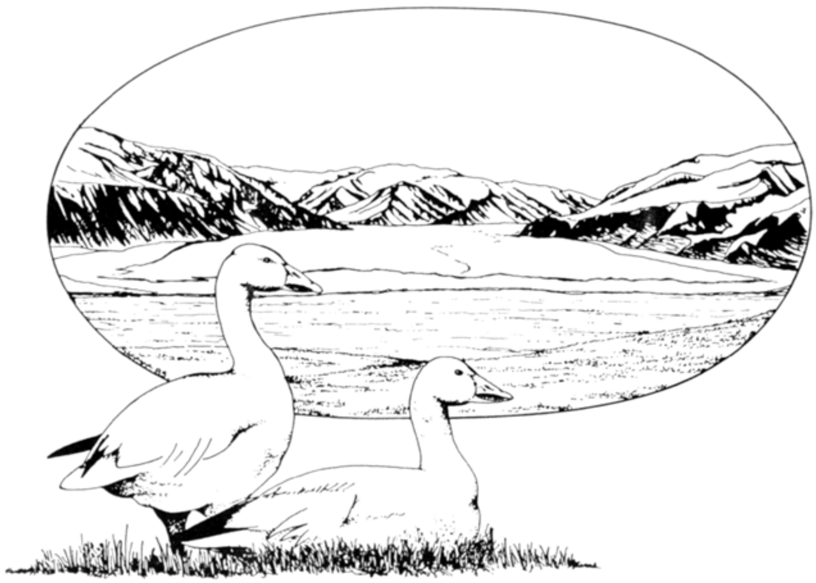
POPULATION STUDY OF GREATER SNOW GEESE AND ITS NESTING HABITAT ON BYLOT ISLAND, NUNAVUT IN 2015: A PROGRESS REPORT



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INTRODUCTION

In 2015, 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 actions during autumn, winter and spring have been undertaken since 1999 in Canada and 2009 in the United States to curb the growth of this population. A synthesis report produced in 2007 evaluated the initial success of these special conservation measures. However, both the Avian Monitoring Review Steering Committee Final Report and the Greater Snow Goose Action Plan released in 2012 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 on those parameters, (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 2015 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) Monitor the abundance of lemmings and study their demography along with factors affecting their cyclic fluctuations of abundance.
5) Monitor the breeding activity of other bird species and in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).
6) Monitor the breeding activity of foxes at dens.
7) Capture and mark adult Arctic Foxes and their pups with ear-tags to study their movements and demography.
8) Sample plants in exclosures to assess annual production and the impact of goose grazing on plant abundance in wet meadows.
9) Maintain our automated environmental and weather monitoring system.

FIELD ACTIVITIES

Field camps. — In 2015, we operated two camps on Bylot Island: the main field station, located 6 km from the coast in the largest glacial valley on the island ("Qarlikturvik Valley", 73° 08' N, 80° 00' W), was occupied from 11 May to 20 August. A secondary camp, located in a narrow valley 30 km south of the main field station and 5 km from the coast ("Camp 2 area", 72° 53' N, 79° 54' W) was occupied from 21 May to 20 July (Fig. 1). Finally, 16 fly camps were also established for 5-11 days at various times throughout the island, west of Dufour Point.

Field parties. — The total number of people in both camps ranged from 2 to 16 depending on the period. Members of our field party included project leaders Gilles Gauthier, Joël Bêty, Josée Lefebvre, Nicolas Lecomte and several graduate students whose thesis projects addressed many of the objectives mentioned above: Cynthia Resendiz (PhD, objectives 1, 2 and 3), Claire-Cécile Juhasz (PhD, objective 1) Dominique Fauteux (PhD, objective 4), Andréanne Beardsell (MSc, objective 5), Yannick Seyer (MSc, objective 5), Guillaume Slevan-Tremblay (MSc, objective 4), Florence Lapierre-Poulin (MSc, objectives 6 and 7). Several other students assisted them in the field, including: Frédéric LeTourneux, Aurélie Chagnon-Lafortune, Marie-Ève Mercier, Mikaël Jaffré, Magaly Oakes, David Gaspard, Katherine Gavrilchuk and Anne-Mathilde Thierry. Other people in the field included Marie-Christine Cadieux, a research professional in charge of goose banding and plant sampling (objectives 3 and 8); Denis Sarrazin, research professional responsible of the maintenance of the weather stations (objective 9); Christian Marcotte, a wildlife technician, from the Canadian Wildlife Service (CWS, Quebec region) and Jean-François Therrien, a biologist from the Hawk Mountain Sanctuary (Pennsylvania, USA). Finally, we hired 1 person from Pond Inlet (Adrian Ootova) to work with us for 10 days during goose banding in August.

Several other people also used our camps during the summer. They were Jean-François Lamarre (PhD student), Don-Jean Léandri-Breton (MSc student), Myriam Trottier-Paquet and Philip Bertrand who studied shorebirds, lapland longspurs and insects under the supervision of Joël Bêty; the field party of Daniel Fortier (Université de Montréal) and Esther Lévesque (Université du Québec à Trois-Rivières), which included Étienne Godin (PhD student), Audrey Veillette (MSc student), Maxime Tremblay (MSc student), Ariane Bisson, Valérie Massé and Laurent Lamarque who studied the permafrost, geomorphology and plant ecology; the field party of Isabelle Laurion (Institut National de la Recherche Scientifique), which included Frédéric Bouchard (post-doc fellow), Vilmantas Preskienis (PhD student) and Michael Billet (University of Stirling, United Kingdom), who studied the carbon cycle in ponds; and Florent Dominé (Takuvik, Université Laval/CNRS), Mathieu Barrère (PhD student) and Maria Belke (PhD student) who studied the snow physical and chemical properties. Adam Ferguson from Parks Canada joined our field crew for a week and Carey Elverum from Parks Canada inspected both camps during the summer. Joe Enook (local Nunavut member of the Legislative Assembly) and Roger Leblanc and his team from Bellefeuille Productions also visited our main field station.

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 312 m ASL, respectively) where air and ground temperature, air humidity, precipitations, snow depth, solar radiation, wind speed and wind direction are recorded on an hourly basis throughout the year (Fig. 1). 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 also 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 Qarlikturvik Valley, both at 2-day intervals.

Monitoring of goose arrival and nesting. — We monitored goose arrival in the Qarlikturvik Valley by counting goose pairs every two to three days from our arrival on the island on 31 May until the end of snowmelt on sample plots. Nest searches were carried out within walking distance (~6 km) of both the main field station and the Camp 2 between 8 and 18 June. Nests were found by systematic searches conducted over various areas in the field. At Camp 2, where the bulk of the goose colony is located, nest searches were 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 and 2-ha plots randomly located throughout the colony. Nest density was calculated over a fixed 20-ha area within the intensively-studied core area. We also attempted to find the nests of as many neck-collared females as possible through intensive searches on foot throughout the nesting colony. 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 daily to record hatch dates and to web-tag goslings.

Goose banding. — From 7 to 13 August, we banded geese with the assistance of 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.

Small mammals. — We sampled the annual abundance of lemmings at two sites in the Qarlikturvik Valley (one in wet meadow and one in mesic habitat) and one site at the Camp 2 (mixed habitat) in July using snap-traps. At each site, we used 240 Museum Special traps set at 80 stations spaced 15-m apart along two to four parallel transect lines 100 m apart and left open for 3 days. We also sample lemming abundance and demography using live-traps. We trapped on 2 permanent grids (330 × 330 m) in the Qarlikturvik Valley (one in wet meadow habitat and one in mesic habitat) with 144 traps per grid and on a 3rd grid (200 × 340 m; 96 traps) in mesic habitat where a predator exclosure experiment was set up in 2012 (the grid is surrounded by a chicken wire fence and covered by criss-crossing fishing line on top). In 2015, we added three live-trapping sites (270 × 270 m; 100 traps; mixed habitat): one between the main field station and Camp 2, one at Camp 2 and one at Dufour Point. We used Longworth traps 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 of the Qarlikturvik Valley and one period in mid-July elsewhere. All trapped animals are identified, sexed, weighed and marked with electronic PIT tags or ear-tags (or checked for the presence of such tags). Finally, we sampled the abundance of lemming winter nests along 60 500-m transects randomly distributed in 3 different habitats of the Qarlikturvik Valley: wetlands, mesic tundra and streams in mesic tundra.

Breeding activity of foxes at dens and marking. **—** All known fox dens located within a 600 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. Automated cameras were deployed at dens showing signs of activity. We attempted to live-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 live-trapped pups with Tomahawk collapsible 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 ARGOS satellites collars. Samples of winter and summer fur, blood, and scats were also collected for genetic and diet analyses.

Monitoring of other bird species. **—** We monitored the nesting activity of Snowy Owls (*Bubo scandiacus*), Long-tailed and Parasitic Jaegers (*Stercorarius longicaudus* and *S. parasiticus*), Glaucous Gulls (*Larus hyperboreus*), Rough-legged Hawks (*Buteo lagopus*) 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. Jaegers were captured at the nest and banded. Some birds also received geolocators.

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 2 sites (Fig. 1): the Qarlikturvik Valley (brood-rearing areas), and the Camp 2 area (nesting colony). At each site, 12 exclosures (1 × 1 m) were installed in late June in two groups of 6 in the same general area every year. At Camp 2, one of the groups of 6 exclosures was moved about 200 m in 2011 due to the natural drainage of some wetlands. Plant biomass was sampled in ungrazed and grazed areas (i.e. inside and outside exclosures) at the end of the plant-growing season on 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 × 10 m transects located near each exclosure every 2 weeks in the Qarlikturvik Valley and once at the end of the season at the Camp 2 area.

PRELIMINARY RESULTS

Weather conditions. **—** Temperatures in spring were generally cool. Air temperature averaged -0.38°C (0.36°C below normal) between 20 May and 20 June, the period of goose arrival and egg-laying, and 1.20°C (0.24°C below normal) during 1-15 June, which is the critical period of egg formation and egg-laying. The snow pack at the end of winter was relatively thin (snow depth was 24 cm on 31 May), which resulted in a rapid snowmelt in the lowlands despite cool temperatures in spring (Fig. 2). Temperature throughout the summer was mild and very sunny and precipitations were extremely low (cumulative rainfall: 8.5 mm, long-term average: 84.4 mm). This summer was by far the driest recorded since 1995.

Goose arrival and nesting activity. **—** The number of geese counted on the hills surrounding the Qarlikturvik Valley (main field station), usually the first area used by geese upon arrival, was high at our first count on 31 May (265 pairs) and increased rapidly over the next few days to peak at 444 pairs on 3 June, a high number (Fig. 3). This suggests that goose arrival on Bylot Island was relatively early this year. The subsequent decline in goose numbers was due to the movements of geese to the nesting colony, away from the Qarlikturvik Valley. The apparent increase at the last count in June could be due to the movement of early failed breeders.

Median egg-laying date in the colony was 12 June, which is the long-term average egg-laying date on Bylot Island (Table 1). Nest density in the center of the colony was high for the second year in a row (9.26 vs. 7.89 nests/ha in 2014) and above the long-term average (Table 1). Only 1 nest was found in the Qarlikturvik Valley (predominantly a brood-rearing area) compared to 76 in 2014. Overall, average clutch size was 3.49, slightly lower than the long-term average (Table 1).

Nesting success of geese. **—** Nesting success (proportion of nests hatching at least one egg) was high this year (77%), a value above the long-term average (Table 1). This was largely due to a relatively low activity of Arctic Foxes (despite a high breeding year, see below) and avian predators around goose nests, which resulted in fewer nests being destroyed this year. During the summer, 78 neck-collared birds were sighted in the colony. Peak hatch was on 9 July, which is the long-term average (Table 1). We tagged 2417 goslings in nests at hatch in the Camp 2 area and none at the main field station. Overall, nesting conditions of geese in 2015 were therefore generally good.

Density of broods. **—** The density of goose faeces at the end of the summer in wet meadows of the Qarlikturvik Valley was high (12.1 ± 2.0 [SE] faeces/m^2; long-term average: 6.4; Fig. 4). Accumulation of faeces began in mid-July, when newly-hatched broods started to move in the valley and increased steadily thereafter until mid-August. Faeces density at the end of the summer was also high in the wet meadows of the nesting colony at Camp 2 (7.9 ± 1.4 faeces/m^2; long-term average: 4.2).

Goose banding. **—** The banding operation was very successful this year due to good weather prevailing throughout the banding period. We conducted 7 drives in our core banding area, i.e. in the lowlands and hills bordering the main field station to the south and north (< 8 km), and 7 additional drives further away, between the Camp 2 and the Qarlikturvik Valley. We banded a total of 3675 geese, including 587 adult females marked with neck-collars and 97 young that had been marked with web-tags at hatch. In addition, we recaptured 183 adults that were banded in previous years. The young:adult ratio among geese captured at banding was lower than last year (0.99:1) and below the long-term average (Table 1). This contrasts with the generally good breeding conditions that prevailed until hatch. Mean brood size toward the end of brood-rearing (2.08 young, n = 136; counts conducted on 3 August) was lower than last year and the long-term average. By combining information on brood size and young:adult ratio at banding, we estimated that 95% of the adults captured were accompanied by young, a high value (Table 1). Overall, these results are indicative of a moderate production of young on Bylot Island by the end of the summer.

***Small mammals.* —** During our survey using snap traps, we cumulated 1424 trap-nights at our 2 trapping sites of the Qarlikturvik Valley from 23 to 28 July, and 702 trap-nights at the Camp 2 from 15 to 18 July. In the Qarlikturvik sites, we caught 2 Collared Lemming (*Dicrostonyx groenlandicus*) and 18 Brown Lemmings (*Lemmus trimucronatus*), which yielded a combined index of abundance of 1.46 lemming/100 trap-nights, a high value (Fig. 5). The estimated abundance was lower in the Camp 2 area, as 2 Collared Lemmings and 1 Brown Lemming were caught, for an index of 0.44 lemming/100 trap-nights. The live-trapping survey conducted throughout the summer in the Qarlikturvik Valley area revealed the same picture. Overall, we captured 323 Brown Lemmings and 21 Collared Lemmings, for an index of 10.0 lemmings/100 trap-nights, a lower number compared to last year (16.6 lemmings/100 trap-nights). A formal estimation of density using capture-recapture analytical methods indeed showed that both lemming species had declined compared to 2014 despite an increasing trend throughout summer 2015 (Fig. 6). The live-trapping survey conducted outside the Qarlikturvik Valley revealed a different picture but was consistent with the snap-trapping data conducted at Camp 2. We captured a total of 11 lemmings (5 Brown and 6 Collared Lemmings) at our three new sites in mid-July, for an index of 0.5 lemmings/100 trap-nights between Camp 2 and the Qarlikturvik Valley, 2.3 at Camp 2, 1.6 at Dufour Point. Finally, the number of lemming winter nests found along our 60 transects in the Qarlikturvik Valley was also high as 179 were found in 2015 compared to 206 in 2014.

***Breeding activity of foxes at dens and marking.* —** We found 2 new fox dens on the island in 2015, bringing the total to 112 known denning sites still intact. Among these dens, we found signs of activity (fresh digging and/or footprints) at 45 of them, a high number. The breeding activity was very high as we found 31 different litters (28% of known denning sites) of Arctic Foxes, a record number comparable to last year (28 litters in 2014), and no litter of Red Foxes. The high breeding activity of Arctic Foxes is typical of what we normally observed in years of high lemming abundance (average: 20%). Minimum litter size of Arctic Fox varied between 2 and 11 pups (6 pups on average). A total of 82 Arctic Foxes (33 adults and 49 juveniles) and no Red Fox were captured during trapping sessions. Seventy-one Arctic Foxes (23 adults and 48 juveniles) captured were new individuals and 11 had been marked in previous years. All new individuals were marked with ear-tags. Among the adults captured, 15 were also fitted with satellite collars to study their home ranges and movements at large spatial scale over the entire annual cycle.

***Monitoring of other bird species.* —** We found 29 active nests of Glaucous Gulls (vs. 41 in 2014), 2 nests of Parasitic Jaegers (vs. 5 in 2014), 38 nests (including 3 confirmed renesting) of Long-tailed Jaegers (vs. 77 in 2014), 21 nests of Rough-legged Hawks (vs. 31 in 2014) and no nests of Snowy Owls (vs. 98 in 2014). The decrease in the nesting activities of all avian predators is typical of what we encountered in a year of decreasing lemming abundance following a peak. We found 89 nests of Lapland Longspurs compared to 82 in 2014. Average clutch size of birds of prey had decreased compared to 2014: it was 2.4 eggs for gulls (vs. 2.7 in 2014), 1.5 eggs for Long-tailed Jaegers (vs. 1.8 in 2014) and 3.8 eggs for hawks (vs. 5.0 in 2014). Average clutch size of longspurs had remained the same with 5.2 eggs vs. 5.3 in 2014. Nesting success of birds of prey had also decreased compared to 2014: it was good for gulls and hawks (63% and 67%, respectively) and low for jaegers (6%). Fledging success (proportion of nests successful in fledging at least one young) was good for longspurs (63% vs. 55% in 2014).

Plant growth and grazing impact. — Plant production in wet meadows of the brood-rearing area was above the long-term average and higher than the last two years (Fig. 7). Above-ground biomass of graminoid plants in the Qarlikturvik Valley reached 69.7 ± 6.6 [SE] g/m^2 in ungrazed areas in mid-August compared to 56.7 ± 6.0 in 2014 (long-term average since 1990: 51.2 g/m^2). Biomass of both *Eriophorum* and *Dupontia* was higher compared to last year (Fig. 7). At the nesting colony (Camp 2 area), graminoid biomass had also increased compared to last year (115.3 ± 2.5 g/m^2, Fig. 8). Biomass of both *Eriophorum* (61.2 ± 19.9 g/m^2) and *Dupontia* (53.5 ± 9.2 g/m^2) increased compared to last year in the exclosures but remained the same in grazed areas. The change in the location of half of the exclosures at Camp 2 in 2011 prohibits a comparison of long-term trend in plant production after that date at this site (Fig. 8).

Grazing pressure was high in the wet meadows of the Qarlikturvik Valley in 2015 as geese had removed 45% of the above-ground biomass (difference between paired grazed and ungrazed plots) by mid-August (long-term average: 31%; Fig. 7). Grazing pressure was high on both *Eriophorum* (51% of biomass removed) and *Dupontia* (46% of biomass removed). Grazing pressure at the Camp 2 area (nesting colony) was slightly lower than at the Qarlikturvik Valley (38% of the graminoid biomass removed by geese) but was higher than last year and higher than the long-term average at this site (26%; Fig. 8). Geese removed roughly the same proportion of the *Eriophorum* and *Dupontia* biomass at this site.

CONCLUSIONS

The production of young geese on Bylot Island was moderate in 2015. Despite cool temperature at the time of laying, the snowmelt was early due to a thin snow cover last winter, which allowed the geese to nest at their usual date in the colony. It also appears that the breeding effort of the population was high as judged by the high density of nests in the core area of the colony. The clutch size was the only nesting parameter that was reduced in 2015 as predation on goose eggs was low, resulting in a high nesting success. This high nesting success of geese was somewhat surprising because there was a record abundance and reproductive effort of arctic foxes on the island. This high abundance was due to the high lemming density in 2014, which lead to a good production of foxes. Although lemming density had declined in several parts of the island in 2015, it remained high in others. This suggests that at least until hatch, lemmings were abundant enough to sustain foxes and to reduce their impact on goose nests. The situation, however, may have changed after hatching. Indeed, the young:adult ratio at banding was lower than anticipated. This suggests that gosling mortality was high last summer. The most likely source of mortality is predation because exposure to inclement weather was minimal during brood-rearing (temperature were mild with very little rain) and plant production was generally good.

Based on the young:adult ratio recorded at banding on Bylot Island, we anticipated a moderate percentage of young in the fall flock with a predicted value of 20%, slightly below the long-term average (23%). The percentage of young measured during juvenile counts conducted in southern Quebec this fall was 14% (n = 25,562), a lower value than anticipated. This suggests that breeding conditions encountered by geese on Bylot Island were better than those prevailing elsewhere in the eastern Canadian Arctic in 2015. This was especially the case further south because central and southern Baffin Island had completely different weather patterns compared to Bylot Island during summer 2015. Indeed, in those areas the spring was very late and the summer was cold, wet and windy. These conditions led to a complete breeding failure of Lesser Snow Geese nesting in the Great Plain of the Koukdjuak on southern Baffin Island (Jim Leafloor, personal communication). It is thus likely that Greater Snow Geese breeding south of Bylot Island also suffered from high breeding failure. We should remember that Bylot Island accounts for only ~15% of the annual breeding population of Greater Snow Geese and thus poor breeding conditions encountered at other sites will significantly reduce the proportion of young in the fall flock.

Above-ground graminoid production in wet meadows of the Qarlikturvik Valley was very good in 2015 and had increased compared to 2014. Annual growth of Arctic plants is sensitive to summer temperature and the mild and sunny weather encountered last summer likely explains this good production. Plant growth in wet meadows, the preferred brood-rearing habitat on Bylot Island, apparently did not suffer from the dry conditions that prevailed throughout much of the summer. Geese were present in large numbers in this habitat throughout the brood-rearing period as shown by the high density of faeces. Accordingly, plant sampling showed that goose grazing pressure in those habitats was high in 2015. The dry conditions that prevailed last summer may have contributed to the high use of wet meadows. Indeed, in normal or wet years, goose families often disperse to upland areas later in the summer to feed. However, broods may have remained in lowlands because standing water was only present in this habitat by late summer and plants in upland areas may have suffered more from the lack of water than those in lowlands. Nonetheless, the good plant production that continued to prevail in 2015 suggests that feeding conditions of geese on Bylot Island have remained good in recent years.

PLANS FOR 2016

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 Canada and since 2009 in the United States. 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*) assessing how climate change may be affecting the carrying capacity of the habitat for geese, *iv*) studying indirect interactions between snow geese and lemmings via shared predators; *v*) studying the ecology of the main predator of geese, Arctic Foxes; and *vi*) assessing the impact of climate change on goose reproduction. In 2016, 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 abundance of lemmings and study their demography.
5) Monitor the breeding activity of other bird species, in particular avian predators (Snowy Owls, jaegers, Glaucous Gulls and Rough-legged Hawks).
6) Monitor the breeding activity of foxes at dens and mark individuals to study their movements and demography.
7) Study the hunting behavior of Arctic Foxes in the goose colony and their interactions with geese.
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.

In 2016, at least 6 graduate students will be involved in the Bylot Island snow goose project. **Cynthia Resendiz** (PhD) will complete her study on the effects of climate change on snow goose reproduction. **Yannick Seyer** (PhD) will continue his study on the migratory and reproductive strategies of the Long-tailed Jaegers. **Claire-Cécile Juhasz** (PhD) will continue her study on the effects of predators and food on the reproductive success of snow geese. **Guillaume Slevan-Tremblay** (MSc) will continue his study on the grazing impact of lemmings on the tundra vegetation. Finally, **Nicolas Coallier** (MSc) will begin a study on the cross-validation of methods to estimate lemming abundance and **Frédéric LeTourneux** (MSc) will start a study of the impact of the US conservation hunt measures on the survival and population dynamics of snow geese.

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

	2006	2007	2008	2009	2010	2011	2012	2013	2014	**2015**	Average[2]
Number of nest monitored	393	494	466	405	372	382	375	451	491	**347**	--
Nest density (n/ha)	2.14	4.07	6.36	4.94	2.95	4.89	5.24	8.85	7.89	**9.26**	4.79
Median date of egg-laying	14 June	16 June	10 June	12 June	13 June	13 June	12 June	13 June	11 June	**12 June**	12 June
Clutch size	3.68	3.91	4.10	3.38	3.68	3.74	3.80	3.58	3.85	**3.48**	3.70
Nesting success[1]	42%	82%	74%	74%	80%	90%	54%	67%	91%	**77%**	67%
Median date of hatching	10 July	11 July	6 July	9 July	10 July	8 July	9 July	10 July	8 July	**9 July**	9 July
Number of geese banded	4603	4260	3395	5417	4267	3802	2512	4865	2001	**3675**	3541
Ratio young:adult at banding	0.74:1	1.11:1	1.11:1	1.07:1	1.18:1	1.19:1	0.92:1	1.10:1	1.19:1	**0.99:1**	1.05:1
Brood size at banding	2.20	2.90	3.07	2.35	2.39	2.80	2.54	2.51	2.58	**2.08**	2.50
Proportion of adults with young at banding	67%	77%	72%	91%	98%	85%	73%	88%	92%	**95%**	83%

[1] Mayfield estimate
[2] Period 1989-2015

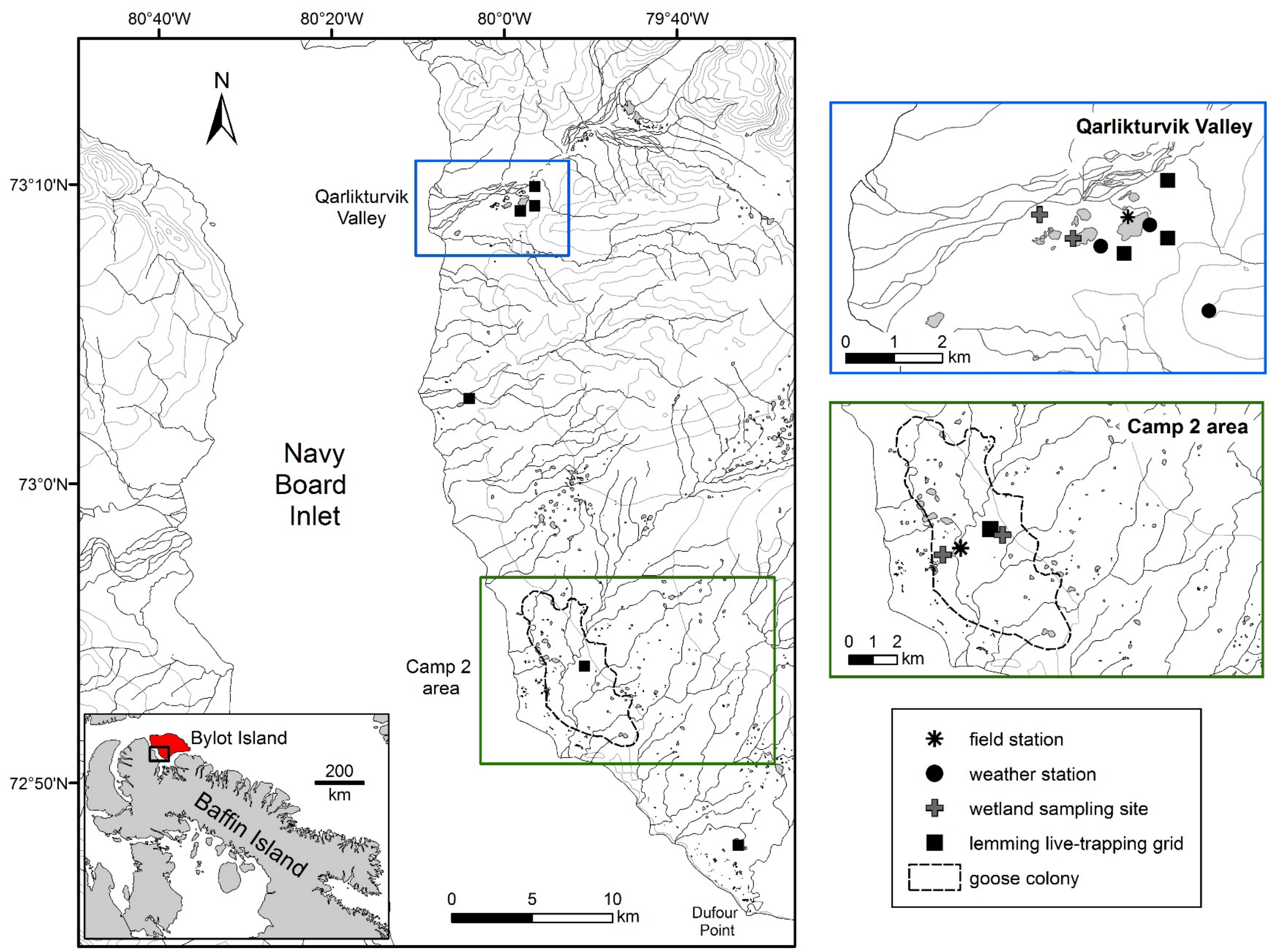

Figure 1. Location of the two main study sites (Qarlikturvik Valley and the Camp 2 area) on the South Plain of Bylot Island, Nunavut. Enlarged maps on the right present these study sites in more details, including locations of our field stations, automated weather stations, wetland sampling sites for plants, lemming live-trapping grids and the extent of the goose colony.

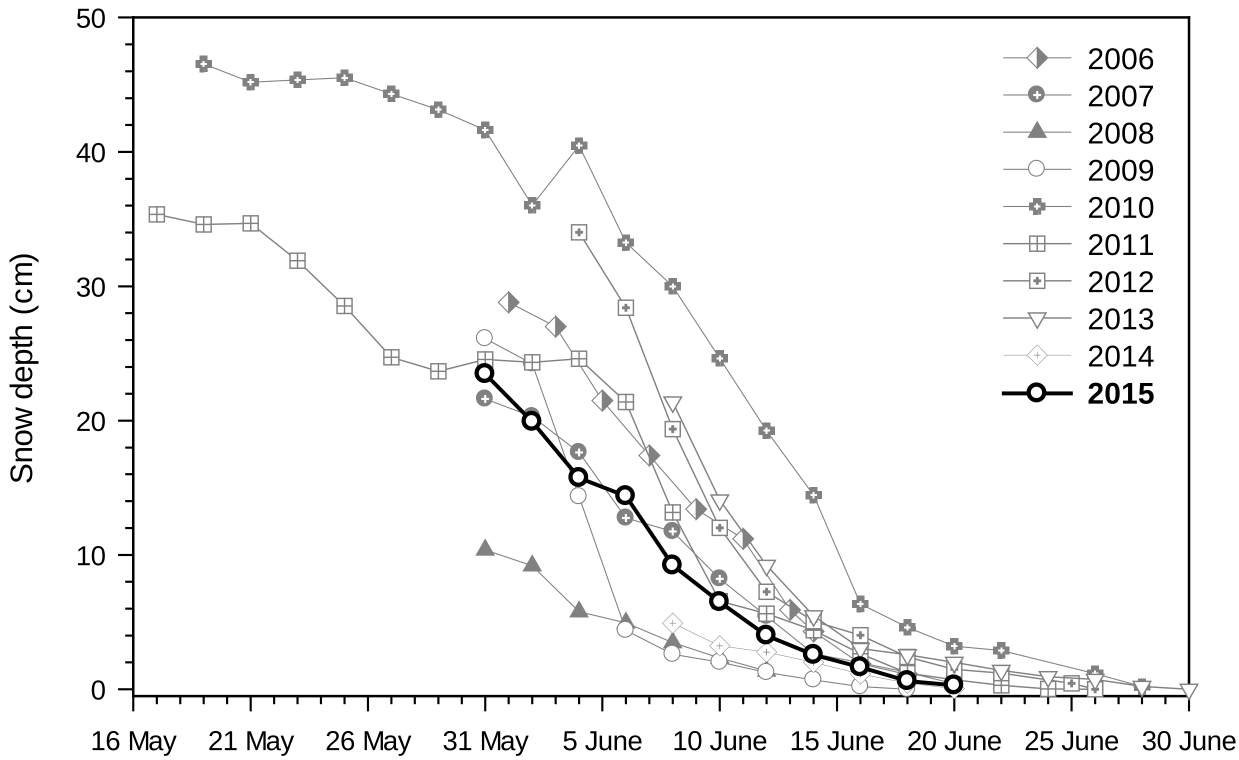

Figure 2. Average depth of snow along 2 transects showing the rate of snowmelt in the lowlands of Bylot Island in spring over the past decade (*n* = 50 stations).

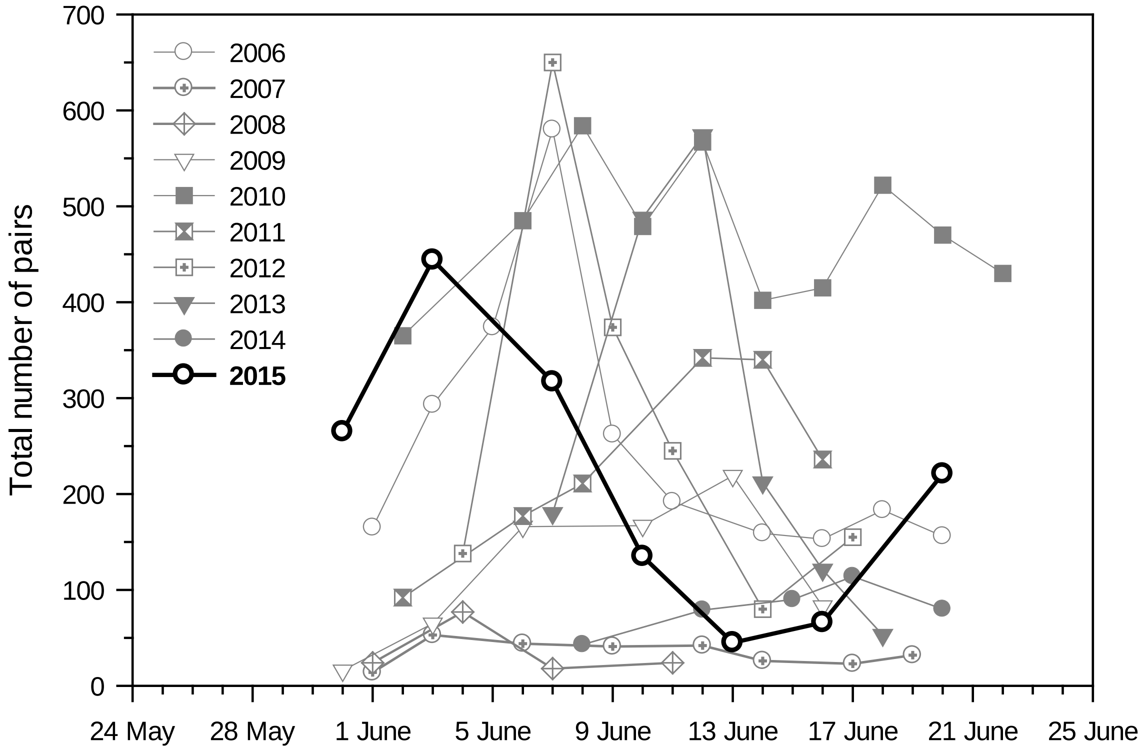

Figure 3. Total number of goose pairs counted in the Qarlikturvik Valley from arrival of our crew on Bylot Island in late May until the end of snowmelt over the past decade.

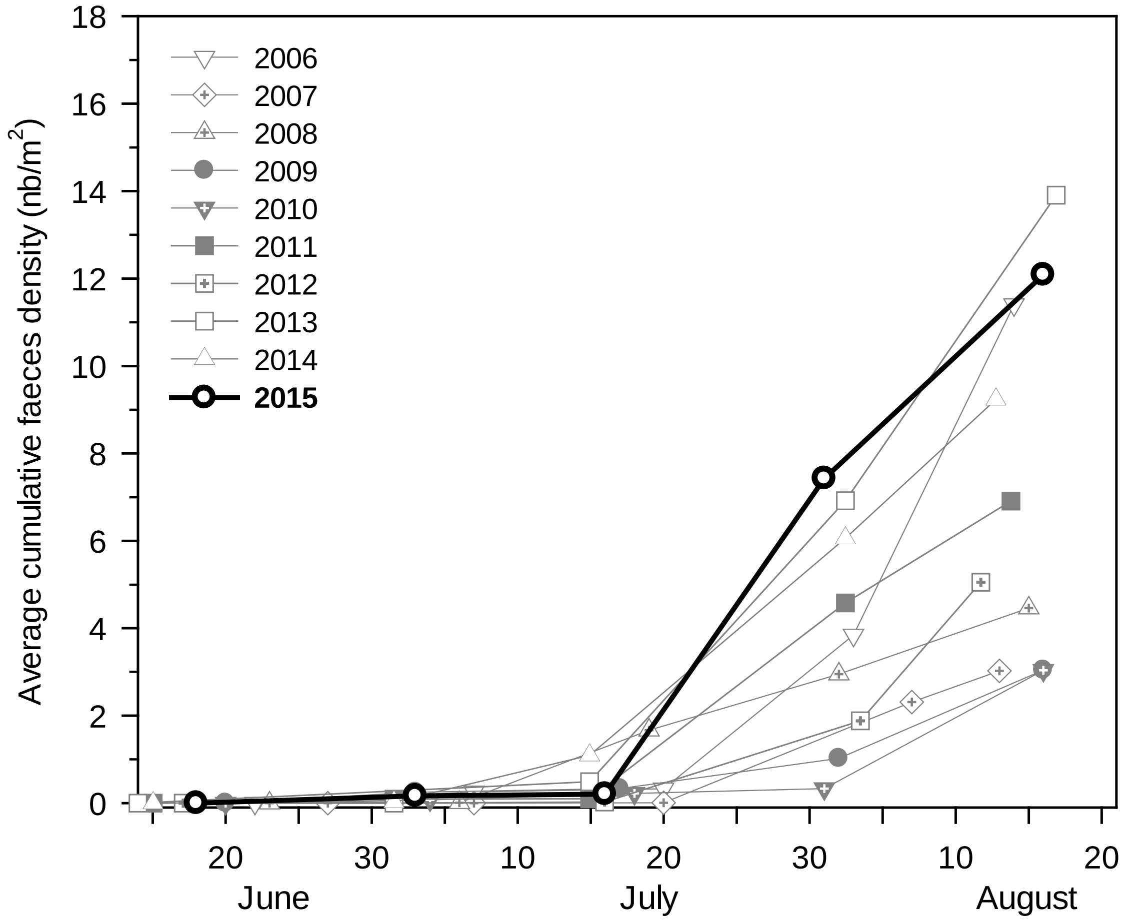

Figure 4. Average cumulative faeces density showing the use of the Qarlikturvik Valley by Greater Snow Goose families on Bylot Island throughout the summer over the past decade (n = 12 transects of 1 x 10 m; except 2013 where n = 5).

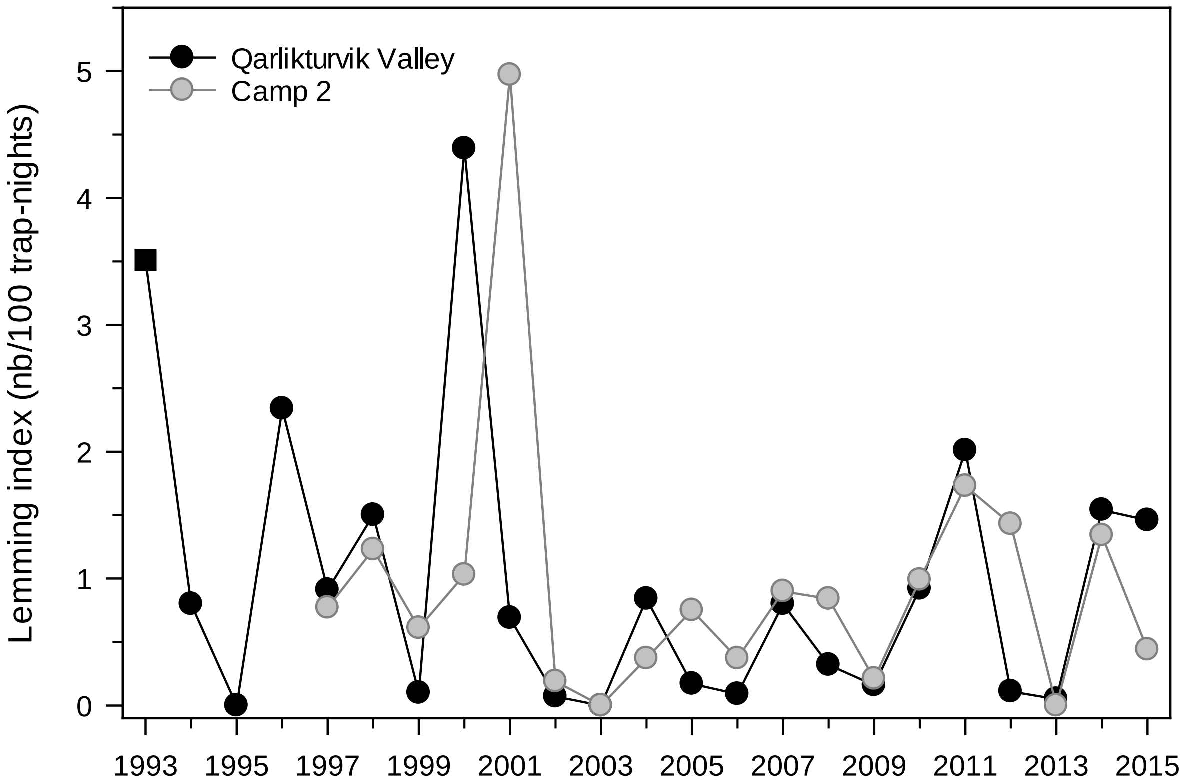

Figure 5. Annual index of lemming abundance based on snap-trapping at two study areas (Qarlikturvik Valley and Camp 2) located 30 km apart on Bylot Island (see Fig. 1).

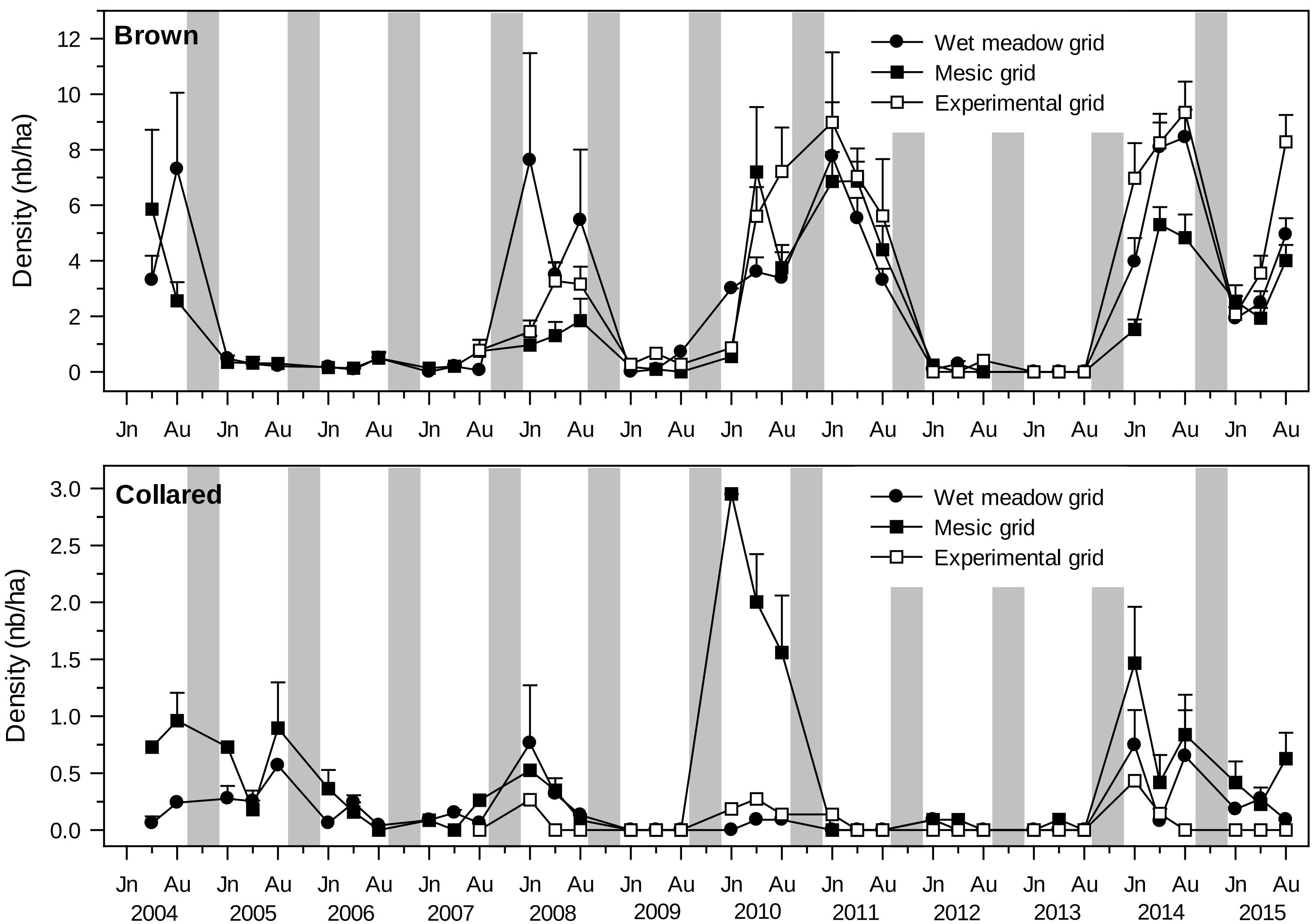

Figure 6. Annual summer density (+ SE) of Brown and Collared Lemmings on 3 trapping grids located in the Qarlikturvik Valley of Bylot Island (snow cover was increased from 2008 to 2011 and predators were excluded from 2012 to 2015 on the experimental grid). The gray area indicates winter. Jn = mid-June, Au = mid-August.

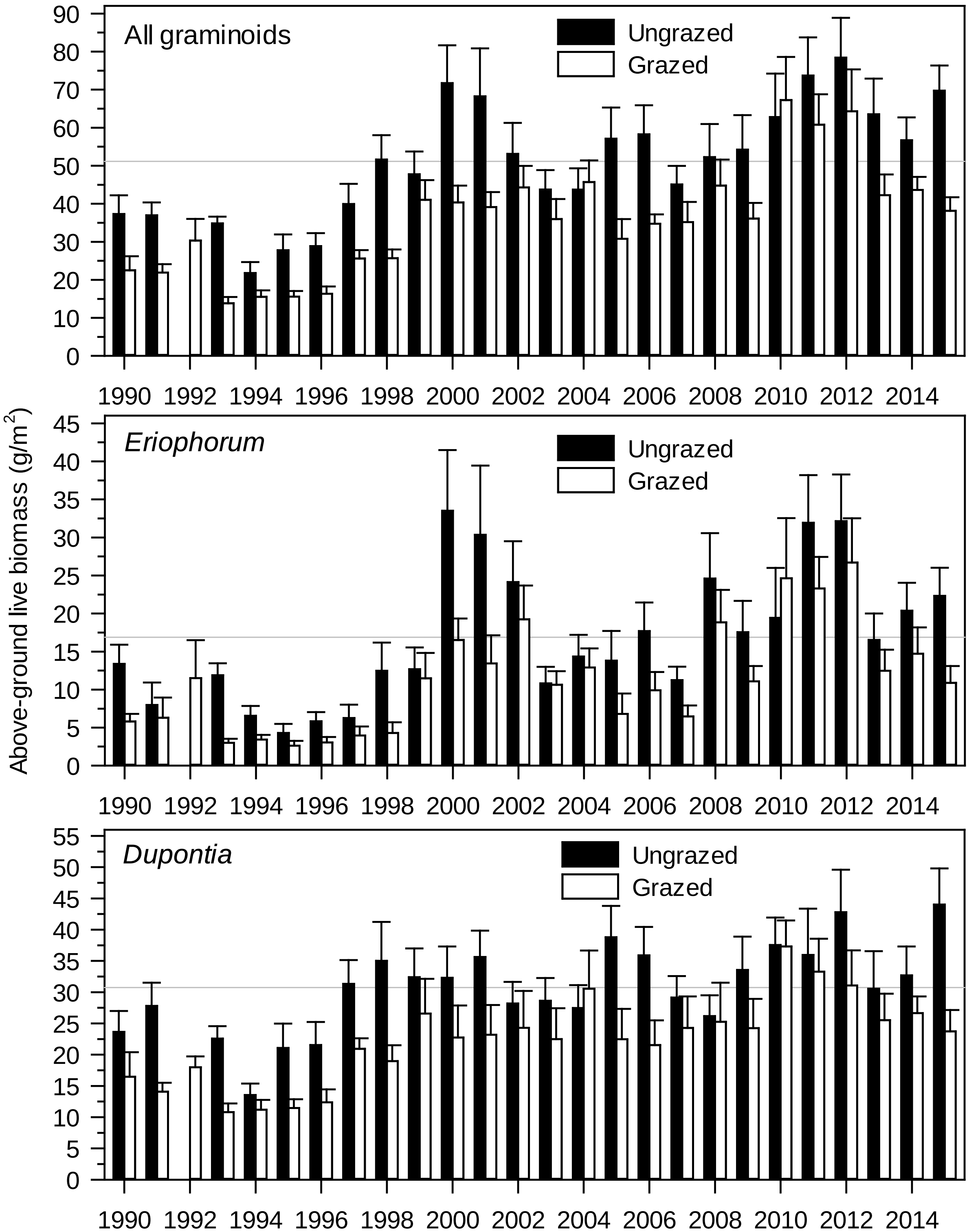

Figure 7. Live above-ground biomass (mean + SE, dry mass) of graminoids on 14 August in grazed and ungrazed wet meadows of the Qarlikturvik Valley, Bylot Island (*n* = 12, except in 2013-2014, *n* = 11). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. There is no data from ungrazed area in 1992. The solid gray line is the long-term average for ungrazed area.

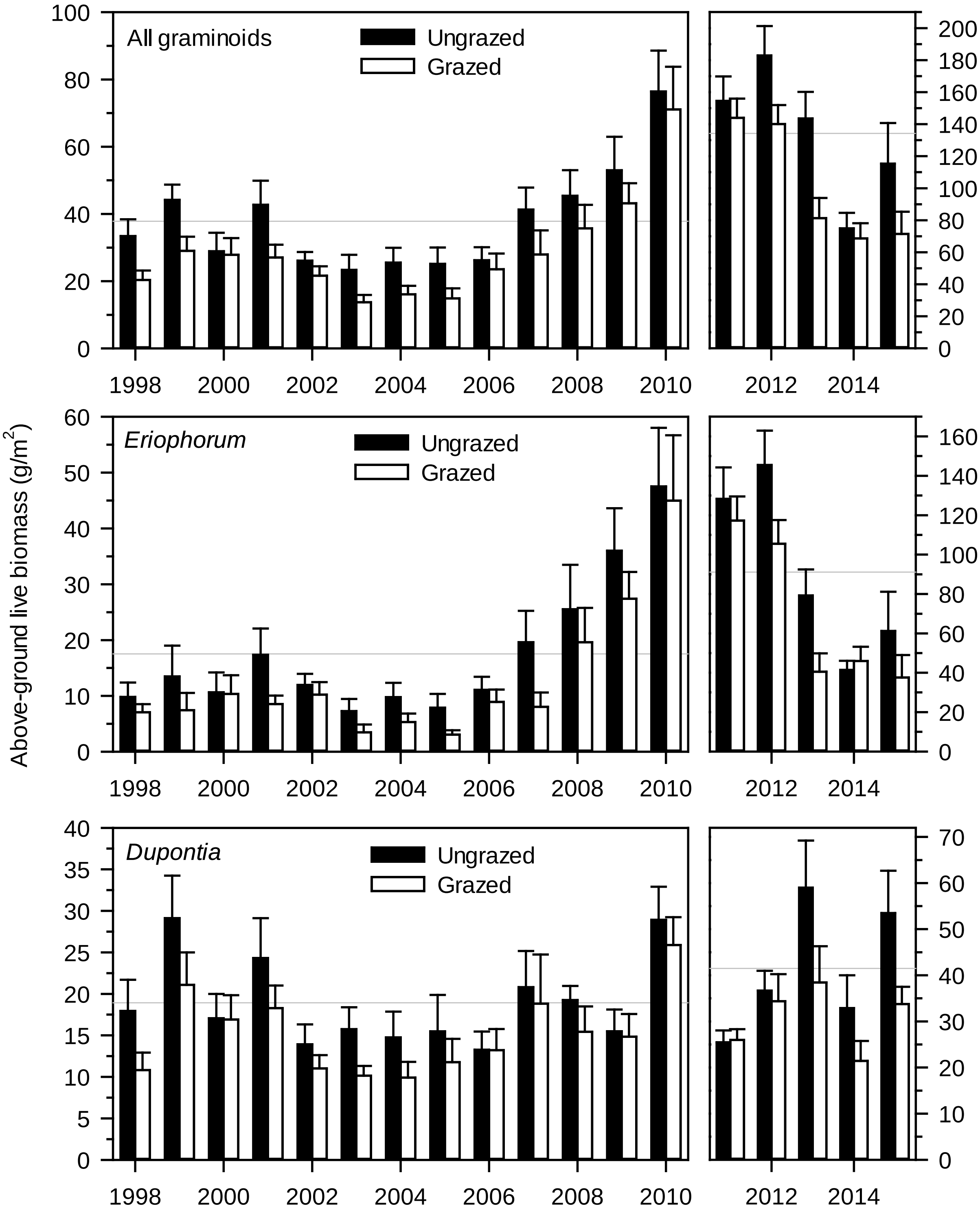

Figure 8. Live above-ground biomass (mean + SE, dry mass) of graminoids on 15 August in grazed and ungrazed wet meadows of the Camp 2 (goose colony), Bylot Island (n = 12, except in 2008 and 2014 n = 8, and 2012, 2013 and 2015 n = 10). Total graminoids include *Eriophorum scheuchzeri*, *Dupontia fisheri* and *Carex aquatilis*. Half of the exclosures had to be moved to a new site in 2011, which explains why the figure was split and the long-term average for ungrazed area (solid gray line) calculated separately before/after 2011.

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C.119. Bêty, J. 2011. Sensitive Arctic birds under the spotlights: global change and recent discoveries. *Society of Canadian Ornithologists Annual Meeting*, Moncton, NB.

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C.103. Gauthier, G., J.-F. Therrien, J. Bêty, F. Doyle & D. Reid. 2010. Surprising migratory movements and site fidelity unraveled by satellite-tracking of snowy owls. *25th International Ornithological Conference*, Sao Paulo, Brazil.

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T.56. Marmillot, V. 2015. Effets des conditions environnementales, de la condition corporelle et du statut hormonal sur la mue de la grande oie des neiges (*Chen caerulescens atlantica*). MSc thesis, Département de biologie, Université Laval, Québec.

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