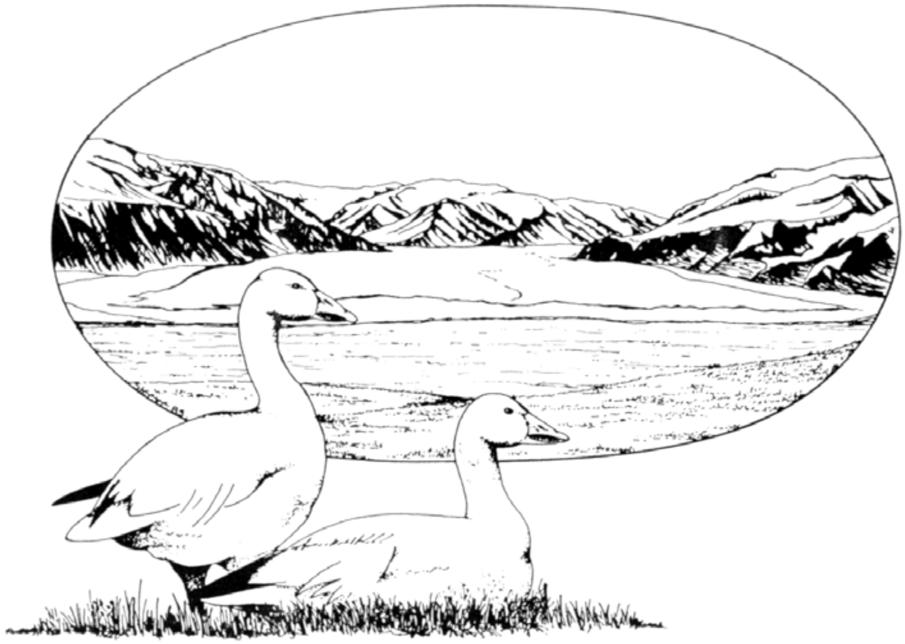
POPULATION STUDY OF GREATER SNOW GEESE ON BYLOT ISLAND (NUNAVUT) IN 2004: A PROGRESS REPORT



Gilles Gauthier Département de biologie & Centre d'études nordiques
Université Laval, Québec

Austin Reed Canadian Wildlife Service
Environment Canada, Québec

Jean-François Giroux Département des sciences biologiques
Université du Québec à Montréal

Dominique Berteaux Département de biologie, chimie et sciences de la santé
& Centre d'études nordiques
Université du Québec à Rimouski

Marie-Christine Cadieux Département de biologie & Centre d'études nordiques
Université Laval, Québec

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INTRODUCTION

In 2004, we continued our long-term study of the population dynamics of Greater Snow Geese (*Chen caerulescens atlantica*) and of the interactions between geese, plants and their predators on Bylot Island. Like many goose populations worldwide, Greater Snow Geese have increased considerably during the late XXth century (annual growth rate of ~10%). The exploding population of snow geese has imposed considerable stress on its breeding habitat, while extensive use of agriculture lands provides an unlimited source of food during winter and migratory stopovers for them. Remedial management during autumn, winter and spring has been undertaken since 1999 to curb the growth of this population. The long-term objectives of this project are to (1) study changes in the demographic parameters of the Greater Snow Goose population, and especially the effects of the recent spring conservation harvest, (2) determine the role of food availability and fox predation in limiting annual production of geese, and (3) monitor the impact of grazing on the vegetation of Bylot Island.

OBJECTIVES

Specific goals for 2004 were as follows:

1) Monitor productivity (egg laying date, clutch size and nesting success) of Greater Snow Geese on Bylot Island.
2) Study the relationship between climatic variables and the reproduction of geese.
3) Study the spatial structure of colonies in relation to habitats and movements between colonies based on marked females and genetic markers.
4) Mark goslings in the nest to provide a sample of known-age individuals to be used to assess the growth of goslings by their recapture in late summer.
5) Band goslings and adults, and neck-collar adult females at the end of the summer to continue the long-term study of demographic parameters such as survival and breeding propensity.
6) Monitor the level of intestinal parasite infestations in goslings and evaluate the impact on their survival.
7) Monitor the abundance of lemmings, and the breeding activity of Snowy Owls and other avian predators.
8) Monitor the breeding activity of foxes at dens and study their selection of denning sites.
9) Capture and ear-tag adult Arctic Foxes and their pups to study their movements around the snow goose colony.
10) Study the egg caching behaviour of Arctic Foxes in the goose colony using radio-tagged eggs.
11) Sample plants in exclosures to assess annual production and the impact of goose and lemming grazing on plant abundance in wet meadows.
12) Maintain and upgrade our automated environmental and weather monitoring system.

FIELD ACTIVITIES

Field camps. — In 2004, we operated two field camps on Bylot Island: the main camp, located at 6 km from the coast in the largest glacial valley on the island (“Base-camp Valley”, 73^{o} 08' N, 80^{o} 00' W), was occupied from 1 June to 22 August. A secondary camp, located in a narrow valley 30 km south of the Base-camp and 5 km from the coast (“Camp-2 area”, 72^{o} 53' N, 79^{o} 54' W) was occupied from 6 June to 18 August. Both of these camps are now protected by semi-permanent bear-deterring fences. Finally, nine fly camps were also established for 3-5 days at a time throughout the island, west of Pointe Dufour.

Field party. — The total number of people in the camps ranged from 2 to 15 depending on the period. Members of our field party included project leaders Gilles Gauthier, Dominique Berteaux, and Jean-François Giroux. There were also graduate and undergraduate students whose thesis projects addressed several of the objectives laid out above. Students were: Nicolas Lecomte (PhD, objectives 1 and 3), Marie-Hélène Dickey (MSc, objective 2), Nicolas Ouellet (MSc, objective 4), Guillaume Szor (MSc, objective 8) Vincent Careau (MSc, objective 10), Marie-Andrée Giroux (objective 9), Ambroise Lycke, and Catherine Mussely. Other people in the field included Gérald Picard, a technician in charge of the banding operation (objective 5); Marie-Christine Cadieux, a research professional in charge of plant sampling (objective 11); Denis Sarrazin, a research professional responsible of the maintenance of the weather stations (objective 12); Gaétan Rochette, a technician, and Benoît Audet, a student, who helped for the goose banding; and Serge Larivière, a researcher who assisted with the fox trapping. Finally, we hired 5 people from Pond Inlet: James Inootik for web-tagging young at hatching, David Panipakoocho and Ronnie Qiyuapik for goose banding, and Aaron Pitseolak and Ernest Merkosak for fox trapping and plant sampling.

Other people that shared our camp for part of the summer include the field party of plant ecologists Esther Lévesque and Line Rochefort: Rémy Pouliot, a MSc student who studied the role of geese in recycling nutrients in wetlands, Benoît Tremblay who monitored the impact of goose grazing in mesic habitats and field assistants Jean-Nicolas Jasmin and Claudia St-Arnaud. Two patrol persons from Parks Canada (Terry Kallut and Adam Ferguson) also joined our field crew for two weeks and Carey Elverum, the chief warden of *Sirmilik National Park*, visited the camp on two occasions.

Environmental and weather data. — Environmental and weather data continued to be recorded at our three automated stations. Our network includes 2 full stations, one at low and one at high elevation (20 m and 370m ASL, respectively) where air and ground temperature, air humidity, solar radiation, wind speed and direction are recorded on an hourly basis throughout the year. A third station monitors soil surface temperature in areas grazed and ungrazed by geese (i.e. exclosures). All automated stations were visited during the summer to download data and were found to be operating normally. A few damaged sensors (especially those recording ground temperatures) were replaced. A fourth weather station, a new 10-m meteorological tower installed in 2003 in wet polygon fens as part of the SILA project (a northern network of climate and environmental change observatories) is now operational. Installation of recording instruments was completed in late July 2004. Finally, daily precipitation was recorded manually during the summer and snowmelt was monitored by measuring snow depth at 50 stations along two 250-m transects at 2-day intervals.

Monitoring of goose arrival and nesting. — We monitored goose arrival in the Base-camp Valley by counting goose pairs every two to three days from our arrival on the island until the end of snowmelt on sample plots. Nest searches were carried out within walking distance (~6 km) of both the Base-camp Valley and the Camp-2 area between 7 and 21 June. Nests were found in 2 ways: 1) through systematic searches at the Base-camp and Camp-2 or 2) searches of randomly located 2.25-ha plots at Camp-2. At both sites, systematic searches for goose nests were concentrated near Snowy Owl nests this year (see results). We also attempted to find the nests of as many neck-collared females as possible throughout both study areas. All nests were revisited at least twice to determine laying date, clutch size, hatching date and nesting success. During the hatching period, we visited a sample of nests almost every day to record hatch dates and to web-tag goslings. In order to examine genetic differentiation among geese nesting in various parts of the island, blood samples were collected from goslings at hatch in several nests at Camp-2 and the Base-camp Valley. Genetic analyses will be conducted on these samples during the winter.

Goose banding. — From 8 to 17 August, we banded geese with the assistance of local Inuit people and a helicopter. All geese captured were sexed and banded with a metal band, and all recaptures (web-tagged or leg-banded birds) were recorded. For the second consecutive year, we participated in the reward band study of the USFWS. A sample of young and adults was measured (mass and length of culmen, head, tarsus and 9th primary). A sample of adult females were fitted with coded yellow plastic neck-collars but we discontinued marking young with coded plastic leg bands due to the very low resighting rate. We continued to inject some young with Droncit©, a drug that kills intestinal parasites, as part of a study on the impact of parasites on survival. In order to examine genetic differentiation among geese using different brood-rearing area on the island, blood samples were collected from females caught in the Base-camp Valley and around Camp-2. Genetic analyses will be conducted on these samples during the winter.

Breeding activity of foxes at dens and marking. — A total of 107 known potential denning sites for foxes were visited once or twice during the summer and inspected for signs of use by foxes and/or presence of reproductive foxes with pups. At dens used for reproduction, we noted the species (Arctic Fox, *Alopex lagopus*, or Red Fox, *Vulpes vulpes*) and minimum litter size, and, whenever possible, we trapped pups and adults with Tomahawk© collapsible live traps (cage traps) or padded leghold traps. Traps were either kept under continuous surveillance or at least visited every 12 hours depending on the site. Captured foxes were measured, weighed and tagged on both ears using a unique set of Dalton Rototags®. Adult foxes were anaesthetized using Telazol®, an anaesthetic commonly used for dogs, to allow safe manipulation.

Selection of denning site by foxes. — To study selection of denning sites by foxes, we measured several variables at each den such as spring snow cover, habitat type, substrate, soil temperature, depth of active layer, orientation and inclination of slope. We also evaluated food resources (lemmings and geese) near denning sites by sampling lemming scats and burrows and the abundance of goose nests. The same variables were also measured at sites randomly located on the south plain of Bylot Island to detect characteristics used by foxes when selecting a denning site.

Egg caching by Arctic Foxes. — We created artificial goose nests by placing two radio-tagged eggs (similar in size, shape and color to goose eggs) and one real egg into old nests randomly distributed in the colony (Camp-2). We located by telemetry radio-tagged eggs removed and hidden by predators, and described characteristics of each cache discovered. The fate of cached eggs was determined by periodic visits until late August. To determine when foxes retrieved cached eggs after our departure, we replaced the remaining radio-tagged eggs by real eggs linked to a modified watch that will record the date that eggs are retrieved. We searched for natural egg caches along eight 2-km transects throughout the colony six times during the summer. Egg caches were detected by evidence of eggshell remnants and a small hole in the tundra. We also observed the behaviour of Arctic Foxes from 2 blinds located in the goose colony to measure their hunting activity, their attack and success rates on goose eggs, the frequency of caching and the behaviour of geese during the attacks.

Small mammals. — We continued to participate in the small-mammal survey coordinated across the NWT and Nunavut by the Renewable Resources office in Yellowknife. We used Museum Special traps baited with peanut butter and rolled oats. We sampled lemming abundance at two sites in the Base-camp Valley (one in wet meadow habitat and one in mesic habitat) and one site at the Camp-2 (mixed habitat) in July. At each site, we used 50 traps set at 10-m intervals along two parallel transect lines 100 m apart (25 traps/transect) and left open for ~10d. A new sampling program based on live-trapping of lemmings was also developed and initiated in 2004. We laid out 2 grids (300×300 m) at the Base-camp Valley (one in wet meadow habitat and one in mesic habitat) each with 100 Longworth© traps baited with apples and set at each grid intersection every 30-m. We trapped during 5-consecutive days every 20 days on each grid from early July to mid-August. All trapped animals were identified, sexed, weighed and marked with electronic PIT tags (or checked for the presence of such tags).

Other bird monitoring. — We also monitored the nesting activity of Snowy Owls (*Nyctea scandiaca*), Jaegers (*Stercorarius* spp.), Glaucous Gulls (*Larus hyperboreus*), and Lapland Longspurs (*Calcarius lapponicus*). Nests of owls and gulls were found through systematic searches of suitable habitat whereas others were found opportunistically.

Monitoring of plant growth and goose grazing. — The annual impact of goose grazing was evaluated in wet meadows dominated by graminoid plants at 2 sites: the Base-camp Valley (brood-rearing area), and the Camp-2 area (nesting colony). At each site, 12 exclosures (1 x 1 m) were installed in late June, and plant biomass was sampled in ungrazed and grazed areas (i.e. inside and outside exclosures) at the end of the plant-growing season on 13 and 14 August. Plants were sorted into sedges (*Eriophorum scheuchzeri* and *Carex aquatilis*) and grasses (*Dupontia fisheri*). Use of the area by geese was monitored by counting faeces on 1 x 10 m transects located near each exclosure every 2-weeks in the Base-camp Valley and once at the end of the season at the Camp-2 area.

PRELIMINARY RESULTS

Weather conditions. — The spring of 2004 was characterized by a normal snowmelt despite cool temperatures. Although temperature was relatively warm in early and mid May, air temperature averaged -0.67°C between 20 May and 20 June (0.53°C below normal) and only 0.05°C during 1-15 June (1.34°C below normal). However, snow depth on 2 June was only 22 cm compared to a long-term average of 31 cm (Fig. 1). The thin snow pack at arrival explains the near normal date of snowmelt despite the cool spring temperature and some light snowfall in mid June. July and August were also relatively cool compared to recent summers. Precipitation was low in June (13 mm of rain) but very high in July (69 mm) and August (60 mm up to 21 August). However, whereas precipitation was frequent in August (12 days out of 21), rainy days were scarcer in July (11 days out of 31) but 65% of the month's precipitation fell in only 2 days (13 and 30 July). These torrential rains resulted again in flooding of lowlands in August, especially polygon tundra which was covered by several cm of water.

Goose arrival and nesting activity. — Arrival dates of geese on Bylot Island were similar to previous years. However the number of geese counted on the hills surrounding the Base-camp Valley (the first area used by geese upon arrival) was very low this year. Our first pair count on 2 June was 27 pairs and up until the complete snowmelt counts remained low (< 200 pairs; Fig. 2). Such low numbers are usually typical of years where goose arrival is considerably delayed (e.g. 2002). Pair counts at arrival nonetheless suggest a reduced number of geese on Bylot Island this year.

The distribution of goose nests was highly unusual this year, probably due to a record nesting activity of Snowy Owls (see below). For the first time in 12 years, most geese at the main colony (Camp-2) nested around owl nests, with a low density of nests in between, even in the central part of the colony. This rendered difficult the estimation of nesting density in the main colony but, overall, the patchy distribution of goose nests indicates a reduced nesting effort this year. Several geese nested in the Base-camp Valley (mostly a brood-rearing area) this year, also in close association with Snowy Owls. Overall, median egg-laying date was 11 June, which is very close to the long-term average (Table 1). However, there was an usually high spatial variation in laying dates as geese nesting in association with owls started laying on average on 10 June (n = 511) whereas those nesting away from owls (including the usual central portion of the colony) started laying around 16 June (n = 132). There was thus a bi-modal distribution of laying dates this year, with a smaller late peak. It is noteworthy that fresh snowfall occurred during the period in between the 2 peaks. Overall, mean clutch size was 3.65, which is again very close to the long-term average (Table 1). As expected, clutch size was higher in nests located near owls (3.74, n = 490) than far away (3.30, n = 125).

Nesting success of geese. — Nesting success (proportion of nests hatching at least one egg) in 2004 was similar to last year and fairly good (78% for all nests, a value above the long-term average, Table 1). Nesting success was higher in the Base-camp Valley (92%, n = 158) than at Camp-2 (colony, 74%, n = 480). At the colony, nesting success also tended to be slightly higher away from owls nests (82%, n = 121) than near them (72%, n = 353). Activity of predators at goose nests, especially Arctic Foxes, was low in the Base-camp Valley and moderate at the colony but slightly higher than in 2003. During nesting and brood-rearing, only 56 neck-collared birds were sighted, a very low number compared to last year (222). Peak hatch was on 7 July, also close to the long-term average (Table 1). We approximately tagged 1765 goslings in nests at hatch, of which 405 were marked in the Base-camp Valley and 1360 in the Camp-2 area. Blood samples were obtained from goslings at hatch in 45 nests of the the Base-Camp Valley and over 100 nests in the Camp-2 colony.

Density of broods. — In 2004, density of goose faeces at the end of the summer in wet meadows of the Base-camp Valley was low (4.7 ± 0.7 [SE] faeces/m^2, Fig. 3) and very similar to the last 2 years (4.9 ± 1.0 in 2003 and 4.4 ± 1.2 in 2002). Accumulation of faeces was delayed and only started at the end of July. Throughout the summer, faeces density was one of the lowest ever recorded in the Base-camp Valley if we exclude the total breeding failure year of 1999. Faeces density at the end of the summer was also low in the wet meadows of the nesting colony at Camp-2 (3.8 ± 1.8 faeces/m^2 vs. 4.9 in 2003).

Goose banding. — The banding operation was reasonably successful this year. We conducted 9 drives in our usual banding area, i.e. in the lowlands and hills bordering the Base-camp Valley to the south and north (<8 km), and 2 additional drives further away, i.e. 1 at the Camp-2 area and 1 near Dufour Point. We banded a total of 3617 geese (compared to 5259 last year), including 486 adult females marked with neck-collars and 96 young which were marked with web-tags at hatch and recaptured. We injected 458 young with Droncit© and 483 with a saline solution (control group). In addition, there were 270 recaptures of adults banded in previous years. We collected blood samples from 58 females in the Base-camp Valley, 45 at the Camp-2, and 45 near Pointe Dufour. Fewer goslings were captured at the banding sites outside our usual banding area. Consequently, the gosling:adult ratio among geese captured at our regular banding site (0.94:1) was higher than for all sites combined (0.87:1). However, both values were much lower than last year and lower than the long-term average (for sake of comparison among years, we retained the first value). Mean brood size toward the end of brood-rearing (2.50 young, SD = 1.09, n = 52; counts conducted from 28 July to 7 August) was normal (Table 1). By combining information on brood size and young:adult ratio at banding, we estimated that only 75% of the adults captured were accompanied by young, which is suggestive of a moderately high mortality of young during the summer. Overall, these values are indicative of a moderate to low production of young on Bylot Island this year.

Breeding activity of foxes at dens and marking. — We found signs of activity (fresh digging and/or footprints) at 50 dens. The breeding activity of foxes was high as we found 16 litters (15% of known denning sites with a different litter), 15 of Arctic Foxes and 1 of Red Foxes. This level of use is much higher than last year (only 4% of the dens were used) and typical of the proportion of fox dens used in previous years of peak lemming abundance (17%) Minimum litter size varied between 1 and 10 pups for Arctic Foxes (5.5 pups on average) and was 6 for the single Red Fox. A total of 7 adult and 42 juvenile Arctic Foxes were captured during trapping sessions. Two adult Arctic Foxes out of 3 marked last year were resighted in 2004. Among the 12 juvenile Arctic Foxes ear-tagged in 2003, 2 were seen this year, and one of them was a female that bred successfully and produced at least 3 pups.

Den site selection by Arctic Foxes. — Preliminary results suggest that Arctic Foxes select sites on either a slope or a ridge to dig their dens, with usually a lower snow cover than elsewhere. Compared to other potential sites within a 100 meter radius, dens usually have a higher soil temperature, a deeper active layer, and steeper slope. They are more often found in sandy soil and on west, south-west or south facing slopes. Analysis on the influence of food resources on denning site selection remains to be done.

Egg caching by Arctic Foxes. — Predators removed 38 radio-tagged eggs from artificial nests and cached them at an average distance of 900 m from the nests. Some eggs were later moved to a new cache more than once, leading to 49 events of changes in cache location for an average distance of about 200 m. In addition to foxes, we also observed a few Common Ravens (*Corvus corax*) caching telemetry eggs. We have the retrieval date of 25 eggs that were linked to recording devices at the end of 2003. Eighteen of them were retrieved between 17 and 30 August 2003, 5 were retrieved during September 2003 and 2 during June 2004. We found 26 natural caches used by foxes to store eggs in the goose colony. We spent over 186 hours in two different blinds from 13 June and 19 July observing fox behaviour. Six different foxes were observed to attack goose nests and to cache eggs.

Small mammals. — During our survey using snap traps, we accumulated 1047 trap-nights in the Base-camp Valley at our 2 trapping sites from 22 July to 3 August, and 500 trap-nights at the Camp-2 from 7 to 17 July. In the Base-camp sites, we caught 8 Brown Lemmings (*Lemmus sibiricus*) in the wet meadow site and none in the mesic site for a combined index of abundance of 0.78 lemmings/100 trap-nights. (Fig. 4). In the Camp-2 site, 2 lemmings were caught, 1 Brown and 1 Collared Lemming (*Dicrostonyx groenlandicus*) for an index of 0.41 lemmings/100 trap-nights. After 2 to 3 years of very low numbers, we expected that 2004 would be a peak in the lemming cycle. Although lemming increased over last year, their abundance, as indicated by our trapping index, appeared much lower than in previous peak years (e.g. 1996 and 2000). During our live-trapping survey, we captured 180 different lemmings, of which 123 were captured more than once. We captured 36 Brown Lemmings and 27 Collared Lemmings in the mesic habitat, and 117 Brown and no Collared ones in the wet habitat.

Other bird monitoring. — After 3 years of nesting absence, we found 9 Snowy Owl nests in the Camp-2 area and 13 in the Base-camp Valley, a record high. In previous lemming peaks, the number of owls nests ranged from 7 to 13 in the Base-camp Valley and only 1 to 2 in the Camp-2 area. The average egg-laying date for the first egg was 18 May (range: 10 to 28 May) and average clutch size was 7.1 eggs (range: 4 to 10). All nests but one were successful in fledging at least one young. We also found 5 nests of Glaucous Gull, more than 20 nests of Long-tailed Jaegers and 27 nests of Lapland Longspurs.

Plant growth and grazing impact. — Plant production in wet meadows of the brood-rearing area was almost identical to last year and very near the long-term average (Fig. 5). Above-ground biomass of graminoid plants in the Base-camp Valley reached 43.7 ± 5.6 [SE] g/m^2 in ungrazed areas in mid-August compared to 43.8 ± 5.1 in 2003. Much of the annual variation in plant production since 1998 is due to variations in *Eriophorum*, the preferred plant of geese; in contrast, production of the Gramineae *Dupontia* varied little during this period (Fig. 5). At the Camp-2 area (colony), total plant production tended to be slightly higher in 2004 (25.5 ± 4.4 g/m^2) than last year (23.3 ± 4.5 g/m^2) but below the average value since 1998 (32.3 ± 3.4 g/m^2)

For the first time, goose grazing in the wet meadows of the Base-camp Valley was undetectable in mid-August (Fig. 5). In a typical year, geese removed about 36% of the annual production at this site. At the Camp-2 area (colony), a grazing impact was detected with 38% of the graminoid biomass removed by geese, a value similar to 2003 (41%) but above the long-term average at this site (29%).

CONCLUSIONS

The production of young on Bylot Island was relatively low in 2004. Although the phenology of migration and reproduction were normal (i.e. geese arrived on the island and initiated nesting at the usual dates), their reproductive effort was relatively low (i.e. the density of geese on the island at arrival and during nesting was low). The geese that did nest benefited from a low nest predation rate and thus had a high nesting success. Even though the breeding activity of nest predators like foxes and jaegers was high, many geese apparently took advantage from protective associations with Snowy Owls due to the exceptionally high abundance of these raptors this year, and from the relative abundance of lemmings, the alternative prey of predators. However, this high nesting success was apparently not sufficient to offset their low reproductive effort. Moreover, predation during brood-rearing may have been higher than during nesting based on the proportion of families still accompanied with young during banding. Based on the young:adult ratio observed during our banding operation, we anticipated a proportion of young in the fall flock of 19% (or 16% if the 2 banding drives outside our regular banding area were included), a moderate value. This prediction was upheld as juvenile counts conducted in Québec indicated a proportion of young of 18% (n = 21 536) in the fall flock, a value below the long-term average (24%).

The relatively low reproductive effort and ensuing production of young this year is somewhat surprising given the normal nesting dates and clutch size, and the high nesting success. Usually, a low reproductive effort is associated with late nesting and reduced clutch size. We suggest 3 factors that may have contributed to the low reproductive effort of geese this year. First, the spring harvest continued in Québec and this may have had a negative impact on the body condition of geese at departure for the Arctic as we reported before (Féret et al. 2003). Second, geese may have encountered severe climatic conditions during the migration as spring temperatures in Northern Québec were cold and the snow-melt was very late this year. This may have delayed their migration or further reduced their condition, thus explaining the relatively low number of geese at arrival. Third, despite a normal snow-melt due to a thin snow-pack, temperatures throughout June were cold. This, in combination with the previous two factors, may have negatively impacted the nesting activity of geese. In contrast, the abundance of nesting owls found by geese upon their arrival may have been a stimulus for some birds to nest relatively early despite the cold temperature in June. Indeed, geese that nested near owls were about 6 days earlier than those that nested far away.

Results from our annual lemming trapping were ambiguous as to whether 2004 was a peak in lemming abundance or not. Based on the previous two lemming cycle observed at our site, we expected this year to be a peak lemming year. Although abundance increased from last year, it was much lower than in previous peaks or even lower than in some intermediate years of the cycle. However, several lines of evidence suggest that 2004 was a genuine lemming peak and that our trapping underestimated its amplitude. First, we had a very high reproduction of all predators (foxes, owls, jaegers), typical of a high lemming year. Second, the reproduction of

Snowy Owls was especially remarkable (a record) and they had a high success in fledging young, which indicate that food (i.e. lemmings) was plentiful. Third, we captured many lemmings in our live-trapping (however, given that this trapping was conducted for the first year, we cannot compare our data to previous years). If this interpretation is correct, it remains puzzling why we caught so few lemmings in our snap traps. We offer two explanations. First, trapping in the Base-camp Valley was conducted during a period with several days of heavy rain (e.g. on 30 July we had 27 mm of rain, an all time record for a single day), and this may have negatively affected trapping success. Second, given the record number of predators like owls, it is possible that lemmings suffered from a very high mortality during the summer and that populations were declining rapidly by late July. The latter interpretation could also explain the apparent relatively high mortality of goslings during the summer in contrast to the low egg predation rate during nesting (i.e. if lemmings were declining in late summer, predators may have turned more to alternative prey like geese).

It is the first year in which breeding was not a total failure that our long-term monitoring of vegetation failed to detect any impact of goose grazing in the Base-camp Valley (though an impact was detected in the colony at Camp-2). We have no satisfactory explanation for this surprising result. Even though production of young was low, they were still present in the Base-camp Valley during the summer as shown by our faeces count. It is possible that broods are slowly changing their habitat use pattern and are abandoning some traditionally used areas. However, this would be surprising given that plant production is still high in those sites. Perhaps more likely, the heavy rain in late summer caused extensive flooding in low-lying areas as in 2003. This may have hampered our sampling, and encouraged broods to move away from these areas toward upland habitat.

Based on the production encountered this year, the Greater Snow Goose population is expected to decline between 2004 and 2005 under the current exploitation regime, which includes a spring harvest. During the period 1998 to 2003, our population model based on the demographic data obtained from the current study and the harvest data from the CWS and USFWS predicted a decline of the population of 8%/year, which matched well the population trends observed in the spring survey in Québec. However, a preliminary estimate for the 2004 survey indicates a spring population of 957,900, a 41% increase over 2003. This number is impossible to reconcile with the demographic data which suggests a relative stability of the population over the same period (<5% change) based on the production in 2003 and the harvest data. Without additional information, we cannot resolve this paradox. Either the 2004 spring survey overestimated the population, or the modified survey procedure implemented since 2001 continued to grossly underestimate the population in the past 3 years. The next spring survey (2005) will be useful to determine which possibility is more likely.

PLANS FOR 2005

The long-term objectives of our work are to study the population dynamics of Greater Snow Geese, and the interactions between geese, plants, and their predators on Bylot Island. A major focus of the project is to monitor changes in demographic parameters (such as survival rate, hunting mortality, breeding propensity, reproductive success, and recruitment) and habitat in response to the spring conservation harvest and other special management actions implemented since 1999 in Québec. Other current focuses of the project include *i*) understanding better the spatial structure of colonies and goose movements on Bylot Island; *ii*) expanding our estimate of the carrying capacity of the Island for geese to upland habitats; *iii*) determining long-term effects of geese on the arctic landscape; *iv*) study indirect interactions between snow geese and lemmings via shared predators; and *v*) study the ecology of the main predator of geese, Arctic Foxes. In 2005, we anticipate to:

1) Monitor productivity (egg laying date, clutch size and nesting success) and nesting distribution of Greater Snow Geese on Bylot Island.
2) Study the spatial structure of colonies and nest site selection.
3) Mark goslings in the nest to provide a sample of known-age individuals to assess the growth and pre-fledging survival of goslings by their recapture in late summer.
4) Band goslings and adults, and neck-collar adult females at the end of the summer, to continue the long-term study of demographic parameters such as survival and breeding propensity.
5) Monitor the level of intestinal parasite infestations in goslings and study their impact on survival.
6) Monitor the abundance of lemmings and study their demography.
7) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owls, jaegers and Glaucous Gulls).
8) Monitor the breeding activity of foxes at dens and capture and mark adults and pups with ear-tags to study their movements and demography.
9) Study egg caching by arctic foxes in the goose colony using radio-tagged eggs.
10) Sample plants in exclosures to assess annual production and the impact of goose and lemming grazing on plant abundance in wet meadows.
11) Maintain our automated environmental and weather monitoring system.

In 2005, at least 7 graduate students will be involved in the Bylot Island snow goose project. **Nicolas Lecomte** (PhD) will finish his project on the spatial structure of snow goose colonies and factors affecting nest site selection in Greater Snow Geese. **Vincent Careau (**MSc) will finish his study on egg caching behaviour of foxes around the Snow Goose colony. **Cédric Juillet** (PhD) will continue to study the effect of hunting on the population dynamic and demography of geese. **Béatrice Riché** (MSc) will investigate the effect of intestinal parasites on the survival of goslings. **Nicolas Gruyer** (MSc) will initiate a new study on the demography of lemming populations. **Marie-Andrée Giroux** (MSc) will study the relative contribution of terrestrial vs marine food sources to the annual diet of Arctic Foxes using stable isotopes. Finally, **Guillaume Szor** (MSc) will complet the sampling of fox dens.

Table 1. Productivity data of Greater Snow Geese nesting on Bylot Island over the past decade

	1995	1996	1997	1998	1999	2000	2001	2002	2003	**2004**	Average[2]
Number of nest monitored	312	367	326	350	266	386	296	470	585	**676**	--
Median date of egg-laying	10 June	14 June	10 June	7 June	17 June	16 June	13 June	16 June	9 June	**11June**	12 June
Clutch size	3.64	3.99	4.27	4.00	3.09	3.51	3.43	3.43	3.90	**3.65**	3.70
Nesting success[1]	14%	65%	83%	79%	12%	83%	57%	53%	82%	**78%**	64%
Median date of hatching	7 July	11 July	7 July	4 July	13 July	13 July	9 July	11 July	6 July	**7 July**	8 July
Number of geese banded	3985	3824	3956	3998	1717	4269	3430	2650	5259	**3617**	--
Ratio young:adult at banding	1.10:1	0.83:1	1.06:1	1.09:1	0.54:1	1.08:1	1.03:1	0.81:1	1.31:1	**0.94:1**	1.04:1
Brood size at banding	2.50	2.34	2.47	2.70	1.67	2.78	2.37	1.67	2.74	**2.50**	2.49
Proportion of adults with young at banding	88%	71%	86%	81%	65%	78%	87%	97%	96%	**75%**	83%

[1] Mayfield estimate

[2] Period 1989-2004

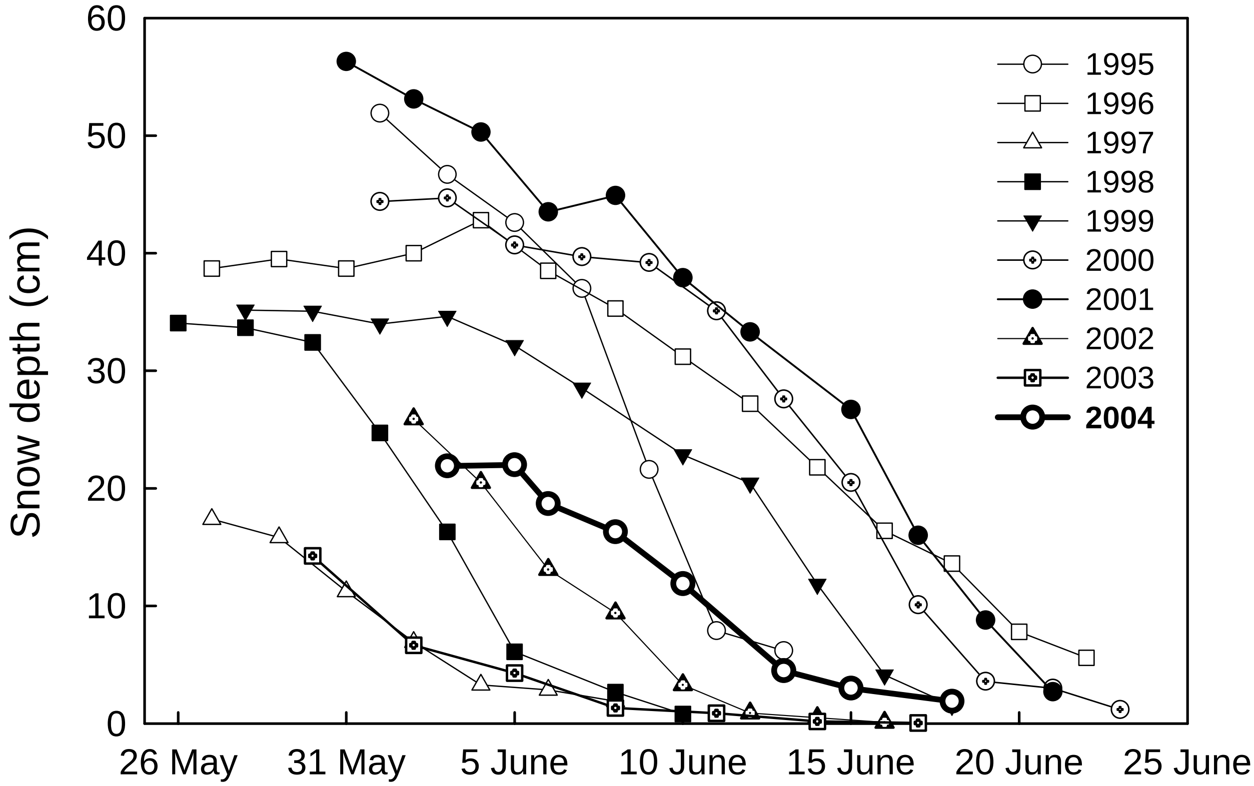

Figure 1. Average depth of snow along 2 transects showing the rate of snowmelt in Bylot Island lowlands (n = 50 stations).

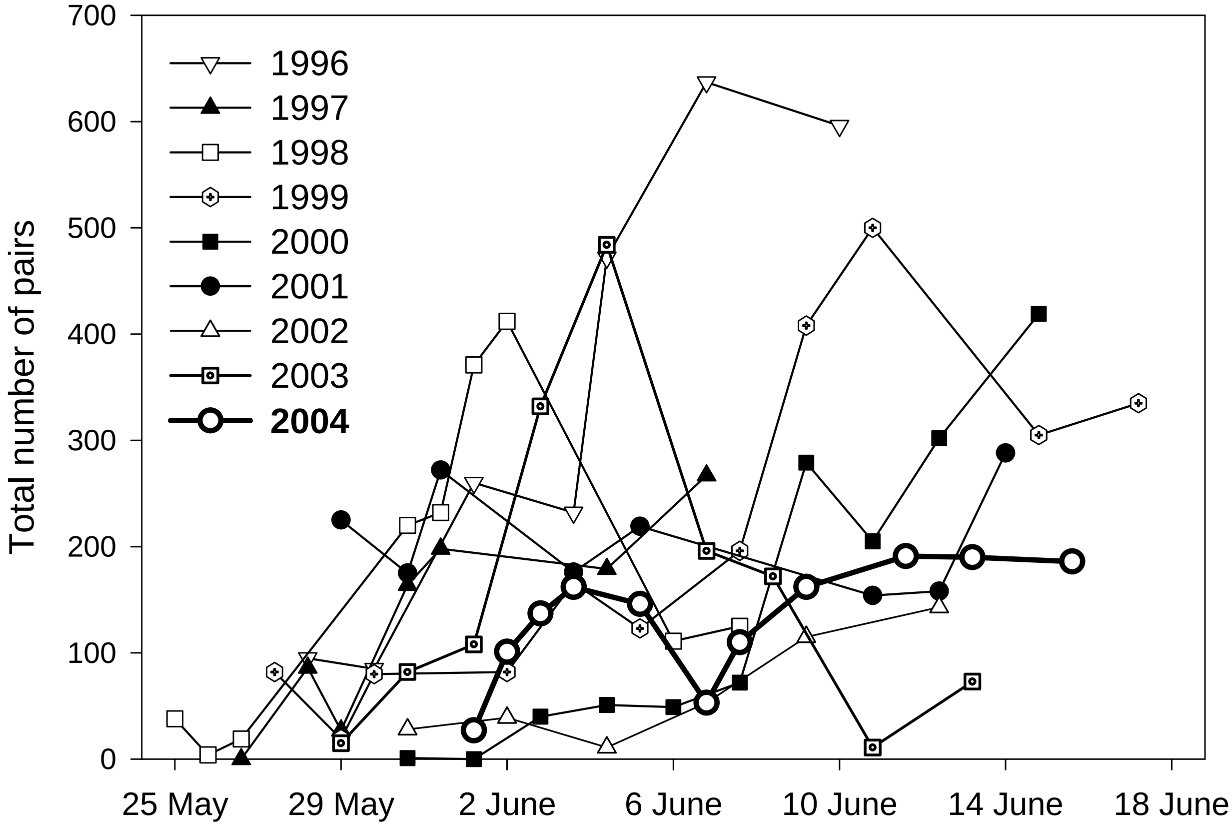

Figure 2. Total number of goose pairs counted in the Base-camp Valley from arrival of our crew on Bylot Island until the end of snowmelt.

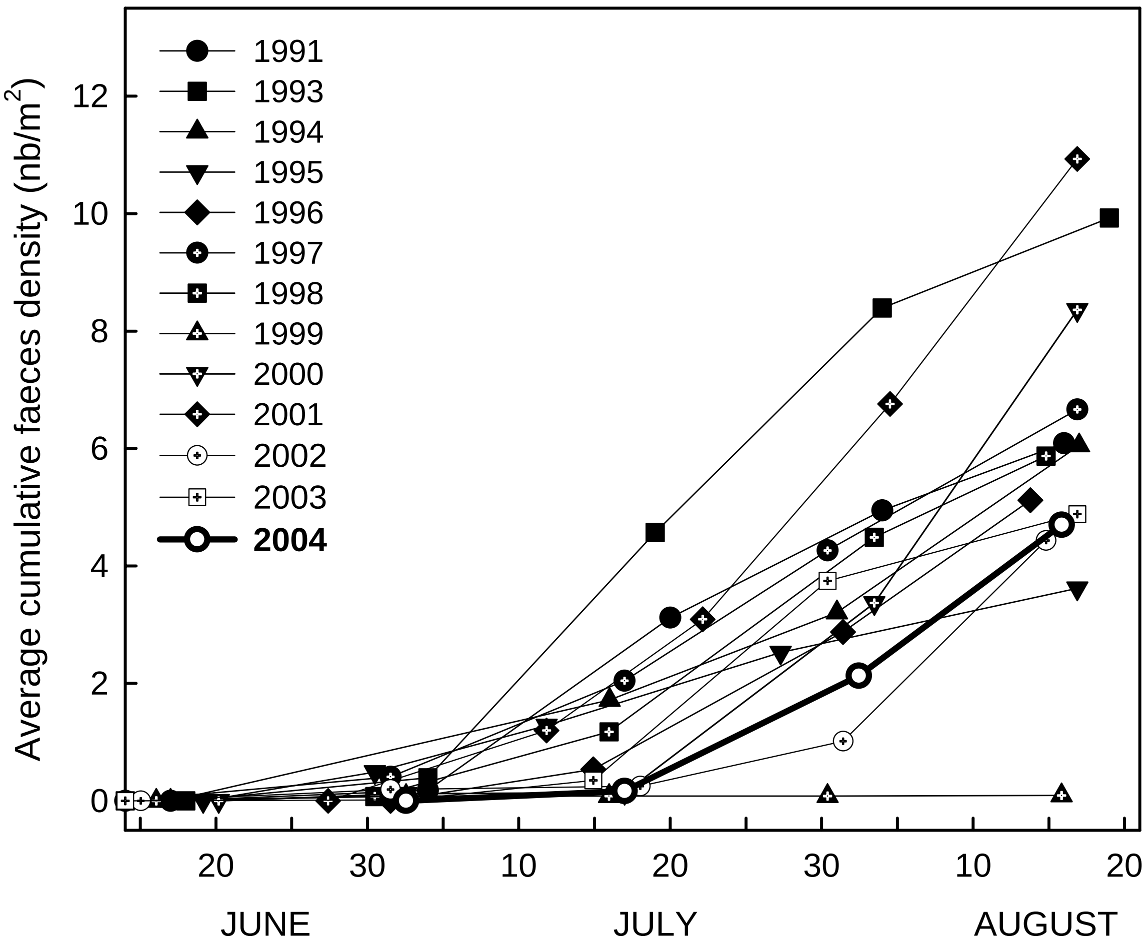

Figure 3. Average cumulative faeces density showing the use of Base-camp Valley by Greater Snow Goose families on Bylot Island throughout the summer (*n* = 12 transects of 1 x 10 m).

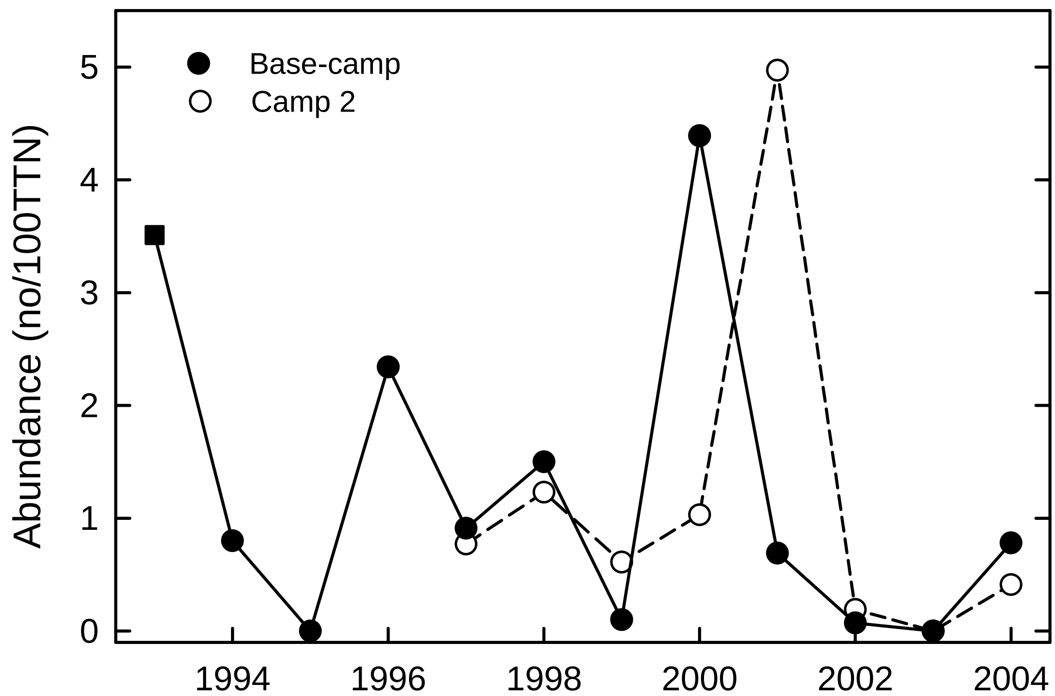

Figure 4. Annual abundance of lemmings at two study areas (Base-camp Valley and Camp-2) located 30 km apart on Bylot Island.

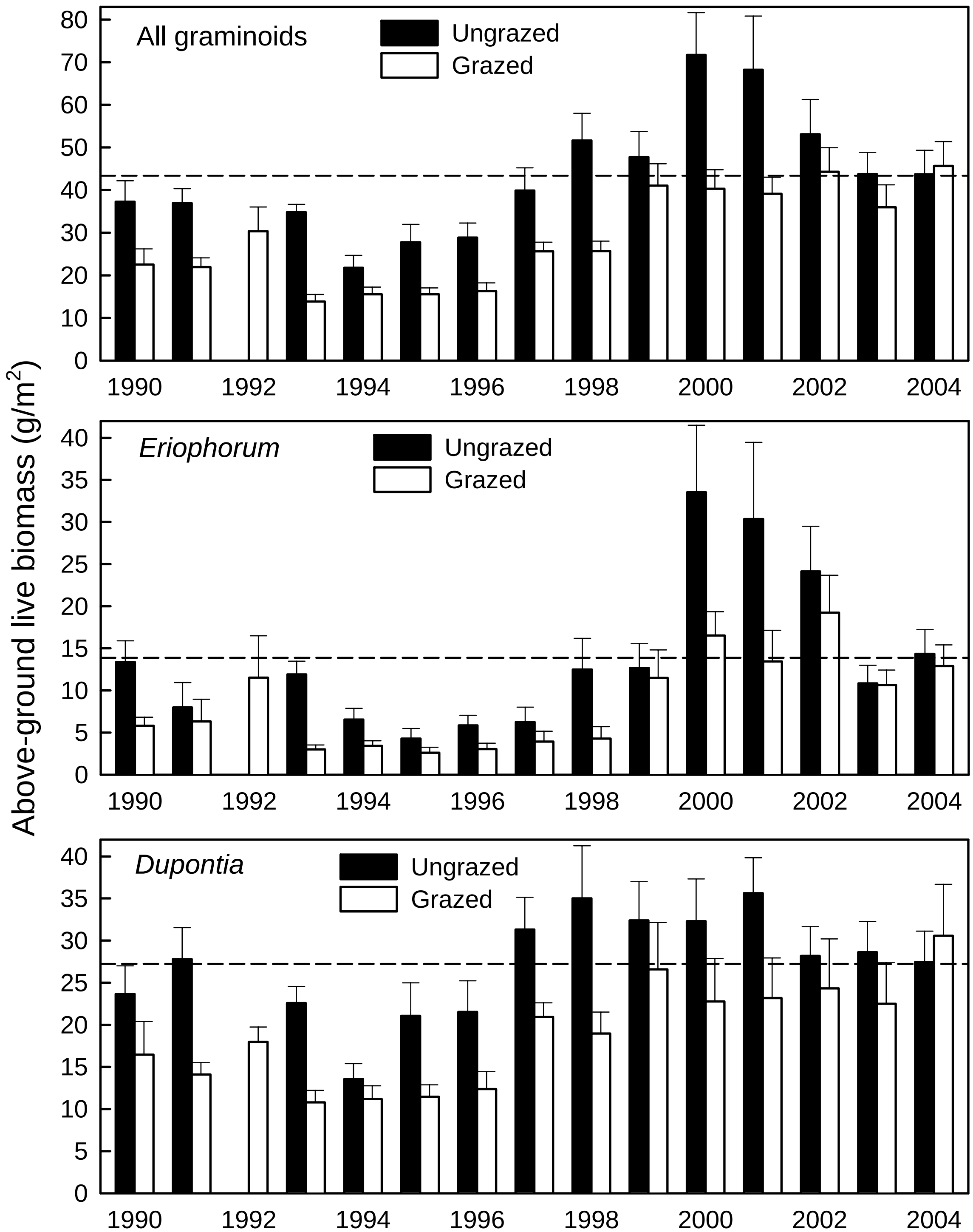

Figure 5. Live above-ground biomass (mean + SE, dry mass) of graminoids around 14 August in grazed and ungrazed wet meadows of the Base-camp Valley, Bylot Island (n = 12). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data from ungrazed area in 1992. The dashed line is the long-term average for ungrazed area.