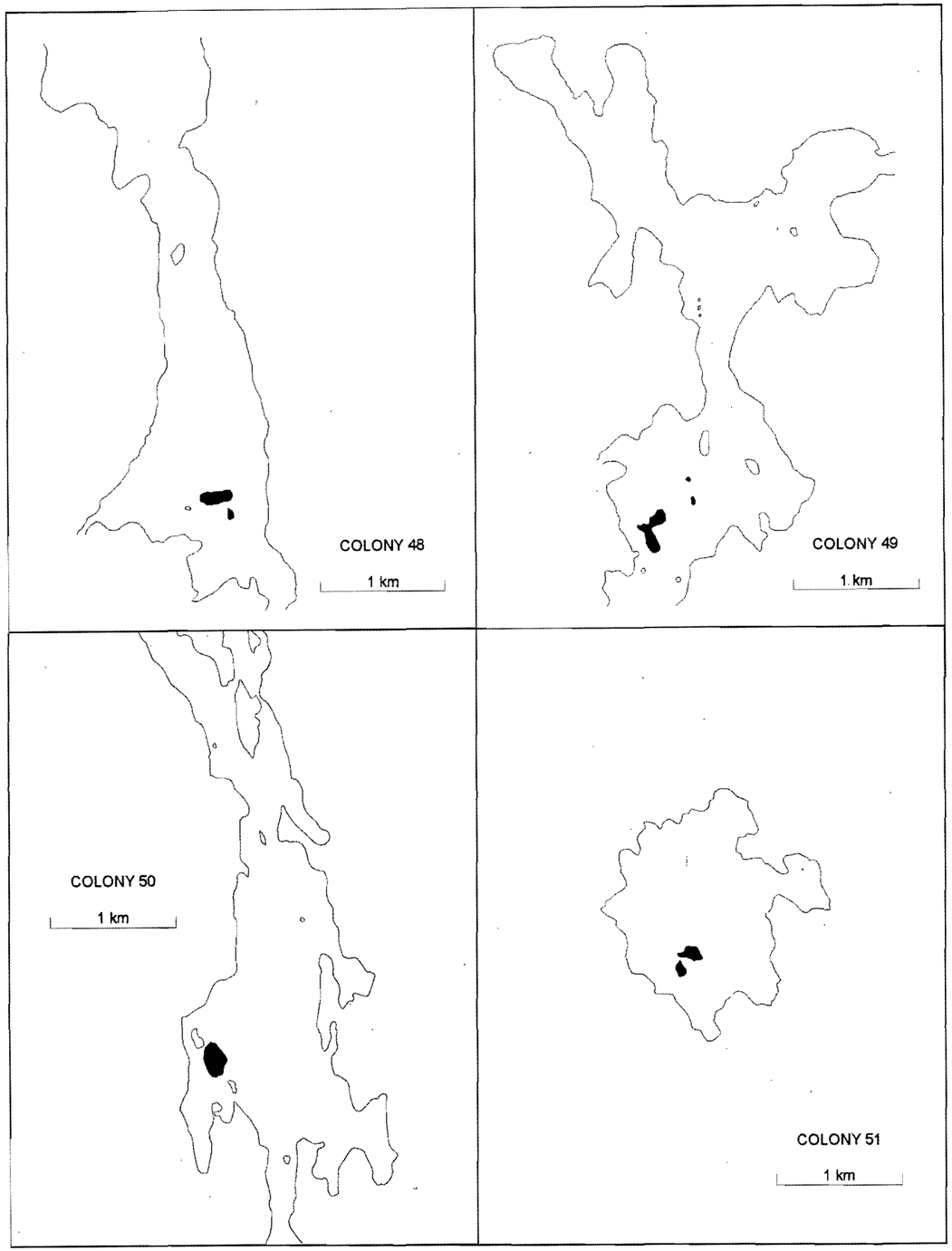

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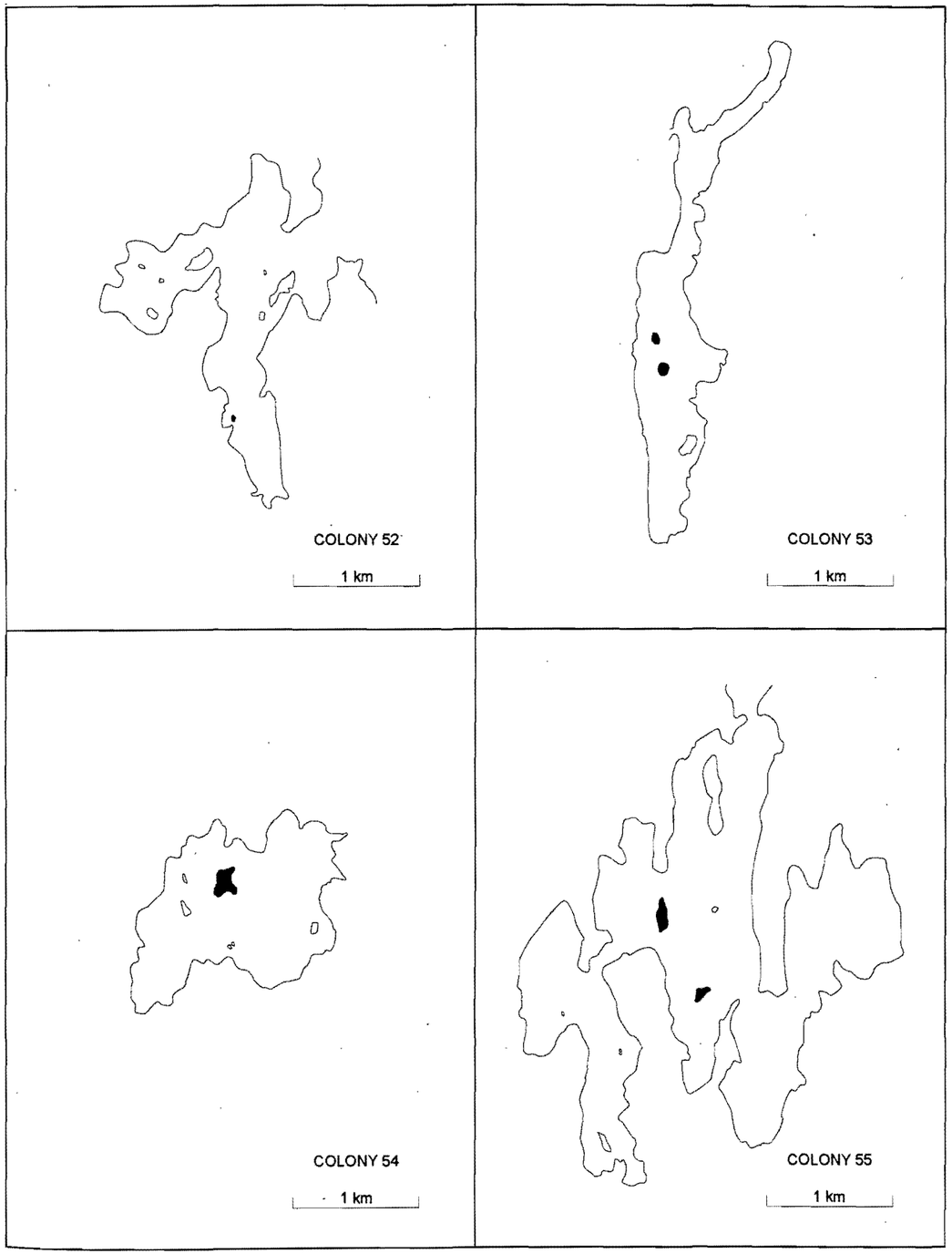

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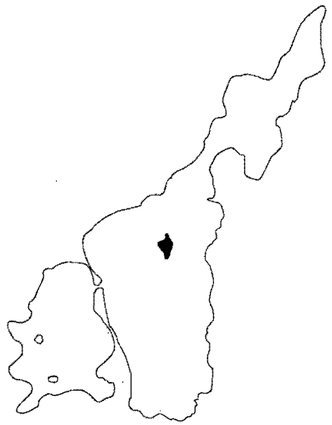


COLONY 56

1 km

COLONY 57

1 km

COLONY 58

1 km

COLONY 59

1 km

Appendix 3 (*continued*)
Maps of small colonies of Ross' and Lesser Snow geese recorded in the Queen Maud Gulf MBS area from 1965 to 1988. Shaded areas were known to have been occupied by nesting birds in one or more survey years. The occupied area on a few colonies was not recorded. Note that the scale on all colonies is consistent, and North is at the top of all figures.

COLONY 60

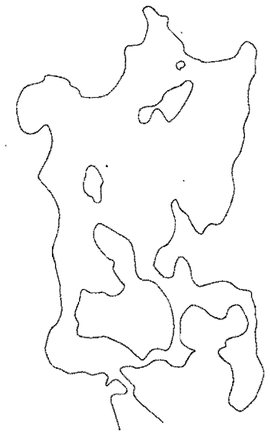
1 km

COLONY 61

1 km

COLONY 62

1 km



COLONY 63

1 km

Appendix 3 (*continued*)
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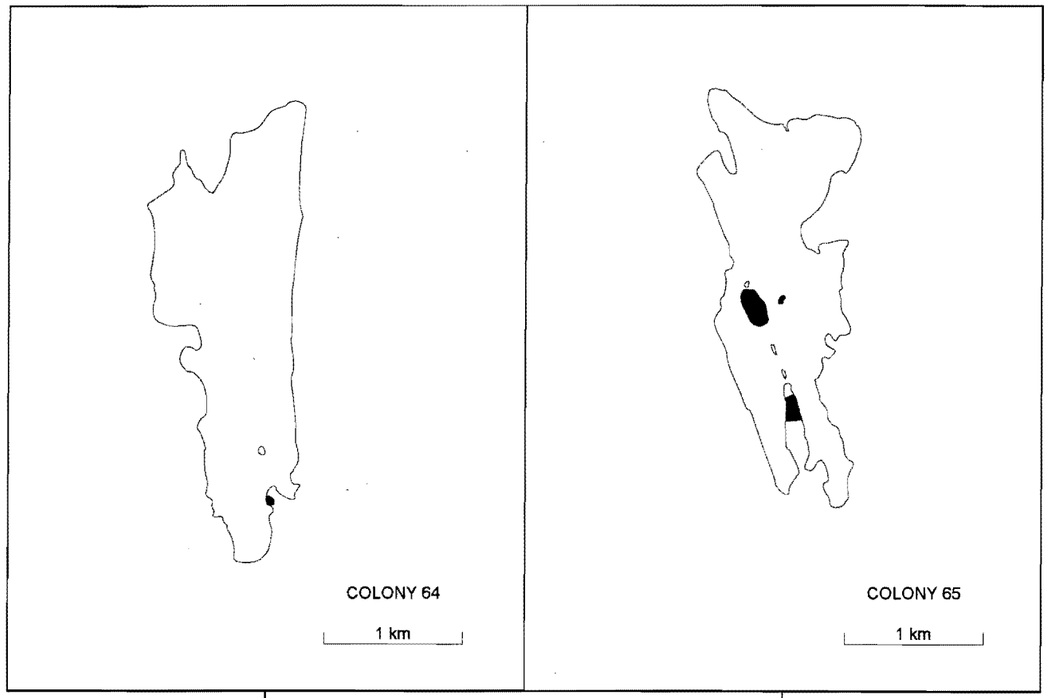

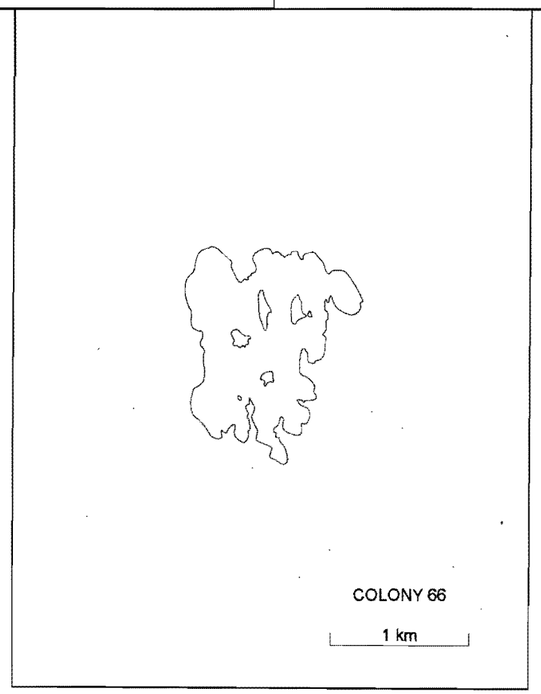

Appendix 4
Comparison of measurements of Ross' Goose and Lesser Snow Goose eggs from the Queen Maud Gulf MBS, 1963, 1968, 1976, and 1988

	Size of eggs (mm)							
	Ross'				Snow			
Measurement	1963[a] (n=175)	1968[b] (n=52)	1976[c] (n=85)	1988[d] (n=100)	1963[a] (n=104)	1968[b] (n=50)	1976[c] (n=80)	1988[d] (n=108)
Breadth								
Mean	48.7	47.5	48.7	48.0	52.8	53.8	53.1	52.4
SD	2.5	1.5	1.8	1.5	1.8	1.3	1.4	1.8
Length								
Mean	73.7	73.1	74.0	74.2	79.6	80.5	78.6	79.0
SD	3.4	2.5	2.8	3.0	3.8	2.0	2.4	3.5

[a] J.P. Ryder (pers. commun.) from Colony 2.
[b] J.P. Ryder (1971b, pers. commun.) from Colony 3.
[c] M.R. McLandress (pers. commun.) from Colony 3.
[d] This study, from colonies 1, 2, 3, 8, 9, 10, 18, 36, and 46.

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