POPULATION STUDY OF GREATER SNOW GEESE ON BYLOT AND ELLESMERE ISLANDS (NUNAVUT) IN 2008: A PROGRESS REPORT

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INTRODUCTION

In 2008, 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 other goose populations worldwide, Greater Snow Geese have increased considerably during the late XXth century. The exploding population 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. A synthesis report produced in 2007 evaluated the initial success of these special conservation measures. However, the recent Action Plan released in 2006 by the Canadian Wildlife Service called for a continued monitoring of the dynamic of this population and of its habitats. In response to those needs, 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 spring conservation harvest, (2) determine the role of food availability and predation in limiting annual production of geese, and (3) monitor the impact of grazing on the Arctic vegetation.

OBJECTIVES

Specific goals for 2008 were as follows:

1) Monitor productivity (egg laying date, clutch size and nesting success) of Greater Snow Geese on Bylot Island.
2) 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.
3) 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.
4) Mark adult females with satellite radio-transmitters to monitor their behaviour, migration, and subsequent reproduction on Bylot Island.
5) Monitor the level of intestinal parasite infestations in goslings.
6) Carry out the aerial survey of snow geese on Bylot Island during brood-rearing (conducted every 5 years since 1983) to determine the size of the breeding colony.
7) Monitor the abundance of lemmings and study their demography.
8) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owls, jaegers and Glaucous Gulls).
9) Monitor the breeding activity of foxes at dens.
10) Capture and mark adults Arctic Foxes and their pups with ear-tags to study their movements and demography.
11) Sample plants in exclosures to assess annual production and the impact of goose grazing on plant abundance in wet meadows.

12) Maintain and upgrade our automated environmental and weather monitoring system.

13) Monitor the goose breeding activity, their grazing impact, and band geese at another arctic colony on Ellesmere Island and surrounding areas.

FIELD ACTIVITIES

Field camps. — In 2008, 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 12 May to 21 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 17 May to 19 July (Fig. 1). Both of these camps are protected by semi-permanent bear-deterring fences. Finally, fourteen fly camps were also established for 4-11 days at various times throughout the island, west of Pointe Dufour.

Field parties. — The total number of people in both camps ranged from 3 to 21 depending on the period. Members of our field party included project leaders Gilles Gauthier, Joël Bêty and Austin Reed, and several graduate students whose thesis projects addressed many of the objectives mentioned above: Arnaud Tarroux (PhD, objective 10), Jean-François Therrien (PhD, objective 8), Madeleine Doiron (PhD student, objectives 2 and 3), Marc-André Valiquette (MSc, objective 8), David Duchesne (MSc, objective 7), Cassandra Cameron (MSc, objectives 9), Emma Horrigan (MSc, objective 11) and Loïc Valéry (Post-doc, objective 1). Several other students assisted them in the field, including: Meggie Desnoyers, Christine Demers, Geneviève Ouellet-Cauchon, Vanessa Duclos, Émilie Chalifour, Pierre-Yves L’Hérault, Adam Desjardins and Elizabeth Tremblay. Other people in the field included Gérald Picard, a technician in charge of the banding operation (objectives 3 and 4); 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); Louise Laurin from the Bird Banding Office in Ottawa; and Marie-Claude Martin, a wildlife technician. Finally, we hired 4 persons from Pond Inlet to work with us: Joassie Otoovak (marking goslings in the nests), Ivan Koonoo (goose banding), Joshua Enookolo (goose banding), Leslie Qanguq (plant sampling).

Other people used our camp during the summer. They were the field party of Esther Lévesque (UQTR) which included Eric Harvey, Joanna Gauthier and Daniel Fortier (Université de Montréal) who studied plant ecology and the permafrost; Laura McKinnon (PhD student), Émilie D’Astous, Élise Bolduc (MSc student) and Martin Patenaude-Monette who studied shorebirds and insects under the supervision of Joël Bêty; and the field party of Isabelle Laurion (Institut National de la Recherche Scientifique) who studied the carbon cycle in ponds. Several persons from Parks Canada visited our camp during the summer. They include Carey Elverum (chief warden of *Sirmilik National Park*), Andrew Maher (park warden), Jane Chisholm (ecosystem scientist, Nunavut Field Unit, Iqaluit), Mark McCormick (park planner, Nunavut Field Unit, Iqaluit), Eva Paul (resource conservation technician, Nunavut Field Unit, Iqaluit) and Paul Ashley (ecosystem scientist, Nunavut Field Unit, Iqaluit). Finally, Lionel Levac, a journalist from the radio show ‘*Pourquoi pas Dimanche*’ on Radio-Canada came to our camp on 5 June to document our research as part of a special series called ‘*Au Nord du Nord: Pond Inlet*’.

Environmental and weather data. — Environmental and weather data continued to be recorded at our four automated stations. Our network includes 3 full stations, two at low and one at high elevation (20 m and 370 m ASL, respectively) where air and ground temperature, air humidity, solar radiation, wind speed and direction are recorded on an hourly basis throughout the year (Fig. 1). A new automated precipitation gauge was installed at our main weather station. A fourth station measures 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. Daily precipitation was recorded manually during the summer. Finally, snowmelt was monitored by measuring snow depth at 50 stations along two 250-m transects and by visually estimating snow cover in the Base-camp Valley, both 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 8 and 18 June. Nests are found by systematic searches conducted over various areas in the field. At the Base-camp Valley where nest density is always low, nests searches are conducted throughout the valley. At Camp-2, nest searches are conducted in two ways: 1) over an intensively-studied core area (ca 50 ha) located in the centre of the colony every year, and 2) within a variable number of 1-ha plots randomly located throughout the colony. Nest density was calculated over a fixed 30-ha area within the intensively-studied core area. 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.

Tracking of radio-marked geese. — During spring staging in Quebec, we captured snow geese at Île-aux-Oies using canon-nets. Among the 1402 individuals captured, we marked 12 adult females previously banded on Bylot Island with a VHF radio-transmitter. For six of them, we replaced their plastic neck-collar with a new one on which a transmitter had been glued and we fitted the others with a new collar. On Bylot Island, we installed two automated receiving stations with antenna on high grounds immediately after arrival, one in the Base-camp Valley (2 June - 20 July) and one at Camp-2 (7-30 June). The receiving stations scanned 24-h a day for the presence of radio signals. Additional manual scans were conducted on snowmobile and on foot during the prelaying and early nesting periods (2-30 June). We also conducted aerial tracking with a helicopter a few time over the south plain of Bylot Island to locate radio-marked geese. Nests of geese with radio-transmitters were found on foot using a portable antenna and a receiver.

Goose banding. — From 7 to 14 August, we banded geese with the assistance of local Inuit people and a helicopter. Goose flocks of a few hundred birds were rounded up and driven by people on foot into a holding pen made of plastic netting. All captured geese were sexed and banded with a metal band, and all recaptures (web-tagged or leg-banded birds) were recorded. A sample of young and adults was measured (mass and length of culmen, head, tarsus and 9th primary) and some adult females were fitted with coded yellow plastic neck-collars. We marked some adult females with GPS/ARGOS solar radio-transmitters mounted on the back of the bird with an elastic Teflon harness. These birds will be tracked throughout their annual cycle to relate events occurring during the spring migration with subsequent reproduction and to obtain an unbiased continental population estimate over the next 3 years. Finally, we collected the intestine from a sample of goslings that died accidentally during banding to examine the level of parasite infection.

Snow goose population survey. — The aerial photographic survey was conducted on the south plain of the island from 21 to 30 July. Ground counts aimed at determining average brood size were also conducted during the same period. The main survey on the south plain covered 47 sample plots (18% of the total area), each one covering 2 × 2 km. Of these plots, 19 represented habitats judged to be of highest quality for brood-rearing, 21 of intermediate quality, and 7 of poorest quality. A total of 220 photographs were taken, from which geese were counted in the laboratory.

Breeding activity of foxes at dens and marking. — All known fox dens located within a 475 km^2 area were visited one to five times during the summer and inspected for signs of use and/or presence of reproductive adults with pups. We attempted to trap adults with padded leghold traps at locations where foxes were seen hunting or travelling. At reproductive dens, we noted the species (Arctic Fox, *Vulpes lagopus*, or Red Fox, *Vulpes vulpes*) and minimum litter size, and, whenever possible, we trapped pups with Tomahawk© collapsible live traps (cage traps). Cage traps were kept under continuous surveillance and leghold traps were visited at least every 6 hours. Captured foxes were measured, weighed and tagged on both ears using a unique set of coloured and numbered plastic tags. In addition, some adult Arctic Foxes were fitted with satellites collars. Samples of winter and summer fur, blood, and scats were also collected for genetic and diet analyses.

Small mammals. — We continued to sample the annual abundance of lemmings 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 204 traps set at 15-m intervals along two to four parallel transect lines 100 m apart (51 to 102 traps/transect depending on the site) and left open for 3 or 4 days. We used Museum Special snap-traps baited with peanut butter and rolled oats. We also continued our sampling program based on live-trapping of lemmings initiated in 2004. We trapped on 2 permanent grids (330×330 m since 2006) at the Base-camp Valley (one in wet meadow habitat and one in mesic habitat) with 144 traps per grid. Since 2007, we also trap on a 3rd grid (270 × 270 m; 100 traps) in mesic habitat where a snow-manipulation experiment was set up with snow fences. We used Longworth© traps baited with apples and set at each grid intersection every 30-m. We trapped for 3 consecutive days during 3 periods (mid June, mid July and mid August) on each grid. All trapped animals are identified, sexed, weighed and marked with electronic PIT tags (or checked for the presence of such tags).

Monitoring of other bird species. — We monitored the nesting activity of Snowy Owls (*Bubo scandiacus*), Jaegers (*Stercorarius* spp.), Glaucous Gulls (*Larus hyperboreus*), and Lapland Longspurs (*Calcarius lapponicus*). Nests were found through systematic searches of suitable habitats or opportunistically and revisited to determine their fate (successful or not) until fledging. We also collected food pellets at gull and owl nests to determine their diet based on prey remains.

Monitoring of plant growth and goose grazing. — The annual plant production and the impact of goose grazing was evaluated in wet meadows dominated by graminoid plants at 3 sites (Fig. 1): the Base-camp Valley and Dufour Point (brood-rearing areas), and the Camp-2 area (nesting colony. At each site, 12 exclosures (1 × 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 between 10 and 15 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 × 10 m transects located near each exclosure every 2 weeks in the Base-camp Valley and once at the end of the season at Dufour Point and the Camp-2 area.

Field activities on Ellesmere Island and surrounding area. — Field work was conducted on Ellesmere Island and surrounding area from 7 July to 8 August. The field party included 3 employees from the Canadian Wildlife Service (Josée Lefebvre, Céline Maurice and Francis St-Pierre). In July, we conducted a Snow Goose brood survey on the Fosheim peninsula on Ellesmere Island, and along the coast of Axel Heiberg Island. Near Eastwind Lake on the Fosheim peninsula, goose exclosures were installed to evaluate the aboveground primary production and to assess the grazing impact. At this site, small mammal snap-trapping was also conducted in both mesic and wet meadow habitats. Goose banding took place using the same technique than on Bylot Island. Finally, and plant biomass was sampled inside and outside exclosures, again using the same technique than on Bylot Island.

PRELIMINARY RESULTS

Weather conditions. — Temperature in spring were warmer than normal. Air temperature averaged -1.07°C between 20 May and 20 June (1.21°C above normal), which corresponds to the period of goose arrival and egg-laying, and 1.67°C (0.35°C above normal) during 1-15 June, the normal pre-laying and laying period. Furthermore, the snow pack was very thin at the end of winter as snow depth on 1 June was only 10 cm, among the lowest values recorded (Fig. 2). The combination of warm temperature and thin snow pack resulted in one of the earliest snow-melt on record on Bylot Island. From early May to mid July, weather was exceptionally good with lots of sunshine and warm temperature (only 20 mm of rain fell during this period). In contrast, the second part of the summer was cool, cloudy and wet. From 15 to 31 July, 86 mm of rain fell and 41 mm from 1-20 August, the highest precipitation on record since 1995.

Goose arrival and nesting activity. — The number of geese counted on the hills surrounding the Base-camp Valley (usually the first area used by geese upon arrival) increased from 24 pairs on 31 May to a peak of 77 pairs on 3 June, which is very low compared to other years (Fig. 3). However, by the time geese started to appear on Bylot Island, most of the lowland areas were already free of snow (an unusual situation) and geese proceeded immediately to the nesting areas. Therefore, these low counts reflect the large amount of habitat available to geese upon arrival and their rapid dispersal to these areas rather than a delayed arrival of birds, as observed in some years.

Median egg-laying date was 10 June, which is earlier than the long-term average and considerably earlier than in 2007 (Table 1). Geese nested early because all nesting habitats were already snow-free when they arrived. Nest density in the colony was higher than last year (4.3 nests/ha vs 3.0 nest/ha in 2007) and above the long-term average. A visual aerial survey of the Camp-2 area during incubation also indicated that the spread of the colony was larger than in previous years. Twenty-three nests were found at the Base-camp Valley (predominantly a brood-rearing area) compared to none in 2007. Overall, average clutch size was 4.10, the highest value reported in over 10 years (Table 1).

Nesting success of geese. — Nesting success (proportion of nests hatching at least one egg) was high this year (74%, a value well above the long-term average, Table 1). Activity of predators at goose nests, especially Arctic Foxes, was similar to 2007. During nesting and brood-rearing, 448 neck-collared birds were sighted, a number higher than last year (345). Peak hatch was on 6 July, which is earlier than the long-term average (Table 1). We tagged 2446 goslings in nests at hatch, 55 in the Base-camp Valley and 2391 in the Camp-2 area. Overall, nesting conditions of geese in 2008 were therefore excellent.

Density of broods. — In 2008, the density of goose faeces at the end of the summer in wet meadows of the Base-camp Valley was surprisingly low (4.5 ± 1.1 [SE] faeces/m^2, Fig. 4) compared to other years (Fig. 4). Accumulation of faeces started early in July, probably a consequence of the early nesting of geese this year, but increased relatively slowly afterward, especially in late summer. This low level of use of wet meadows by broods near our Base-Camp may be partly due to the extensive flooding of polygons that prevailed in late July and throughout August due to record precipitation. Faeces density at the end of the summer was higher at Dufour Point, another brood-rearing area (6.6 ± 1.6 faeces/m^2; no data in 2007) as well as in the wet meadows of the nesting colony at Camp-2 (6.1 ± 1.4 faeces/m^2 vs. 4.1 ± 0.9 in 2007).

Goose banding. — The banding operation was difficult this year due to a moderate density of broods around the lowlands of the Base-camp Valley and especially the bad weather that prevailed in August. We conducted 9 drives, most of them outside the Base-camp Valley (<8 km). We banded a total of 3395 geese, including 447 adult females marked with neck-collars and 45 young which had been marked with web-tags at hatch and were recaptured. We also marked 15 adult females with GPS/ARGOS radio-transmitters. In addition, we had 316 recaptures of adults banded in previous years. The gosling:adult ratio among geese captured at banding (1.11:1) and mean brood size toward the end of brood-rearing (3.07 young, SD = 1.27, n = 138; counts conducted from 30 July to 6 August) were similar to last year and higher than the long-term averages (Table 1). By combining information on brood size and young:adult ratio at banding, we estimated that 72% of the adults captured were accompanied by young, a value lower than the long-term average, which suggests a that mortality rate of young during the summer may have been higher than normal. Overall, these results are indicative of a good production of young on Bylot Island by the end of the summer.

Tracking of radio-marked geese. — In 2008 on Bylot Island, we detected the signal of 7 of the 12 adult females marked with VHF radio-transmitters in Québec earlier in spring, and we found a nest for 3 of them. In contrast to 2006, the tracking of birds marked with satellite transmitters in August 2007 and 2008 has been going well so far. Six satellite transmitters that were installed on Bylot Island in 2006 and 2007 are still transmitting data consistently. Eighteen other transmitters have been recovered from hunters (n=12) and in the field (n=6; all from 2006, during which we had difficulties with transmitter harnesses) for refurbishment and re-use in spring 2009. An additional 3 individuals with transmitters have been reported as harvested to the banding office, but we have not yet been able to recover those transmitters from the hunters. In the summer of 2008, 15 new birds were marked on Bylot Island, and a total of 22 female geese were tracked in fall 2008 (for a total of 43 birds successfully tracked during the entire fall migration to southern Québec, 8 of which were also followed for a second fall migration). Data downloaded on 15 December 2008 indicated that of 15 birds for whom we had data from the prior week, 4 were still in the southern Québec and Ontario en route southward, 1 was in Arkansas, 2 in New York, 2 in New Jersey and 6 in Delaware. The migration away from Bylot Island started during the first week of September for most birds, but arrival on wintering grounds in the United States has been highly variable.

Snow goose population survey. — Analyses of the data indicated a population of 42,589 ± 5,358 (SE) adult geese and 51,363 ± 7,095 goslings during the survey. Based on a mean brood size of 3.29 goslings/family (n = 240 broods), the adult component was estimated to include 29,822 successful breeders (adults with young) and 12,768 non- and failed-breeders (adults without young). The overall number of geese did not change significantly from that of the previous survey in 2003.

Breeding activity of foxes at dens and marking. — We found 4 new fox dens on the island in 2008, bringing the total to 103 known denning sites still intact. Among these dens, we found signs of activity (fresh digging and/or footprints) at 58 of them, a high number. The breeding activity of foxes was very high as we found 23 different litters (23% of known denning sites) of Arctic Foxes and one of Red Foxes, a record number. The level of den use was much higher than last year (11% of dens used in 2007) and typical of the proportion of fox dens used in previous years of high lemming abundance (~17%). Minimum litter sizes varied between 1 and 13 pups (5.5 pups on average) for Arctic Foxes while Red Foxes had a minimum litter size of 2 pups. A total of 17 adult and 50 juvenile Arctic Foxes were captured during trapping sessions and marked with ear-tags. Among those, 16 adults were fitted with satellite collars to study their home ranges and movements at large spatio-temporal scale over a 1-year period. We also recaptured 7 foxes that had been marked in previous years.

Small mammals. — During our survey using snap traps, we cumulated 1619 trap-nights at our 2 trapping sites of the Base-camp Valley from 26 July to 3 August, and 612 trap-nights at the Camp-2 from 12 to 14 July. In the Base-camp sites, we caught no Collared Lemmings (*Dicrostonyx groenlandicus*) and 5 Brown Lemming (*Lemmus sibiricus*), which yielded a combined index of abundance of 0.32 lemmings/100 trap-nights, a low value (Fig. 5). The estimated abundance was higher in the Camp-2 area, as 1 Collared Lemming and 4 Brown Lemmings were caught, for an index of 0.84 lemmings/100 trap-nights. The apparent low estimate of lemming abundance yielded by our snap-trap survey contrasted sharply with the results of our more thorough live-trapping survey in the Base-camp area. Overall, we captured 244 different lemmings (223 Brown and 21 Collard), including 85 that were captured more than once, for an index of 6.99 lemmings/100 trap-nights (excluding recaptures), a very high number compared to previous years (0.93 and 1.02 lemmings/100 trap-nights in 2007 and 2006, respectively). We believe that our abundance index based on snap-traps was biased low, especially at the Base-camp Valley, because it was conducted during a period of heavy rain and extensive flooding in some areas, which likely limited movements of lemmings. We therefore conclude that data from the live-capture survey are more reliable and that we had a peak of lemming abundance in 2008.

Monitoring of other bird species. — For the second year in a row, Snowy Owls were nesting on Bylot Island. Even though we surveyed a smaller part of the island in 2008, we found more nests (20) than in 2007 (17) and their distribution differed. There was 9 nests in the Base-camp Valley (compared to 1 in 2007), 1 in the Camp-2 (same number in 2007), and 10 scattered between our 2 camps areas (15 in 2007). We also found 30 nests of Glaucous Gulls, 78 nests of Long-tailed Jaegers, 2 nests of Parasitic Jaegers and 107 nests of Lapland Longspurs. For all these species, the number of nests found in 2008 increased compared to 2007. Nesting success (proportion of nests successful in fledging at least one young) was low for longspurs (29% vs. 62% in 2007), high for owls (100% vs. 60% in 2007) and jaegers (70% vs. 9% in 2007) and moderate for gulls (60% vs. 40% in 2007). Average clutch size was 7.2 eggs for owls (vs. 6.4 in 2007), 2.8 eggs for gulls (vs. 2.3 in 2007), 5.7 eggs for longspurs (vs. 5.7 in 2007), and 2.0 eggs for jaegers (vs. 1.9 in 2007).

Plant growth and grazing impact. — Plant production in wet meadows of the brood-rearing area was higher than last year and the long-term average (Fig. 6). Above-ground biomass of graminoid plants in the Base-camp Valley reached 52.3 ± 8.7 [SE] g/m^2 in ungrazed areas in mid-August compared to 45.1 ± 4.9 in 2006 (long-term average since 1990: 45.6g/m^2). At the Camp-2 area (colony), graminoid biomass in 2008 was also higher than last year (45.4 ± 7.7 vs. 41.3 ± 6.6 g/m^2 in 2007; Fig.7) and above the long-term average (32.9 g/m^2 since 1998), but still lower than in the Base-camp Valley. At Dufour Point, the other brood-rearing area, graminoid production reached 51.4 ± 14.5 g/m^2 (Fig. 8; no data in 2007), which is higher than at the Base-camp Valley but similar to the long-term average since 1998 (50.4 g/m^2).

Grazing pressure was low in the wet meadows of the Base-camp Valley as geese removed only 14% of the above-ground biomass (difference between paired grazed and ungrazed plots) by mid-August compared to 22% in 2007 (long-term average: 33%; Fig. 6). This relatively light grazing pressure is consistent with the low density of goose faeces measured at this site in 2008. At the Camp-2 area (colony), the grazing pressure was higher than with 21% of the graminoid biomass removed by geese compared to 32% in 2007 (long-term average at this site: 29%; Fig. 7). At Dufour Point (other brood-rearing area), grazing pressure was high with 38% of the graminoid production removed (long-term average: 27%; Fig. 8).

Goose nesting and banding on Ellesmere Island and surrounding area. — By the time we arrived on Ellesmere Island, most goose nests were hatching or were already hatched and broods were present. Therefore, nest monitoring was not possible although field observations suggest that goose nesting was earlier than in 2007. A total of 72 broods were seen during the survey with an average of 4.14 young/brood. This value is higher than the brood size observed on Bylot Island in 2008 (3.07) but slightly less than the one observed last year (4.28 young/brood; n=36) on Ellesmere. However, family groups were smaller and more scattered than those observed on Bylot Island, which forced us to conduct 11 banding drives, all on Ellesmere and Axel Heiberg Islands. We banded a total of 567 geese, including 66 adult females marked with neck-collars. In addition, we recaptured 4 adult males, two of which were originally banded on Bylot Island and the two others in southern Quebec. The annual plant production and the impact of goose grazing were evaluated in both mesic and wet meadows habitat. In both habitats, 8 exclosures (1 × 1 m) were installed in early July, and plant biomass was sampled in ungrazed and grazed areas (i.e. inside and outside exclosures) at the end of the plant-growing season in late July and early August. Plants were sorted into family groups.

CONCLUSIONS

The production of young geese on Bylot Island was high in 2008 and several factors contributed to this. The phenology of migration and reproduction was advanced (i.e. geese arrived on the island and initiated nesting early). This was likely a consequence of good climatic conditions encountered during the second half of the migration and upon arrival on Bylot Island as there was indications that the early spring was generalized throughout most of Baffin Island in 2008. Therefore, geese were able to move immediately to the nesting areas, which were already snow-free, and to quickly lay their eggs. The early spring can also explain the high reproductive effort of geese recorded (i.e. high density of nests and large clutch size). Geese further benefited from a moderate nest predation rate and thus had a good nesting success, which contributed to the good production. The high abundance of lemmings (based on our live-trapping survey) most likely explains this good nesting success because it is the preferred prey of predators such as foxes, gulls and jaegers. Under such conditions, predators prey less on birds' eggs as they concentrate their foraging on lemmings.

Considering the good conditions encountered until hatch, we were surprised by the young:adult ratio at banding, which was lower than anticipated. Indeed, the value was identical to 2007, even though goose nesting conditions were better in 2008 than in 2007. A first clue to explain this apparent paradox is the relatively low proportion of families with young at banding in 2008, which may be an indication of high gosling mortality during the summer. This could be a consequence of the cool and very wet conditions that prevailed during much of the brood-rearing period this year. Such conditions can affect goslings directly (by increasing exposure) as well as indirectly by reducing feeding time and food availability, as extensive flooding in wetlands prevents goslings from feeding on their preferred food. Based on the youg:adult ratio recorded at banding, we anticipated a proportion of young in the fall flock of 26%, which is considered a good production (i.e. above the long-term average of 23%). However, the proportion of young measured during juvenile counts conducted in southern Québec in fall was considerably higher than this value (40%, n = 32,017) and was indicative of an exceptionally good production at the population level. Why such a large difference between the value predicted from the Bylot Island data and the observed value? This exceptionally good production is consistent with the breeding conditions encountered on Bylot Island until hatch. Therefore, this suggests that these favourable conditions early in the season may have prevailed throughout much of the breeding range of the Greater Snow Goose but that the cool and wet conditions encountered in late summer on Bylot Island were perhaps more localised and did not affect other colonies. Indeed, good weather generally prevailed on Ellesmere Island during most of the brood-rearing period in 2008.

Plant production in the wet meadows of Bylot Island was fairly good in 2008, presumably because of the early onset of the growing season and the sunny and warm conditions that prevailed in the first half of the summer when plant growth is most rapid. Despite the good production of young this year, we recorded a relatively low use of the wet meadows by broods, and a low grazing pressure. A possible explanation of that is the heavy rain and extensive flooding that prevailed during a good part of the brood-rearing period on Bylot Island may have forced goslings to move away from the preferred wet meadows in the lowlands toward mesic habitats in the upland, which are less susceptible to flooding.

PLANS FOR 2009

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 (annual plant production and grazing impact) in response to the spring conservation harvest and other special management actions implemented since 1999 in Québec. In 2007, field work was initiated at a second arctic field site, Ellesmere Island, in order to increase the spatial coverage of the monitoring and to determine whether Bylot Island was representative of the entire breeding range of the population. This field work will be continued in 2009. Other aspects of the project include *i*) understanding better the links between events occurring during the spring migration and the subsequent breeding success of geese; *ii*) determining the long-term effects of geese on the arctic landscape; *iii*) expanding our estimate of the carrying capacity of Bylot Island for geese to upland habitats; *iv*) study indirect interactions between snow geese and lemmings via shared predators; *v*) study the ecology of the main predator of geese, Arctic Foxes; *vi*) examine the impact of avian predators on goose reproductive success. In 2009, 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) 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.
3) 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.
4) Monitor the level of intestinal parasite infestations in goslings and study their impact on survival.
5) Monitor the abundance of lemmings and study their demography.
6) Monitor the breeding activity of other bird species, in particular avian predators (Snowy Owls, jaegers and Glaucous Gulls).
7) Monitor the breeding activity of foxes at dens and capture and mark adults and pups with ear-tags to study their movements and demography.
8) Sample plants in exclosures to assess annual production and the impact of goose and lemming grazing on plant abundance in wet meadows.

9) Maintain our automated environmental and weather monitoring system.

10) Monitor the goose breeding activity, their grazing impact, and band geese at another arctic colony on Ellesmere Island and surrounding areas.

In 2009, at least 7 graduate students will be involved in the Bylot Island snow goose project. **Peter Fast** (PhD) will finish his study of the causes and reproductive consequences of changes in migratory behaviour of snow geese. **Madeleine Doiron** (PhD) will finish her investigation of the impact of climate change on the plant nutritive quality and gosling growth. **Meggie Desnoyers** (MSc) will study the spatial structure of snow goose flocks and the stability of associations among non-related individuals. **Cassandra Cameron** (MSc) will continue her genetic study of the social structure of Arctic Foxes. **Sandra Lai** (PhD) will study the annual and seasonal movements of Arctic Foxes around the goose colony using satellite telemetry. **Jean-François Therrien** (PhD) will continue to study the migration and the nesting ecology of Snowy Owls and jaegers. Finally, **Frédéric Bilodeau** (PhD) will study the impact of winter climate and predation by weasel and foxes on the population dynamics of lemmings.

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

	1999	2000	2001	2002	2003	2004	2005	2006	2007	**2008**	Average[2]
Number of nest monitored	266	386	296	470	585	676	346	393	494	**466**	--
Nest density (nb/ha)	1.22	3.23	2.70	5.17	8.87	1.10	3.90	2.57	3.00	**4.34**	3.47
Median date of egg-laying	17 June	16 June	13 June	16 June	9 June	11 June	12 June	14 June	16 June	**10 June**	12 June
Clutch size	3.09	3.51	3.43	3.43	3.90	3.65	3.60	3.68	3.91	**4.10**	3.73
Nesting success[1]	12%	83%	57%	53%	82%	78%	66%	42%	82%	**74%**	65%
Median date of hatching	13 July	13 July	9 July	11 July	6 July	7 July	8 July	10 July	11 July	**6 July**	9 July
Number of geese banded	1717	4269	3430	2650	5259	3617	5304	4603	4260	**3395**	--
Ratio young:adult at banding	0.54:1	1.08:1	1.03:1	0.81:1	1.31:1	0.94:1	1.03:1	0.74:1	1.11:1	**1.11:1**	1.03:1
Brood size at banding	1.67	2.78	2.37	1.67	2.74	2.50	2.42	2.20	2.90	**3.07**	2.52
Proportion of adults with young at banding	65%	78%	87%	97%	96%	75%	86%	67%	77%	**72%**	81%

[1] Mayfield estimate
[2] Period 1989-2008

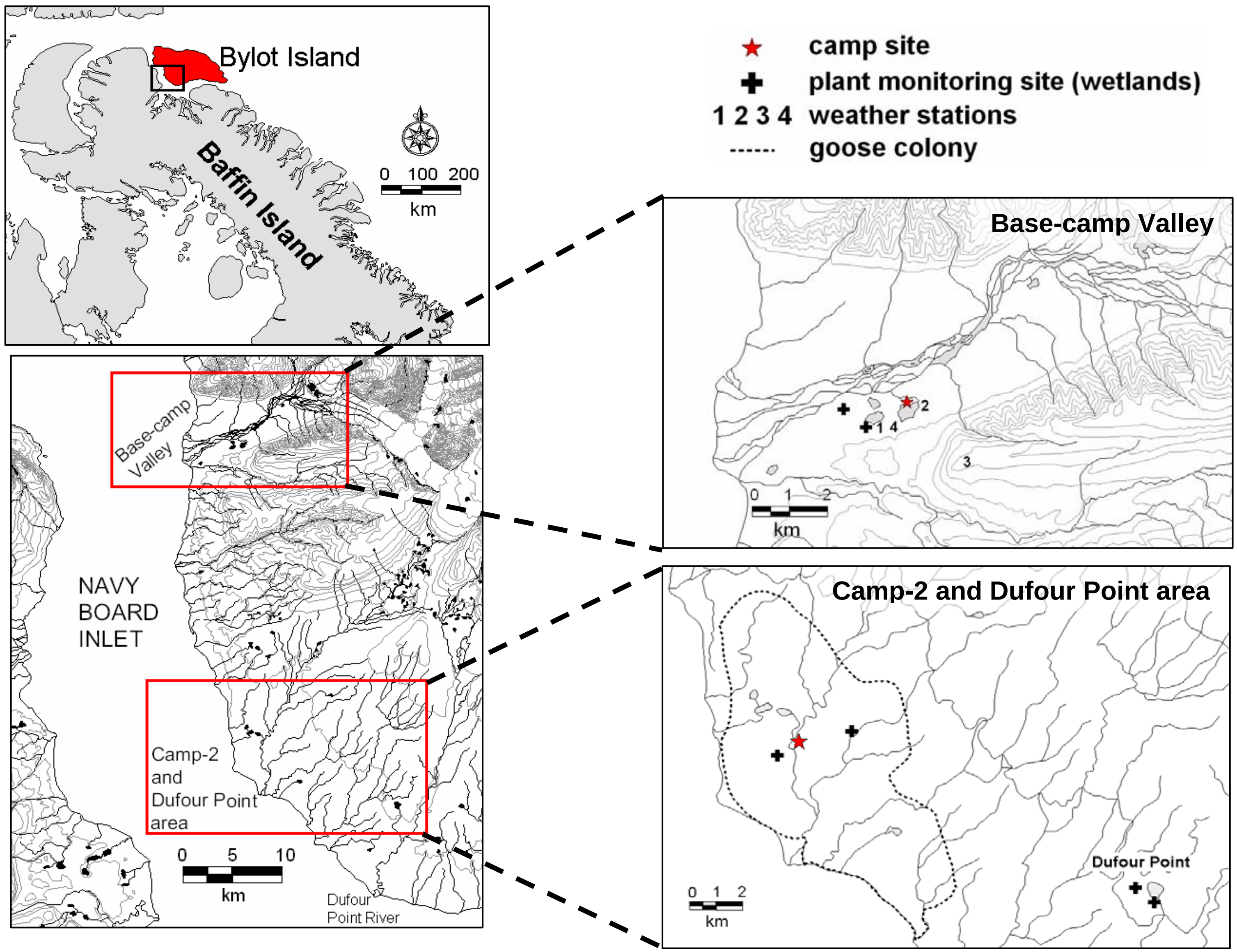

Figure 1.General location of the study area, Bylot Island, Nunavut, and of the two main study sites (Base-camp Valley and the Camp-2 area) on the South plain of the island. Enlarged maps on the right present these study sites in more details, including camp locations, sampling sites and our four weather stations.

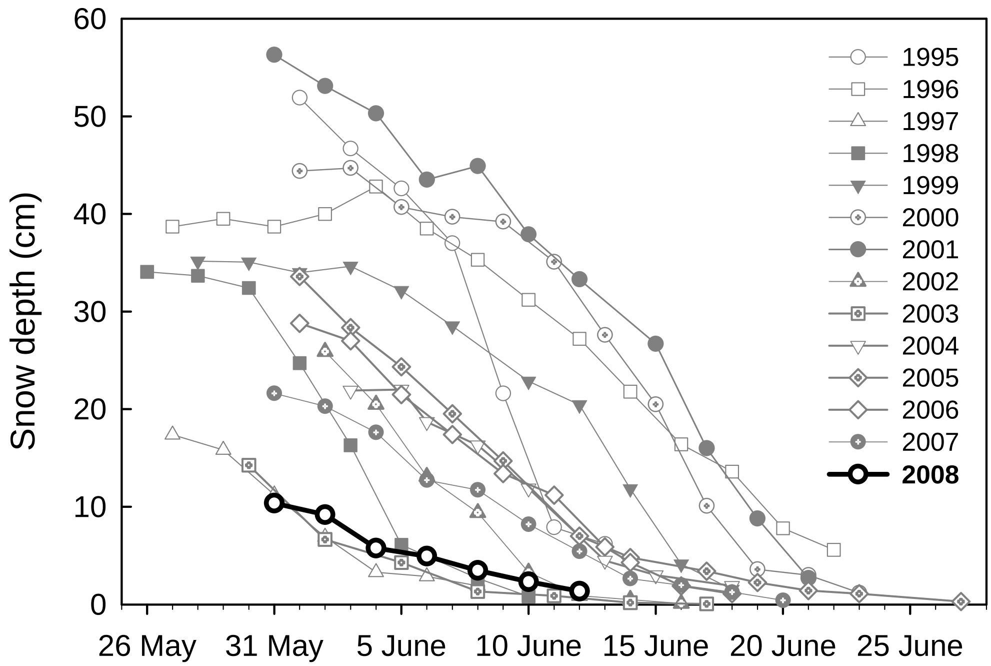

Figure 2. Average depth of snow along 2 transects showing the rate of snowmelt in Bylot Island lowlands (*n* = 50 stations).

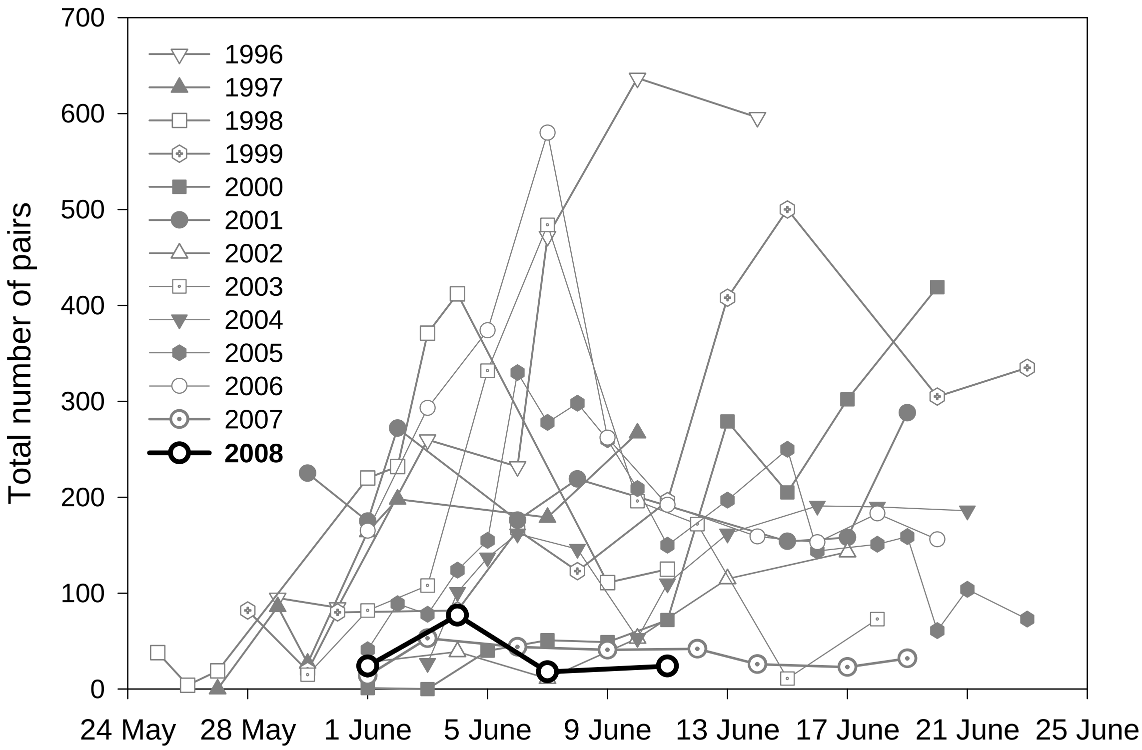

Figure 3. Total number of goose pairs counted in the Base-camp Valley from arrival of our crew on Bylot Island until the end of snowmelt.

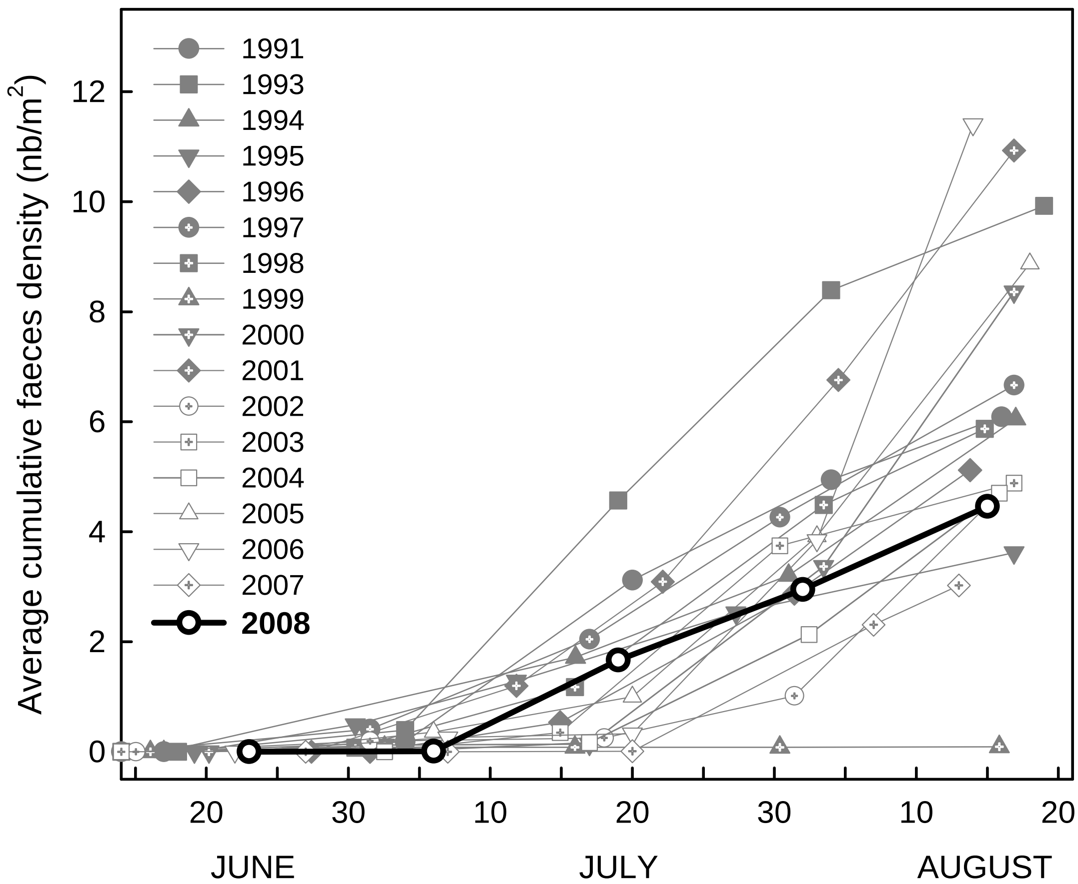

Figure 4. Average cumulative faeces density showing the use of the Base-camp Valley by Greater Snow Goose families on Bylot Island throughout the summer (n = 12 transects of 1 x 10 m).

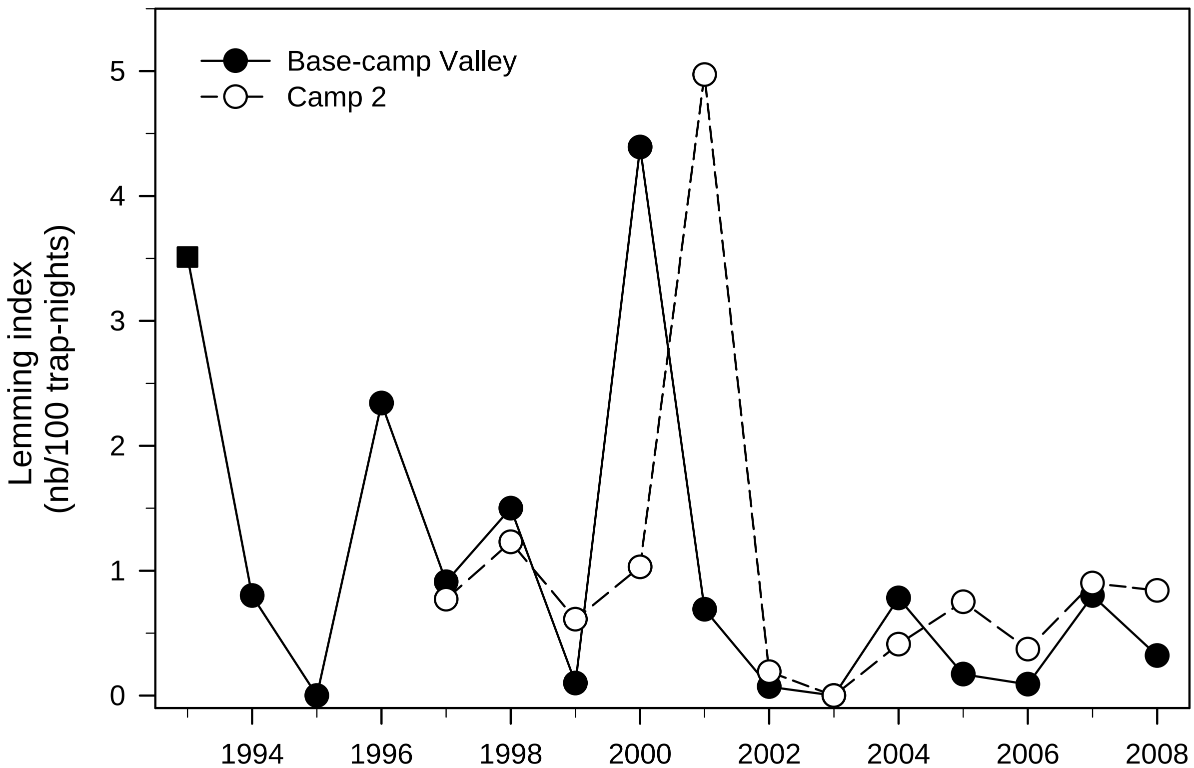

Figure 5. Annual abundance of lemmings at two study areas (Base-camp Valley and Camp-2) located 30 km apart on Bylot Island.

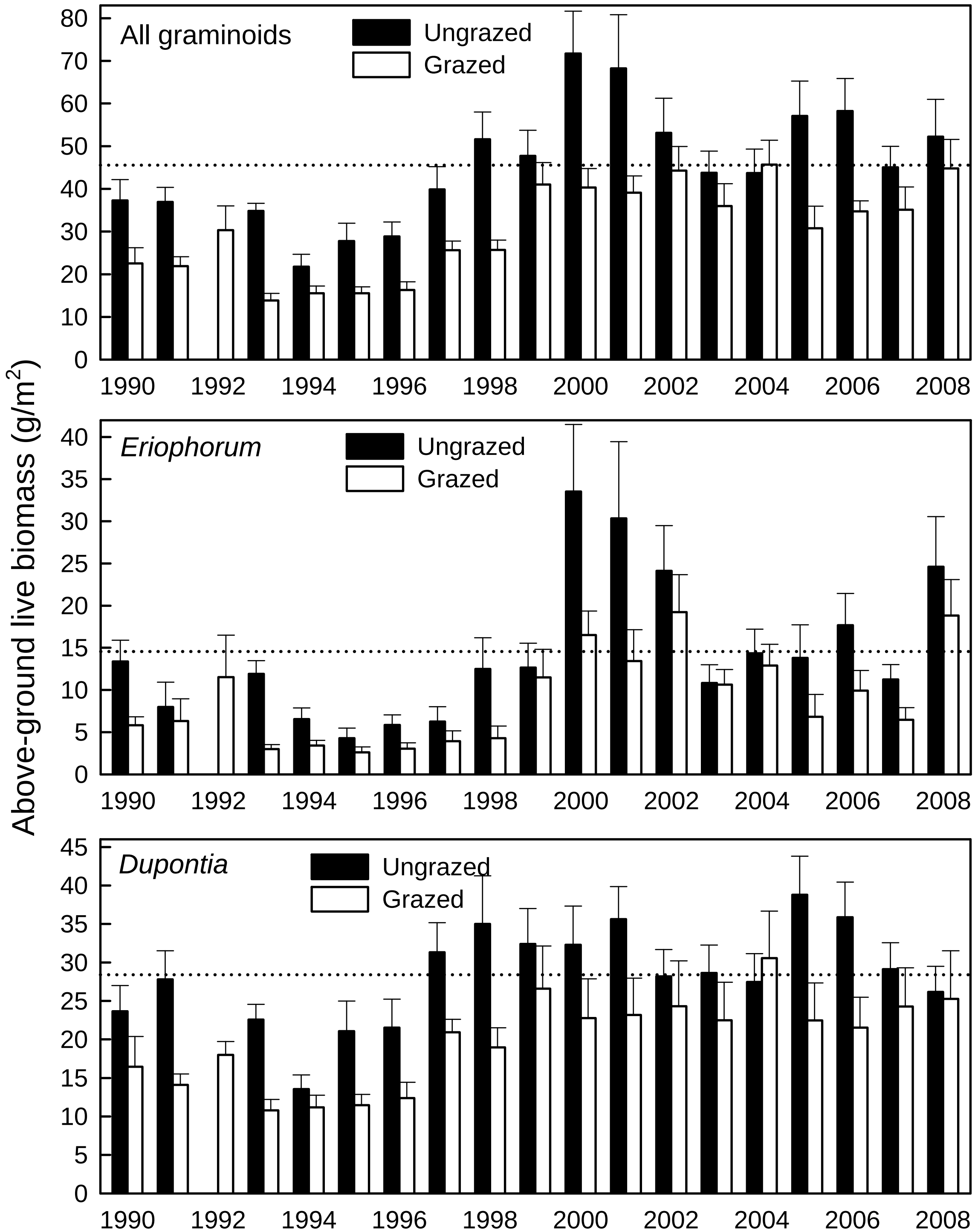

Figure 6. Live above-ground biomass (mean + SE, dry mass) of graminoids on 12 and 15 August in grazed and ungrazed wet meadows of the Base-camp Valley, Bylot Island (n = 12). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There

is no data from ungrazed area in 1992. The dashed line is the long-term average for ungrazed area.

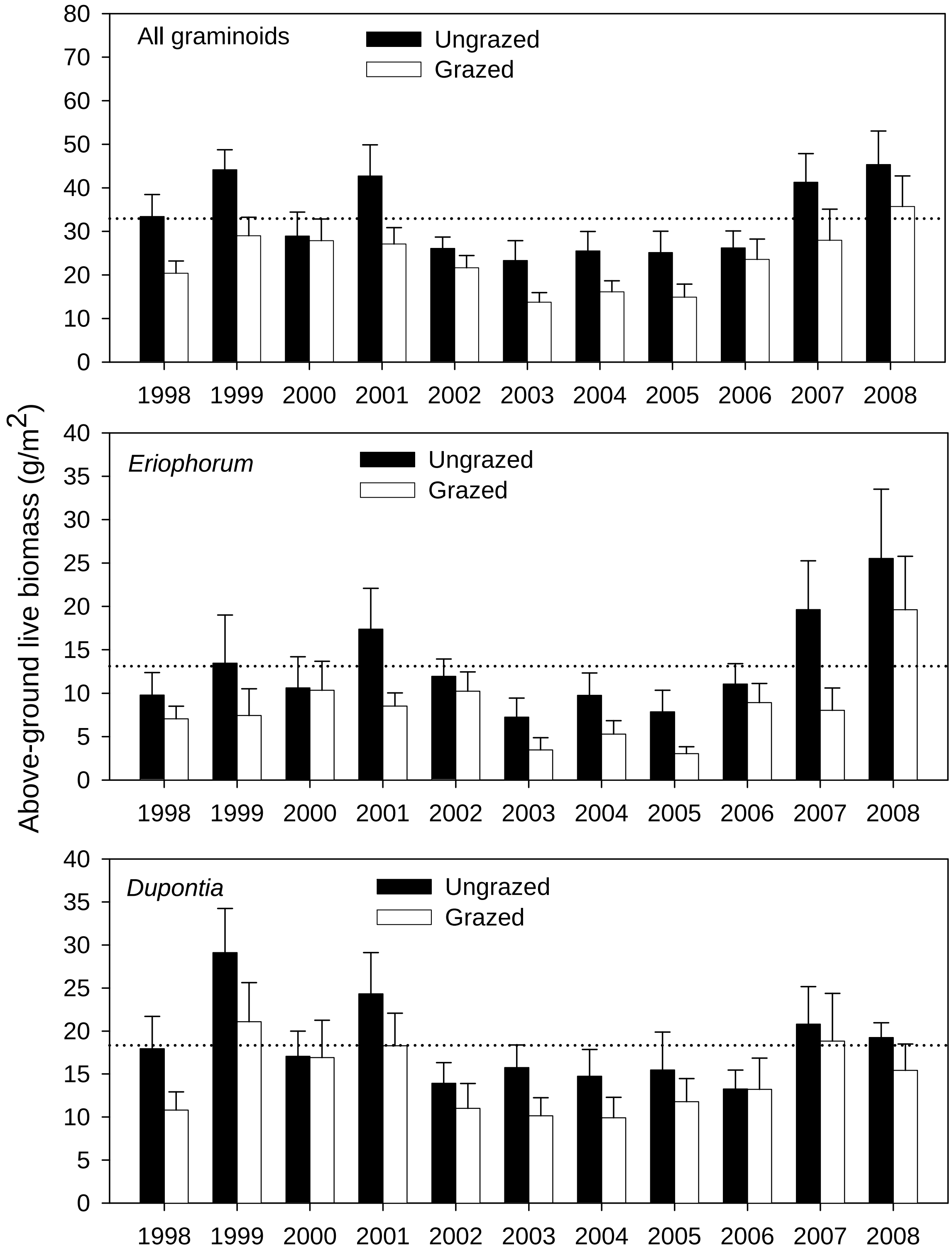

Figure 7. Live above-ground biomass (mean + SE, dry mass) of graminoids on 10 August in grazed and ungrazed wet meadows of the Camp-2 (goose colony), Bylot Island (n = 12, except in 2008 where n = 8). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. The dashed line is the long-term average for ungrazed area.

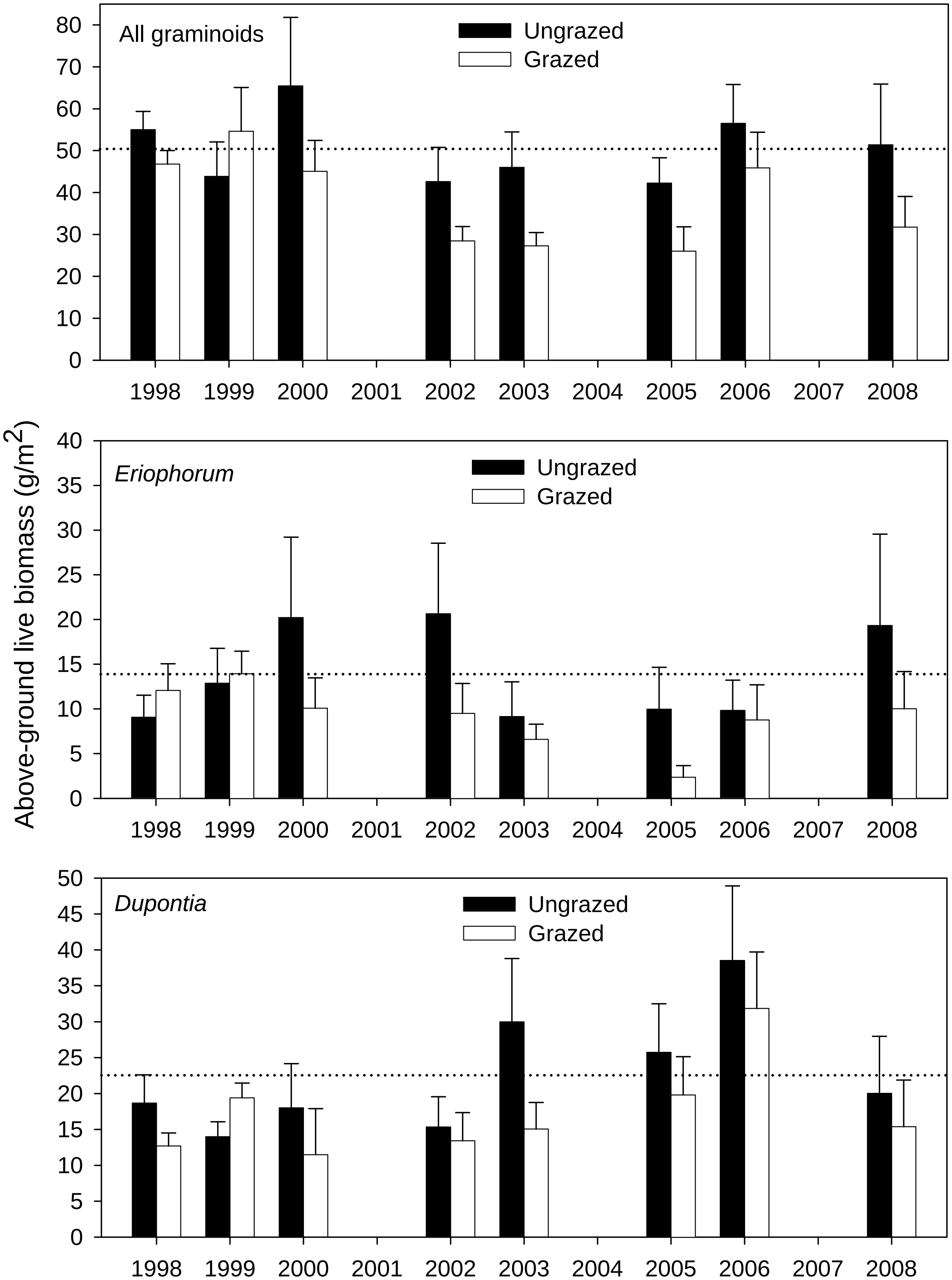

Figure 8. Live above-ground biomass (mean + SE, dry mass) of graminoids on 13 August in grazed and ungrazed wet meadows of Pointe Dufour, Bylot Island (n = 12, except in 2008 where n = 9). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data in 2001 and 2004. The dashed line is the long-term average for ungrazed area.

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