

**SURVEYS FOR NESTING AND BROOD-REARING BRANT  
AND LESSER SNOW GEESE, BARROW TO FISH CREEK DELTA,  
AND LESSER SNOW GOOSE BANDING NEAR THE  
IKPIKPUK RIVER DELTA, ALASKA, 2008**

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**DEPARTMENT OF WILDLIFE MANAGEMENT**  
BARROW, ALASKA

PREPARED BY  
**ABR, INC.—ENVIRONMENTAL RESEARCH & SERVICES**  
FAIRBANKS, ALASKA





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**ANNUAL REPORT**

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**North Slope Borough**  
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## INTRODUCTION

Proposed and potential oil developments in areas west of the Colville River delta, within the National Petroleum Reserve–Alaska, have prompted increased inventory and monitoring activities for wildlife resources in the area. Since 1994, the North Slope Borough (NSB) Department of Wildlife Management has supported a program to determine the status and productivity of Brant (*Branta bernicla*) colonies in the area west of the Colville River delta (Ritchie and Flint 1994; Ritchie 1996, 1998a, 1998b, 2001; Ritchie and Rose 1996; Ritchie and Wildman 2000; Ritchie et al. 2002, 2004, 2006, 2007, 2008a; Ritchie and Shook 2003, 2005). In addition, since 1995, the NSB has supported regional surveys of a number of areas where Lesser Snow Geese (*Chen caerulescens caerulescens*) nest and rear their broods. A number of small or incipient Snow Goose colonies were identified in surveys as early as 1991 (Ritchie and Burgess 1992, 1993), and a large colony near the mouth of the Ikpikpuk River has been the particular focus of recent monitoring efforts (e.g., Ritchie et al. 2007, 2008a).

Since surveys began, the major goal of this program has been to monitor the distribution, abundance, and status of colonial geese in the region. Annual breeding-pair surveys that are conducted by the U.S. Fish and Wildlife Service (USFWS) are designed to monitor widely distributed breeding birds and are less useful for species with clumped distributions, such as colonially nesting geese. Similarly, annual molting goose surveys conducted by the USFWS in the Teshekpuk Lake area focus on molting geese (primarily non-breeding geese or failed breeders not from local nesting areas) in large lakes between Harrison and Smith bays, but do not include many coastal sites where local geese rear their broods. Specific objectives of our surveys were to evaluate the annual abundance of nesting and brood-rearing Brant and Snow Geese, to assess elements of their productivity, including nesting success and gosling production, and to describe their distribution in the region. Field tasks have included:

- Since 1992, annual aerial surveys in June of the Ikpikpuk River delta Snow Goose colony;

- In 1991–1995, 1999, and 2002, aerial surveys in June of the Kukpowruk/Epizetka River deltas (hereafter Kukpowruk River delta) Snow Goose colony;
- In 1992 and 1993, ground-based nest-fate searches in July to determine nesting success at the Kukpowruk River delta Snow Goose colony;
- In 1992–1993 and 2001–2008, ground-based nest-fate searches in July to determine nesting success at the Ikpikpuk River delta Snow Goose colony;
- Since 1996, annual aerial surveys in June of 45 selected Brant nesting colonies between Barrow and Fish Creek, spanning the main nesting area for Brant in this region of northern Alaska;
- Since 1994 (excluding 1998), annual aerial surveys of brood-rearing Snow Geese and Brant between Barrow and Fish Creek in July.

Since 2000, we have tried to improve our estimates of productivity for the rapidly growing Snow Goose colony on the Ikpikpuk River delta through

- photo censuses of brood-rearing groups during the annual aerial surveys in July to more accurately estimate annual productivity; and
- banding Snow Geese during late brood-rearing to determine migration routes and wintering areas, assess immigration/emigration and survival, identify the sources of immigration, and monitor the population increase.

A complete summary of the survey types and areas covered by ABR in the course of long-term monitoring of colonial geese for the NSB, 1991–2008, is presented in Appendix A. This report presents the results of the fifteenth consecutive year of aerial surveys of Brant and Snow Goose nesting colonies in northern Alaska, west of the Colville River delta (1994–2008). The brood-rearing surveys are in their thirteenth year (1995–1997 and 1999–2008) and have been

augmented by photo census since 2001. Ground-based searches at varying levels of intensity have occurred in 12 of 17 years since 1992 at the Kukpowruk River (1992–1993, 1995–2001, 2003, and 2007–2008; since 1995, these surveys were conducted by the NSB [R. Suydam, per. comm.] and their data were shared for reporting here) and in 10 years since 1992 at the Ikpikpuk River (1992–1993, 2001–2008). Banding of brood-rearing Snow Geese has been accomplished annually in the Ikpikpuk/Piasuk River deltas (hereafter, Ikpikpuk River delta) since 2000, except in 2004.

In 2008, we expanded monitoring efforts for Snow Geese by mounting additional banding efforts in 3 North Slope locations at which we have documented rapid increases in local breeding populations of Snow Geese: the Kukpowruk River delta (in Kasegaluk Lagoon near Point Lay), the Colville River delta, and the Sagavanirktok River delta/Foggy Island Bay area (hereafter, Sagavanirktok River delta). The North Slope Borough and ConocoPhillips Alaska, Inc., supported efforts on the Kukpowruk River delta. ConocoPhillips Alaska, Inc., supported banding efforts on the Colville River delta and BP Exploration (Alaska), Inc., supported banding efforts on the Sagavanirktok River delta. Previous field reports to ConocoPhillips (Ritchie et al. 2008b) and BP Exploration (Ritchie et al. 2008c) describe those field efforts, while this report consolidates information from all 4 banding sites across the North Slope in 2008, including banding returns that have been received since the field efforts.

## STUDY AREA

The study area for monitoring breeding Brant and Snow Geese covers much of coastal Arctic Alaska (Figure 1), although areas of focus have shifted during some periods since monitoring was initiated in 1991. Initial efforts to monitor nesting Snow Geese in 1991 focused solely on a recently identified colony near the mouth of the Kukpowruk River in northwest Alaska. Aerial surveys during nesting 1992–1995, and aerial surveys during brood-rearing 1994–1995 extended over about 700 km of coast between the west channel of the Colville River delta and the southwest end of

Kasegaluk Lagoon. During these and all subsequent survey efforts (including both nesting and brood-rearing surveys), the study area was primarily coastal, generally covering coastal wetlands within 1.6 km of the coast and up to about 5 km inland in river deltas, flooded river mouths or inlets, and large drained-lake complexes. Beginning in 1994, Brant as well as Snow Geese were recorded during nesting and brood-rearing surveys. Starting in 1996, nesting and brood-rearing aerial surveys were restricted to the Beaufort Sea coast between Point Barrow and Fish Creek, just west of the Colville River delta (Figure 1). While brood-rearing surveys continued to cover all coastal wetlands in this area, the nesting surveys focused on monitoring the status of 45 specific Brant colonies and 1 Snow Goose colony (in the Ikpikpuk River delta)(Figure 1). Aerial surveys of the Kukpowruk colony also were conducted during nesting in 1999 and 2002, but covered none of the intervening coastline between Barrow and Kasegaluk Lagoon.

The study area comprises coastal tundra with numerous oriented thaw-lakes and is part of the Arctic Coastal Plain Ecoregion, bounded on the north by the Beaufort Sea (Gallant et al. 1995). Vegetation in the study area is dominated by wet-graminoid/herbaceous plant communities. Along the coast, gravel spits, unvegetated mudflats, and salt marsh are extensive in some areas.

To allow for comparisons among years, the study area was divided into sections (Ritchie 1996). Sections 1 and 2 are located west of Barrow and are not included in this report as they have not been surveyed since 1995. These sections were dropped from the study area due to budget constraints and because it included only a few small colonies of Brant and no major brood-rearing or molting habitats for Brant or Snow Geese (Ritchie 1996; although this part of the coast is an important fall staging area for Brant [Johnson 1993]). The other 3 sections (3–5, Figure 1) are included in this report and have been surveyed annually since 1994, with minor adjustments made to their boundaries in 1997 (Ritchie 1998). These 3 sections are:

- Dease Inlet (Section 3: coastal and inland areas extending from Barrow in the

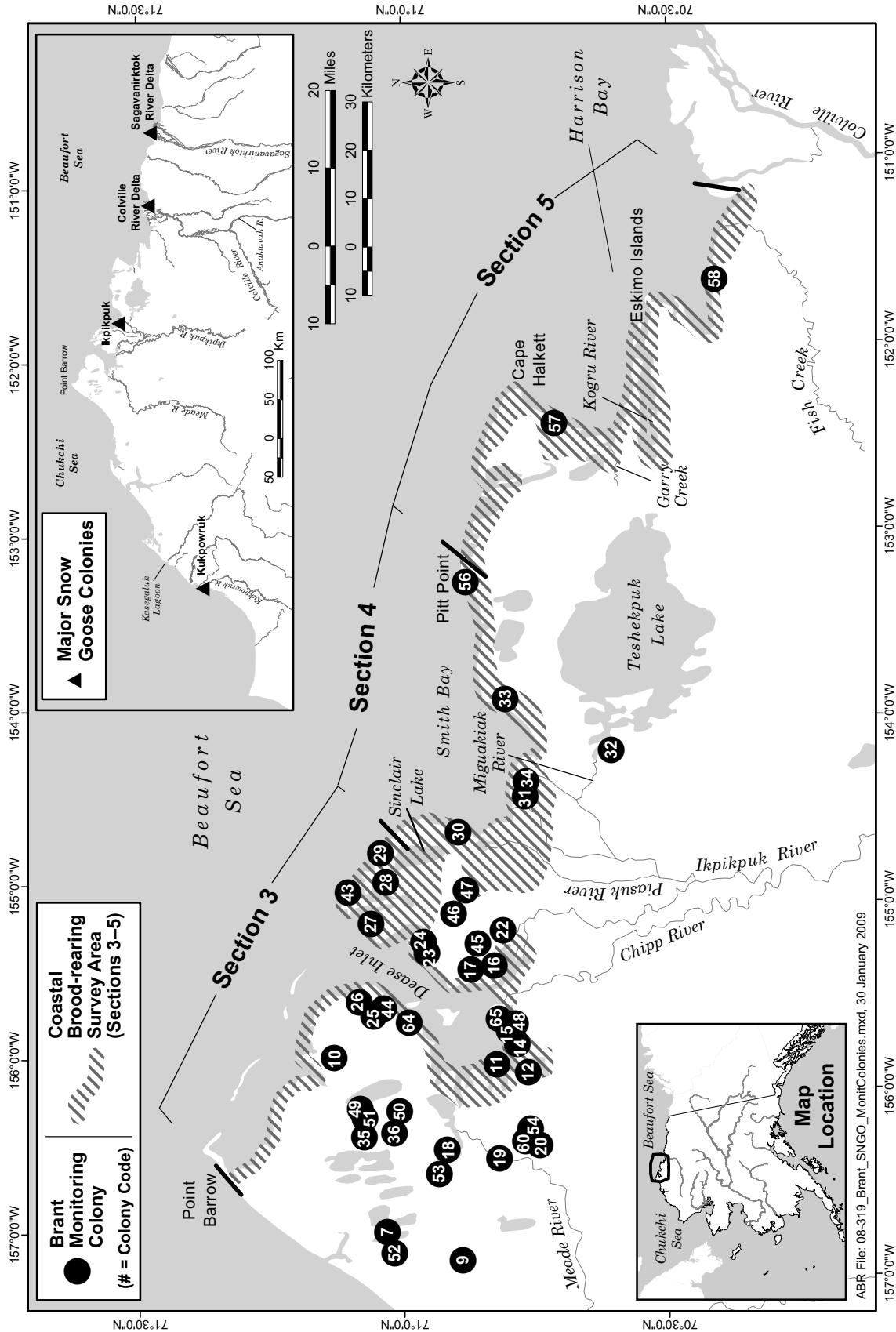


Figure 1. Study area for surveys to monitor breeding Brant and Snow Geese, including locations of 45 specific Brant colonies, 4 major Snow Goose colonies, and brood-rearing survey area along Alaska's northern coastline.

northwest to Sinclair Lake northwest of Smith Bay),

- Smith Bay (Section 4: all of Smith Bay and inland areas from Sinclair Lake to Pitt Point), and
- Harrison Bay (Section 5: east of and including Pitt Point to the eastern side of Fish Creek delta or the western channel of the Colville River).

In 2008 we also attempted to band Snow Geese at 3 previously identified colonies along the Arctic Alaskan coastline, the Kukpowruk River delta (previously mentioned), and 2 colonies east of previous survey efforts on the Colville and Sagavanirktok river deltas. General descriptions of these study areas and results have been included in 3 field reports (Ritchie and Rose 2008, Ritchie et al. 2008b, Ritchie et al. 2008c). Banding information from these 3 study areas are included in this annual report.

## METHODS

### COLONY MONITORING SURVEYS

Since 1996, colony monitoring has focused on 45 known Brant nesting colonies and 1 Snow Goose colony (in the Ikpikpuk River delta) between Barrow and Fish Creek (Figure 1). By focusing on 45 specific colonies of Brant, the nesting survey provides information on nesting effort and population only for these specific locations and does not necessarily reflect accurately the regional abundance of Brant. Although low numbers of nesting Brant are widely distributed across the study area, these 45 Brant colonies were selected for long-term monitoring from all known colonies found during more wide-ranging surveys in 1994 and 1995 (Ritchie 1996). Selection criteria included logistics (i.e., the route selected was chosen because it minimized flight time) and colony size (all larger colonies were included, along with a number of smaller colonies). We also recorded Snow Goose nests in the Brant colonies or those observed opportunistically during the Brant colony survey.

A Cessna 185 aircraft with a pilot and 2 observers was used for colony monitoring. The nesting survey was flown at 95–140 km/h and

30–100 m above ground level (agl) on 15, 16, and 20 June 2008. Since 2005, higher altitudes [ $>250$  m agl] were maintained during surveys at the Ikpikpuk Snow Goose colony in an effort to reduce disturbance as the colony has dramatically increased in size. We used an onboard geographic positioning system (GPS) to locate the 45 known Brant colonies for surveys, aided also by USGS 1:250,000-scale topographic maps. During all surveys, 2 observers, positioned on opposite sides of the aircraft, recorded estimated numbers of adults and nests for each nesting location. The pilot aligned the plane to make the best pass for counting and also identified nest sites that might inadvertently be missed by the observers (e.g., in front of the plane). Colonies often were circled to afford better counts.

For Brant, a nest was recorded if either a down-filled bowl or an adult in incubation posture was observed. Male Brant typically flush in response to approaching aircraft and incubating females also occasionally flush, but empty Brant nests can be fairly conspicuous due to copious down. For Snow Geese, all pairs on the ground, either standing or with 1 bird incubating were considered to represent nesting pairs (Kerbes 1982). Nesting male Snow Geese attend the incubating female, particularly during disturbances, and aircraft disturbance rarely causes birds of either sex to flush from nest sites. Also, in contrast to Brant, unoccupied Snow Goose nests are inconspicuous and difficult to verify from the air. Aerial counts yield minimal estimates for both species, but are particularly biased for Brant because of the difficulty of identifying all nests from the air (Ritchie et al. 1990).

### GROUND SURVEYS OF SNOW GOOSE COLONIES

We conducted a ground search of the Kukpowruk Snow Goose colony in 1992 and 1993 and of the Ikpikpuk Snow Goose colony 1992–1993 and 2001–2008. Similar ground searches of the Kukpowruk colony were conducted by the NSB in 1995–2001, 2003, and 2007–2008 (R. Suydam, NSB, pers. comm.) and their data are included here. Ground searches were undertaken to enumerate, accurately map, and to assess the fate and productivity of Snow Goose nests. In recent

years budget and logistical constraints have prevented complete searches of the rapidly expanding Ikpikpuk colony and, typically, ground crews were allowed 5 days to search the major and most readily accessible nesting islands in the western delta where nests typically are most abundant. Ground searches are best conducted within a week or 2 of hatching in the colony and, in 2008, the ground search was conducted 12–16 July. We accessed the Ikpikpuk River delta via a fixed-wing aircraft (typically either a Heliocourier or a Cessna 206) and established a camp along the western side of the delta. An inflatable 2-person kayak was used to travel between islands. In most recent years since the rapid growth of the Ikpikpuk colony, a hand-drawn map (on a color aerial photo map base) of the approximate distribution of nesting pairs was recorded during the nesting aerial survey and was used to help locate Snow Goose nests during the July ground and August aerial searches (see below) of the Ikpikpuk River delta.

During ground surveys, nests were classified as *successful* if at least 1 eggshell fragment in the nest bowl was largely separated from a thickened shell membrane (Downing 1980), *unsuccessful* if eggshell fragments were firmly attached to papery shell membrane or if shell fragments were totally missing (Downing 1980). A few nests were classified as *unknown* when physical evidence seemed equivocal. Precise locations of nests were recorded using a handheld GPS. Because nests typically were densely packed, we left a marker in each nest bowl (a small piece of cut-up tongue depressor) to prevent double-counting of nests. All locations later were entered into a geographic information system (GIS) database (ArcGIS software). Habitat features (e.g., mound, polygon rim, polygon depression, no relief) were described briefly for most nests (these data are not presented in this report.)

In most years since the initiation of banding efforts (see below) and the rapid growth of the Ikpikpuk colony, we also attempted a low-altitude (<100 ft) helicopter survey in early August over nesting islands that were not ground-searched. During these August aerial surveys, 1 observer counted nests from the helicopter. In 2008, this aerial survey quickly determined that storms and flooding had removed the majority of nests that

were reported during the aerial survey in June, thus rendering the count ineffective. Additionally ground searches in August 2008 were similarly ineffective at improving the aerial and ground-search estimates of nest numbers.

## BROOD-REARING SURVEYS

In contrast to the nesting aerial surveys, which focused on 45 specific colonies, the brood-rearing surveys are intended to provide information on the numerical abundance and breeding success of Brant and Snow Geese across the study area. Brood-rearing surveys are best conducted several weeks after hatching, when goslings are large, more-or-less independent, and easily enumerated. In 2008, the brood-rearing survey was conducted 29 July–1 August. The survey was flown by Piper Supercub aircraft at approximately 75–150 m agl and 120 km/h with a pilot and 1 observer. Locations of all Brant and Snow Geese were recorded with an onboard GPS (datum base: WGS 84). Information recorded for each group included species and numbers of adults and young. All locations later were entered into a GIS database (ArcGIS software).

Since 2002, photo counts have revealed that our aerial estimates are accurate for group sizes up to about 50 geese, but that we usually underestimated numbers of adults and young for larger group sizes (Ritchie et al. 2006, 2007, 2008a; Ritchie and Shook 2005). Since 2002, to improve the accuracy of our counts of Snow Geese and Brant, we photographed all large (>50) brood-rearing groups, unless the group was too dispersed to photograph all birds. Many smaller groups also were photographed to test observer proficiency at estimating flocks of various sizes. In 2008, photographs were taken with a Canon EOS 20D digital SLR camera (8.2 megapixel), and a 17–85 mm image-stabilizing lens. Digital photos were used to count the number of adults and goslings of each species and to identify color phase (white or blue) of Snow Geese.

## SNOW GOOSE BANDING

On the Ikpikpuk River delta, a Robinson 44 helicopter was used to assist in the capture of Snow Geese for banding. In 2008, banding was conducted on 1–3 August (poor weather prevented

additional banding efforts on 4–5 August). After a reconnaissance of brood-group locations by helicopter, a centrally-located capture site was selected and a circular enclosure or pen was erected. Then the helicopter was flown toward a group of Snow Geese (generally within 2 km of the enclosure or pen), causing the geese to group together, and the helicopter was then used to slowly move the geese toward the pen by flying approximately 50–100 m behind the geese. When the geese were within 200 m of the pen, a 3–5 person crew (hiding near the capture pen) encircled the flock and slowly walked the birds into the enclosure. The speed of the aircraft and the aircraft's distance from the geese varied, with the primary objective of keeping the geese moving at a steady walking pace.

Once inside the enclosure, each bird was captured and processed by the banding crew. For each bird captured, we recorded the age, sex, and color phase. If captured adults were previously banded, we recorded the USFWS metal band number. Unmarked birds, both adults and goslings, were banded with size 7B metal bands. After processing the geese, we placed each banded bird in a second netted enclosure. To limit possible separation of goslings from their parents, all birds were released simultaneously after banding was completed.

Banding efforts at the Kukpowruk River delta were described in Ritchie and Rose (2008). As described in that report, the 2008 effort at the Kukpowruk River delta was primarily a reconnaissance of the brood-rearing area and an effort to enlist local support and logistical assistance for future banding efforts. No birds were captured or banded at the Kukpowruk River delta in 2008. Banding efforts at the Colville River and Sagavanirktok River deltas were described in Ritchie et al. 2008b and 2008c, respectively. Capture and banding methods were similar at all sites, except that small single-engine helicopters are prohibited for work supported by BP, so a larger twin-engine 2-pilot Bell 212 helicopter was used and the capture methods were adapted as required.

Band recovery information was extracted from bimonthly reports from the USGS–BRD Bird Banding Lab to update our database. This report

includes information on band returns through 6 December 2008.

## **RESULTS AND DISCUSSION**

### **SPRING AND SUMMER CONDITIONS**

Weather is an important influence on the breeding performance of arctic-nesting geese (Boyd et al. 1982, Alisauskas 2002). In particular, cold temperatures during nest initiation may prevent or reduce breeding if snow melt is delayed and nest site availability is limited. Continued cold temperatures during incubation may increase energy expenditure and dramatically reduce productivity and even survival of nesting females. Cumulative degree-days over a particular period (days, weeks, or months) are a commonly used means of comparing the relative warmth or coldness between dates or sites; for example, heating or cooling degree-days or growing degree-days can be defined variously to evaluate temperatures conducive to particular activities or processes. Because the threshold between freezing and thawing is particularly influential in biological and physical processes, thawing degree-days are used commonly in arctic environments to compare spring and summer temperatures between sites or years. Cumulative thawing degree-days are computed as the sum in degrees Celsius of daily mean temperatures above zero over a particular period. Two National Weather Service (NWS) weather stations are located on opposite ends of the coastal study area, the Kubaruk weather station on the east and the Barrow's Wiley Post–Will Rogers Memorial Airport weather station on the west. A third weather station, at Colville Village on the Colville River delta, also has a 12-year data record for comparison.

At the eastern edge of the study area, in the Kubaruk oilfield (National Weather Service [NWS] Kubaruk weather station), the timing of snow melt was slightly earlier than average in 2008. Snow depth was above average on 15 May at the Kubaruk airstrip, but the snow melted rapidly during late May and was largely gone during the first week of June (ABR, unpub. data). Temperatures were well above average in late May and early June, above average in late June and early July, close to average in late July, and below

average in early August. Mean monthly temperatures in the Kuparuk oilfield in 2008 were 2° C warmer for both May and June than the long-term (20-year) mean for those months ([www.ncdc.noaa.gov/oa/ncdc.html](http://www.ncdc.noaa.gov/oa/ncdc.html)). Temperatures for Colville Village in 2008 were 2° C warmer in

May and 1° C warmer in June compared to the 12-year period for which data are available. During the period of waterfowl arrival and peak nest initiation (15 May–15 June), 107 cumulative thawing degree-days were recorded in the Kuparuk oilfield (Figure 2), the fourth warmest in 20 years

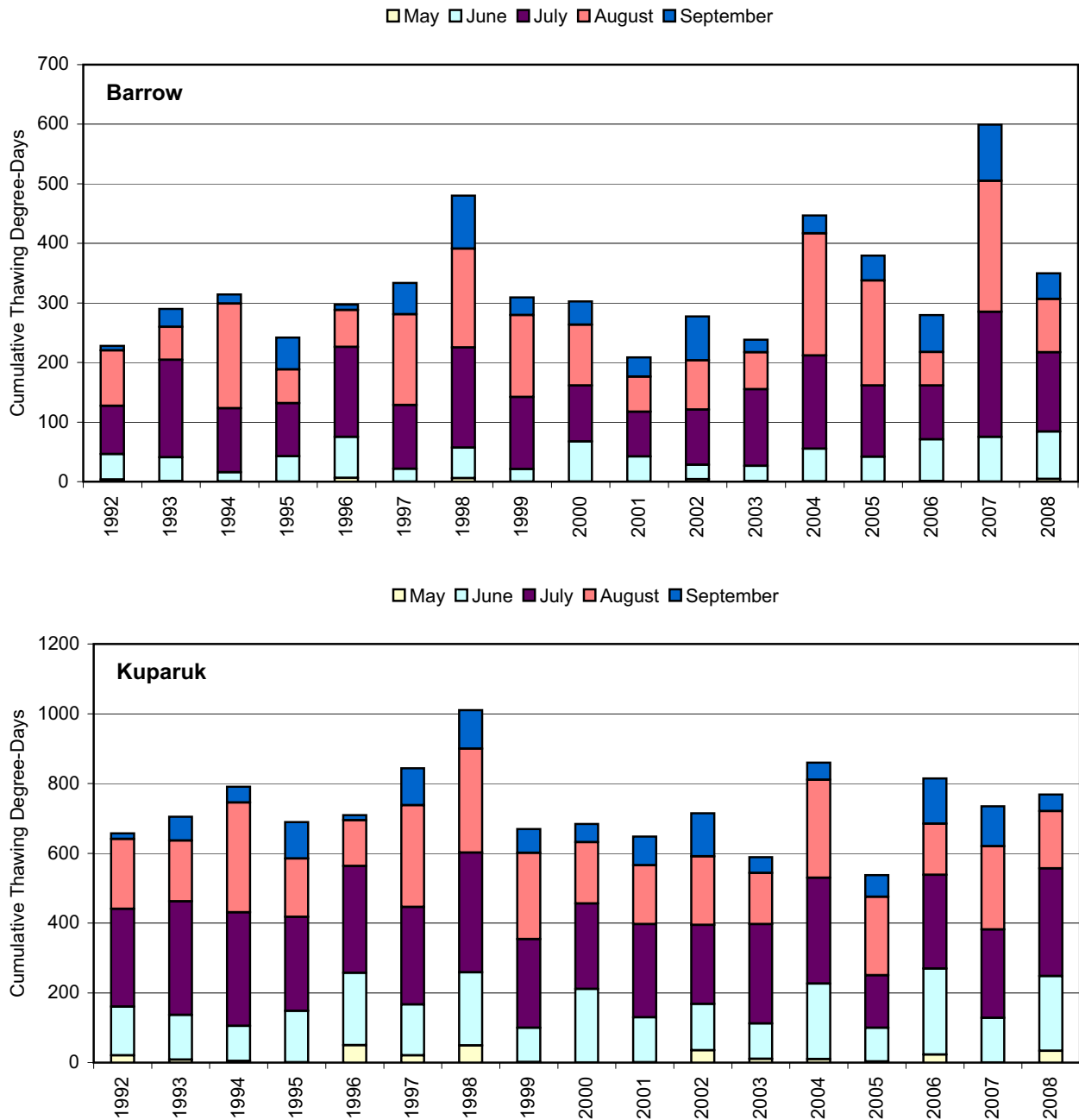


Figure 2. Thawing degree-days by month at the Barrow and Kuparuk Airport meteorological stations, Alaska, 1992–2008.

(range = 19–128 thawing degree-days). Temperatures were particularly warm at the end of May and 34 thawing degree-days were recorded for that month, the fourth highest in the 26-year record at Kuparuk. Warm temperatures continued into early June and the cumulative number of thawing degree-days for June was the third highest in the 26-year record. At Colville Village, 19 thawing degree-days were recorded in May, and the total of 65 thawing degree-days for the waterfowl arrival and peak nest initiation period was the third highest recorded for this area.

Barrow also experienced warm temperatures during May and the 5 cumulative thawing degree-days was the third highest in the 33-year record (Figure 2). June 2008 continued the warm trend with 79 cumulative thawing degree-days, the highest number on record at Barrow. July temperatures continued to be somewhat warmer than average, with 133 cumulative thawing degree-days, while cumulative thawing degree-days in August and September were

somewhat below the long-term mean. Until about 2005, temperatures in Kuparuk and Barrow appear to have tracked similarly; although Barrow is consistently cooler (the cumulative annual thawing degree-days at Barrow typically are between 200 and 300, versus 600–800 cumulative annual thawing degree-days at Kuparuk). Since 2005, however, these 2 stations have differed. Although located at the eastern edge of the study area, the Kuparuk station probably is more representative than the Barrow station for most of the study area in most years. In summary, weather and nesting conditions in 2008 appeared to be warmer than average during laying, incubation and hatching period, and near average during much of brood-rearing.

**BRANT**

**COLONY MONITORING SURVEYS**

All 45 Brant colonies were surveyed between 15 and 20 June 2008 (Figure 1, Table 1, Appendix B). Flight conditions were good on 15 and 16 June

Table 1. Number of Brant nests by survey section (region), number of monitoring colonies surveyed (target and maximum = 45), and number and percent of colonies occupied, Barrow to Fish Creek, Alaska, 1994–2008.

Year	Nests				Colonies		
	Dease Inlet	Smith Bay	Harrison Bay	Total	No. Surveyed	No. Occupied	% Occupied
1994	119	52	nd <sup>a</sup>	171	43	24	55.8
1995	204	50	40	294	45	40	88.9
1996	150	45	64	259	45	25	55.6
1997	208	43	73	324	44	32	72.7
1998	189	42	72	303	45	31	68.9
1999	275	35	61	371	45	38	84.4
2000	247	54	77	378	45	38	84.4
2001	285	30	71	386	43	33	76.7
2002	201	30	43	274	45	36	80.0
2003	300	48	21	369	44	34	77.3
2004	246	75	53	374	42	35	83.3
2005	205	92	20	317	45	33	73.3
2006	239	66	41	346	45	32	71.1
2007	207	71	25	303	43	34	79.1
2008	378	54	50	482	45	37	82.2
Mean	230.2	52.5	50.8	319.2 <sup>b</sup>	44.3	33.5	75.6

<sup>a</sup> nd = no data

<sup>b</sup> Does not include 1994 data because of Harrison Bay was incompletely surveyed in that year



2008, but on 16 June fog and low clouds obscured some colonies near Admiralty Bay and these colonies were revisited on 20 June. Two Brant colonies within the larger Snow Goose colony on the Ikpikpuk River delta were searched from a higher elevation (>250 m) to reduce disturbance to nesting Snow Geese. Some active Brant colonies showed evidence of nest loss or abandonment prior to the surveys (i.e., nesting material was scattered and few adults present), but signs of nesting attempts at unoccupied colonies were not apparent. No new colonies were identified in 2008. In 2008, we recorded a minimum of 482 nests at 37 occupied colony locations (Table 1), an increase of 59% from the previous year and roughly 51% higher than the average number of nests recorded during our 15 years of monitoring. The mean annual number of nests for all monitored colonies for the period 1995–2008 is 319 (range = 171–482 nests; Table 1, Appendix B; 1994 is excluded from the calculation due to incomplete survey in that year) and the total number of nests among all 45 colonies was relatively constant through 1997. The total number of Brant nests among the 45 monitored colonies appears to have increased since 1994 (Figure 3), particularly in the Dease Inlet region and, in the last decade, in the Smith Bay region (Figure 3).

Thirty-seven (82 %) of the 45 visited colonies were occupied (i.e., at least 1 nest was present) in 2008, compared with mean occupancy of 75.6% (33.5 colonies) over 15 years (Table 1). Over all 15 years, percent occupancy has ranged from 56% (1994 and 1996) to 89% (1995). Only 7 (16%) of all monitored colonies have been occupied in all 15 years of surveys (Figure 4). However, most colonies were used regularly during the study: 84% of all colonies were used at least 8 years during the study period. Similar colony sizes ( $n = 45$ ) were reported from surveys on Banks Island in 1992–1993 (Cotter and Hines 2000); for example, two-thirds of colonies comprised fewer than 10 nests. By comparison, the occupancy rate for the 10 Banks Island colonies that were surveyed in both years was 70% (Cotter and Hines 2000). Similarly, many small colonies on the central Arctic Coastal Plain in the Prudhoe Bay area are used intermittently (Stickney and Ritchie 1996).

Smaller colonies appear to have lower annual rates of occupancy, possibly a reflection of their

size. For example, colonies in our study area with <8 years of occupancy averaged fewer than 6 nests per colony during the 15-year monitoring period ( $n = 7$ , range 2–13 nests). The use of Brant colonies in the Central Arctic Coastal Plain also varied among years (Stickney and Ritchie 1996); some sites, deemed ‘secondary sites and tending to have <5 nests’, were used only once or intermittently during 4 consecutive survey years. Further, small aggregations of Brant may be more susceptible to predation, evidenced by small colonies having low nest success compared to larger colonies (Raveling 1989, Sedinger and Stickney 2000). For small colonies, in particular, the outcome of predation might be ‘abandoned’ colonies in some years.

The 45 Brant colonies in the survey are not divided equally among survey sections, 37 colonies are in the Dease Inlet section, 6 in the Smith Bay section, and only 2 in the Harrison Bay section (Figure 1). Among the 37 colonies in the Dease Inlet section, a total of 378 nests were observed in 2008, the highest number recorded during our 15-year study and substantially greater (64%) than the long-term mean of 230 nests (range 119–378, Table 1). The 6 colonies in the Smith Bay section had 54 nests in 2008, similar to the long-term mean of 53 nests (range 30–92), but 24% lower than the number recorded in 2007. The 2 relatively large colonies in the Harrison Bay section totaled 50 nests in 2008, also similar to the long term mean of 51 nests in that region (range 20–77), and double the number found in 2007. The number of Brant nests and percent occupancy of colonies appears to vary independently in each of the 3 survey sections. The maximum number of nests occurred in 2008, 2005, and 2000, in Dease Inlet, Smith Bay, and Harrison Bay respectively, and the minimum numbers in 1994, 2001–2002, and 2005, respectively. The 2 large colonies in Harrison Bay were occupied during every year they were surveyed (all years except 1994), while only 2–5 of 6 total colonies in Smith Bay and 19–33 of 37 total colonies in Dease Inlet were active annually. The largest number of total colonies active was in 1995 and the smallest in 1994. The lack of correlation in apparent breeding effort across the region suggests that factors affecting nesting effort or success differ among colonies or regions.

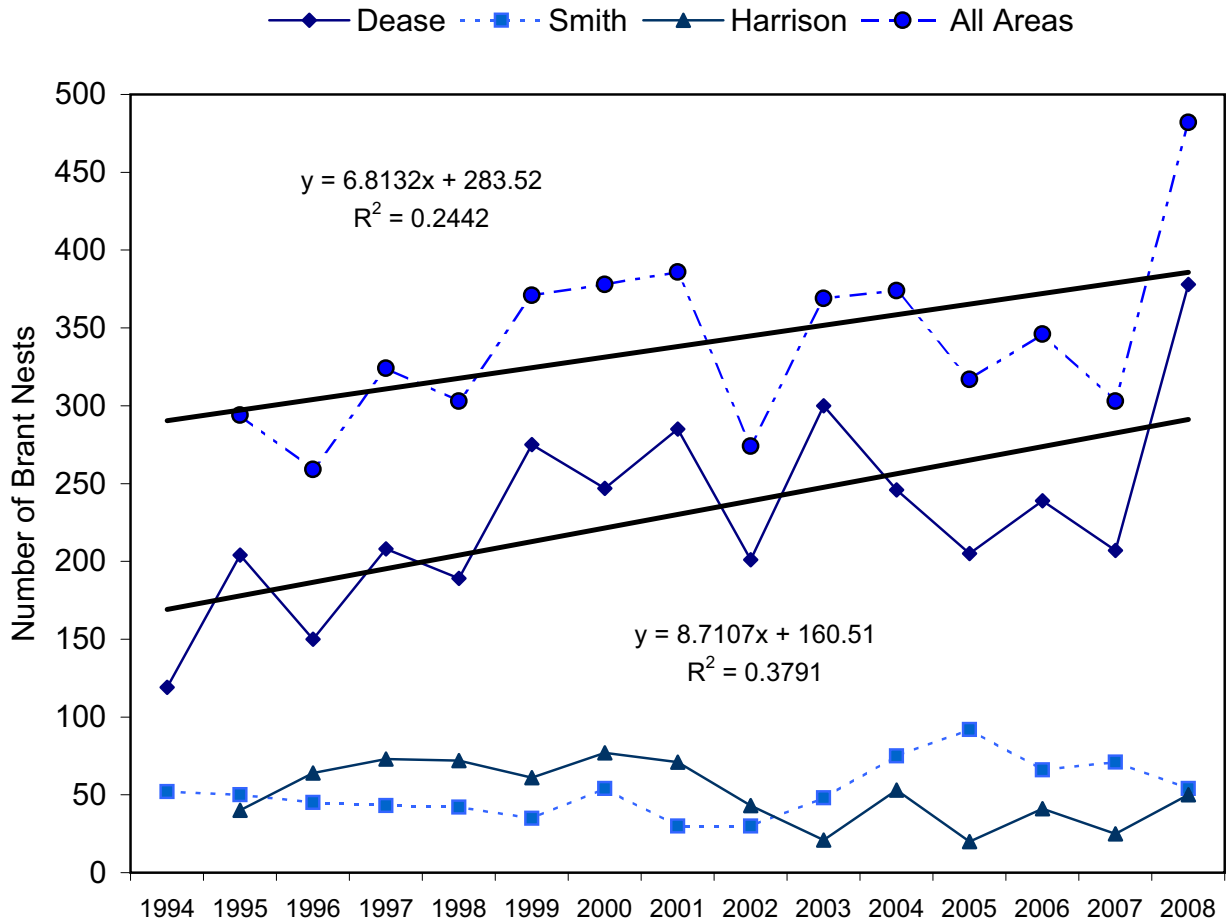


Figure 3. Number of Brant nests recorded on aerial surveys, Barrow to Fish Creek, Alaska, 1994–2008.



Figure 4. Distribution of years of occupancy among 45 Brant colonies that were monitored for 15 years, Barrow to Fish Creek, Alaska, 1994–2008.

Weather is an important influence on the breeding performance of arctic-nesting geese (Boyd et al. 1982, Alisauskas 2002). In particular, cold temperatures may prevent or reduce breeding if snow melt is delayed. Across the survey area, however, neither the warmest nor coldest Junes (Figure 2) were associated with high or low nesting effort at the 45 colonies monitored. Summing cumulative thawing degree-days for May and June at Barrow, the coldest nesting periods occurred in 1994, 1999, and 1997 (<22 thawing degree-days) and the warmest nesting periods occurred in 2008, 2007, 1996, and 2006 (>70 thawing degree-days). In Kuparuk, the coldest nesting periods were 1999, 2005, and 1994 (<106 thawing degree-days) and the warmest were 2006, 1998, and 1996 (>250 thawing degree-days). Excluding 1994 (when 2 large colonies were not surveyed), Brant nests were least abundant in the monitored colonies in 1996, 2002, and 1995 (<300 nests) and most abundant in 2001, 2000, 2004, and 2008 (>370 nests). Other factors that may affect the number of Brant nesting annually include predators, spring staging conditions, snow cover, flooding (or other weather factors possibly not well-represented by thawing degree-days).

## BROOD-REARING SURVEYS

### Aerial Counts

From the air, we visually estimated 12,429 Brant in 147 groups in the coastal area between Barrow and Fish Creek in 2008 (Table 2, Figure 5, Appendices C and D; adjusted estimates from photo counts are provided in the following section). This estimate included 8,946 adults in groups without broods, 2,163 adults in groups with broods, and 1,320 goslings. The number of adult birds was the fourth highest since 1995 (Figure 6), but 43% lower than the maximum recorded in 2003. The total number of brood-rearing groups was the third highest on record and the total number of groups was the second highest. However, only 32% of all Brant groups were brood-rearing groups (i.e., goslings were present) in 2008, compared to the mean of 43% brood-rearing groups over all 13 years of surveys. In 2008, the number of adults in brood groups was 43% higher than the long-term mean, and the number of goslings was the second-highest ever

recorded (51% higher than the mean value). Goslings comprised 38% of the total brood-rearing Brant counted in 2008, slightly higher than the annual mean of 36% over 13 years of surveys (Appendix E).

The number of brood-rearing/molting adult Brant in our coastal study area appears to have increased from 2,000–5,000 prior to 2001 to 7,000–20,000 after 2001 (Table 2), primarily due to an increase in the number of adults in groups without broods (Figure 6). Over all years, adult molting Brant in groups without goslings averaged 65% of total birds annually in this coastal area (Table 2). Between 1995 and 2000, 32–69% of adults were in groups without goslings. Between 2001 and 2004, the proportion of adults in groups without goslings increased to 82–91%. After 2005, the proportion of adults in groups without goslings decreased to 55–77%.

The distribution of brood-rearing and molting Brant among the 3 sections of the Beaufort Sea coast varies among years. In 2008, as in most years of this study, the Harrison Bay section contained the greatest number of Brant adults and goslings (Figure 7). The proportion of Brant found in the Harrison Bay section tends to be higher in years when the total number of Brant is higher, and the increase in total numbers typically is due to an increase in the numbers of adults in groups without broods. Spikes of Brant without broods in the Harrison Bay section probably result from an influx to the Teshekpuk Lake molting area of non-breeding and failed breeding birds from other areas of northern and western Alaska (see discussion below). This may have occurred in 2008, when numbers were over twice as high in Harrison Bay than in the other 2 sections combined, and the total number of Brant and the number of adults without broods both were well above the long-term mean. Gosling numbers were slightly below average in the Dease Inlet and Smith Bay sections, and above average in the Harrison Bay section in 2008 (Figure 7, Appendix D).

Although we believe that our coastal brood-rearing survey provides good information on the regional abundance of breeding Brant, it must be acknowledged that brood-rearing groups of Brant are also known to use inland habitats on the North Slope (Stickney and Ritchie 1996). In most

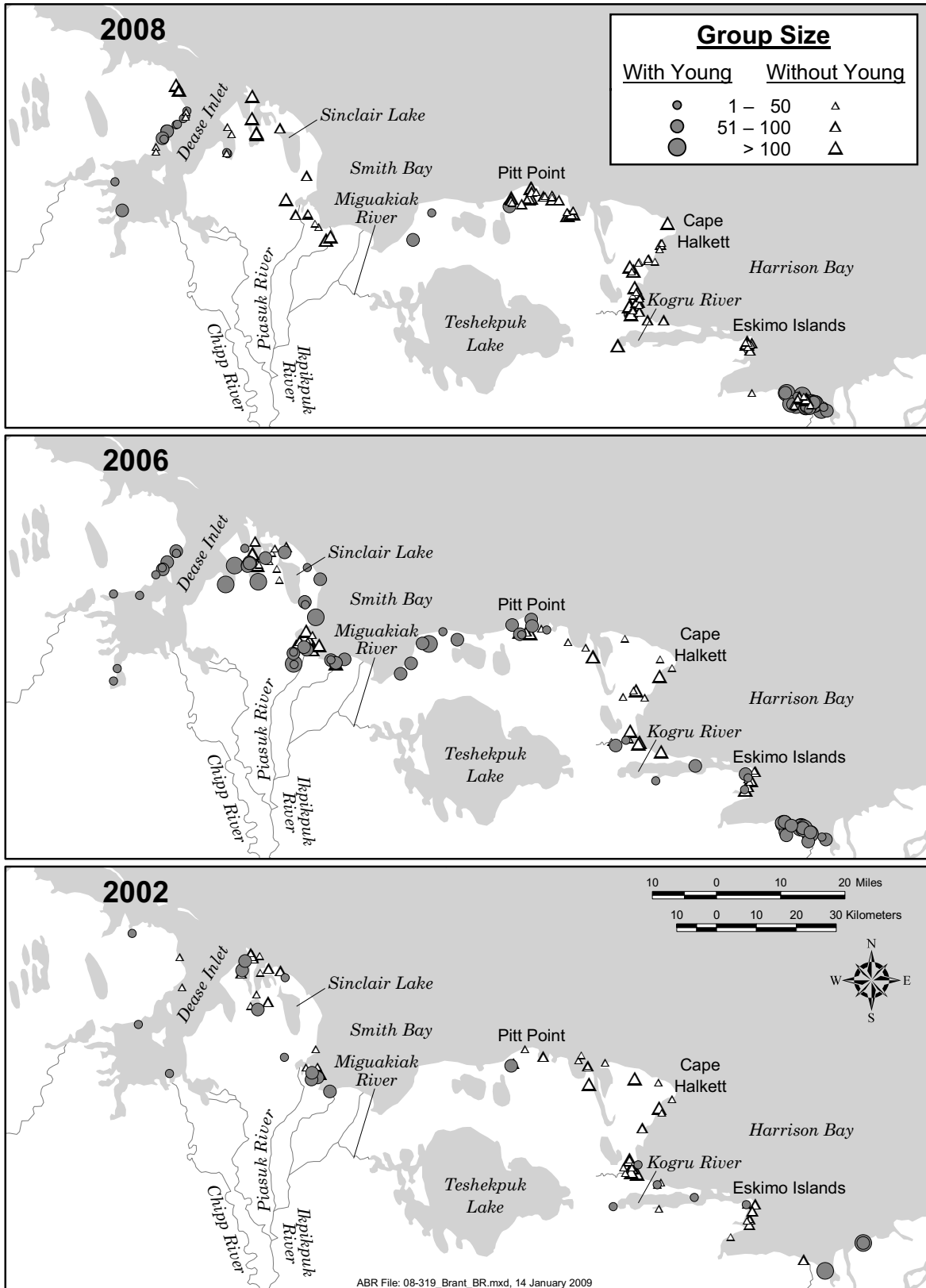


Figure 5. Distribution of Brant brood-rearing groups and groups without young, Barrow to Fish Creek, Alaska, 2002, 2006, and 2008.

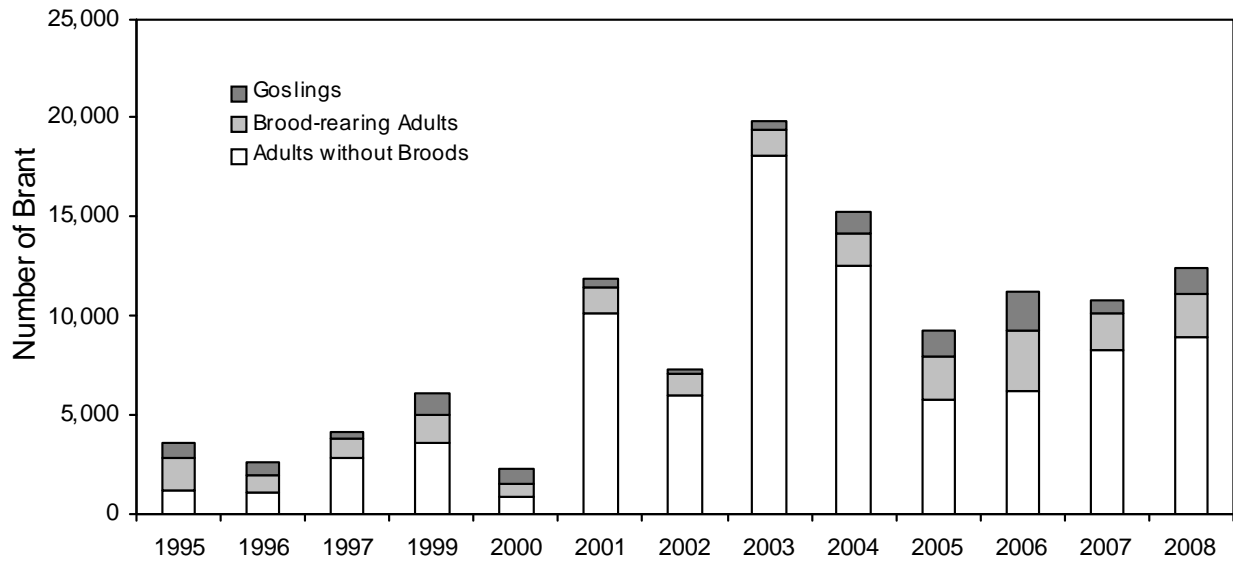


Figure 6. Numbers of adult Brant without broods, brood-rearing adult Brant, and goslings based on visual estimates during aerial surveys, Barrow to Fish Creek, Alaska, July 1995–1997 and 1999–2008.

parts of the North Slope, the number of brood-rearing Brant in inland habitats appears to be relatively small. One exception, however, may be the extensive area of large lakes north and east of Teshekpuk Lake, where large numbers of Brant occur regularly during July and where the USFWS conducts the Teshekpuk Lake molting survey annually during mid-July, when numbers of Brant typically peak in the area (Mallek 2009, Lewis et al. undated reports for 2007 and 2008). Our coastal brood-rearing survey during late July overlaps the coastal portion of the Teshekpuk Lake molting survey area and previous comparisons of our survey results with those of the USFWS molting survey (see Ritchie et al. 2008a) illustrated that Brant movements between the 2 surveys prevent a clear identification of birds counted by either survey for an improved estimate of total numbers of brood-rearing Brant. However, further comparisons and additional information, from an intensive study by Lewis et al. (undated reports on studies in 2007 and 2008) of numbers and movements in the molting area throughout the molting period, increase our confidence that our coastal surveys in late July provide fairly good estimates of the locally breeding population of Brant.

Although brood-rearing groups are present in the molting area, most of the Brant in the Teshekpuk Lake area are failed- and non-breeding birds that have migrated into the area from distant nesting areas, including other regions of the North Slope (Lewis et al. undated reports for 2007 and 2008) as well as the Yukon-Kuskokwim Delta (hereafter, the Y-K Delta) (Derksen et al. 1979, King and Hodges 1979). In 2008, the Teshekpuk Lake molting area survey (Mallek 2009) counted 19,397 adult Brant in the entire Teshekpuk Lake molting area on 15–18 July. Lewis et al. counted 23,356 Brant on the 33 main molting lakes in the Teshekpuk Lake molting area on 8–9 July 2008; this number fell to 17,425 (74.6%) on 29 July, and 9,185 (39.3%) on 4–5 August. During our coastal survey on 29–30 July, we counted only 5,332 adult Brant in the portion of our coastal survey that overlaps (approximately) the Teshekpuk Lake molting area. Not surprisingly, our coastal survey fails to document the bulk of the molting population. However, Mallek (2009) counted a total of 90 goslings in the entire Teshekpuk Lake molting area in mid July 2008, compared to a total of 112 goslings recorded by our coastal survey in late July, suggesting that by 29–30 July most broods had moved into the outer coastal zone covered by our survey.

Table 2. Composition of groups of brood-rearing/molting Brant based on visual estimates during aerial surveys, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Year	Total Groups		Brood Groups		Adults Without Broods		Adults With Broods		Total Adults	Goslings	Total Birds in Brood		% Goslings in Brood Groups	Total Birds	% Adults without Broods
	Groups	Broods	Groups	Broods	Without Broods	With Broods	in Brood Groups	Groups							
1995	39	25	1,180	1,552	2,732	909	2,461	36.9	3,641	32.4					
1996	38	26	1,130	828	1,958	633	1,461	43.3	2,591	43.6					
1997	72	30	2,866	885	3,751	423	1,308	32.3	4,174	68.7					
1999	96	46	3,605	1,378	4,983	1,070	2,448	43.7	6,053	59.6					
2000	25	19	790	670	1,460	808	1,478	54.7	2,268	34.8					
2001	76	20	10,102	1,308	11,410	435	1,743	25.0	11,845	85.3					
2002	84	21	6,020	989	7,009	262	1,251	20.9	7,271	82.8					
2003	118	29	18,070	1,295	19,365	450	1,745	25.8	19,815	91.2					
2004	167	49	12,536	1,609	14,145	1,091	2,700	40.4	15,236	82.3					
2005	106	36	5,747	2,202	7,949	1,305	3,507	37.2	9,254	62.1					
2006	125	72	6,170	3,092	9,262	1,975	5,067	39.0	11,237	54.9					
2007	139	36	8,347	1,756	10,103	716	2,472	29.0	10,819	77.2					
2008	147	47	8,946	2,163	11,109	1,320	3,483	37.9	12,429	72.0					
Mean	95	35	6,578	1,517	8,095	877	2,394	35.9	8,972	65.1					
SD	44	15	5,040	672	5,389	476	1,107	9.2	5,277	19.4					

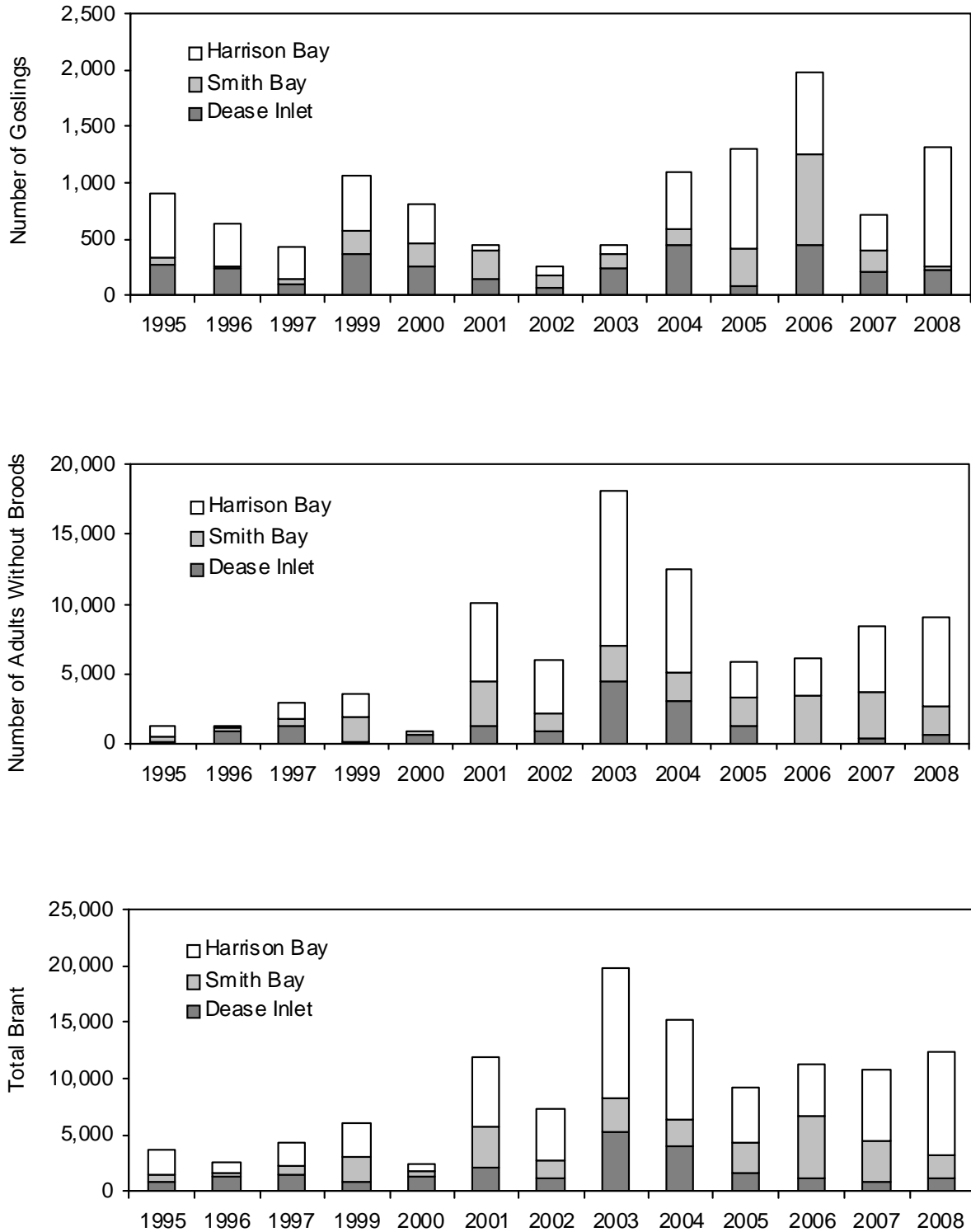


Figure 7. Distribution of Brant goslings, adults without broods, and total birds among 3 sections of the Beaufort Sea coast, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Lewis et al. reports additional data on the regional movements of Brant that further support that our coastal survey accounts for most of the brood-rearing birds in the region. According to Lewis et al., the numbers of Brant in the Teshekpuk Lake area peaked in early to mid July and remained relatively constant until about 25 July both 2007 and 2008. In both years, approximately 40% of Brant in the Teshekpuk Lake molting area occupied coastal habitats in mid July. Although few broods were present in either coastal or inland portions of the Teshekpuk Lake area, fewer than half of all goslings that were present were located in coastal habitats during the USFWS survey in mid-July (20 of 45 goslings in 2007, 38 of 90 goslings in 2008; Mallek 2008, 2009). Lewis et al. further reported that by late July 2007 and 2008, Brant numbers declined in the Teshekpuk Lake molting area as molting adults without goslings began to regain flight, apparently dispersing to adjacent terrain outside the area of the molting survey. Furthermore, the distribution of Brant shifted toward the coast, and greater than 90% of Brant in the Teshekpuk Lake molting area were located in coastal salt-marsh habitats by 30 July each year (Lewis et al. reports for 2007 and 2008), which is concurrent with our coastal survey (29–30 July in 2008). These observations suggest that our surveys probably do include a relatively high proportion of local breeding Brant. They also suggest that our coastal surveys may include many of the molting adults that have dispersed to coastal areas within and adjacent to the Teshekpuk Lake molting area by late July.

Although somewhat aside from our study objectives, mounting evidence indicates that the molt migration of Brant to the Teshekpuk Lake molting area involves failed and non-breeding birds from across the North Slope as well as from the Y-K Delta. Lewis et al. tagged Brant whose nests had failed near Barrow, Dease Inlet, and on the Colville River delta in 2007 and subsequently documented many of these failed breeders in both coastal and inland portions of the Teshekpuk Lake molting area. Notably, of 19 Brant trapped at failed nests in the Colville River delta, at least 12 molted in the Teshekpuk Lake area, and 9 of those were relocated on the salt marsh slough at the mouth of Garry Creek (Lake 149, in Mallek 2009). In 2008, this slough contained 2,374 (12.2%) of the total

19,397 adult Brant recorded in the Teshekpuk Lake molting area survey (more than any other single waterbody; Mallek 2009) and 1,185 (10.7%) of the total 11,109 adult Brant recorded on our entire coastal survey. Of 7 failed breeders tracked from colonies near Dease Inlet and Barrow in 2007, 4 molted on inland lakes and 2 molted in coastal lakes in the Teshekpuk Lake molting area, and 1 molted in a coastal lake outside of the Teshekpuk Lake molting area.

Additional evidence indicates a molt migration to Teshekpuk Lake from the Y-K Delta. In 2003, for example, when productivity of Brant on the Y-K Delta was particularly low due to predation and flooding (C. Nicolai, Univ. of Nevada Reno, pers. comm.), we observed record numbers of Brant in our study area. A further comparison of the number of Brant nests in 5 colonies on the Y-K Delta (data from Wilson 2008) with the number of adults without young in our survey area suggests a molt migration to coastal North Slope areas covered by our surveys. Since 1995 (the first year of our survey), the estimated total number of nests at those 5 colonies has decreased at a rate of about 907 nests/yr ( $R^2 = 0.35$ ,  $P = 0.042$ ; Figure 8), while the number of molting adults in our survey area has increased by about 641 birds/yr, although this trend did not differ significantly from zero ( $R^2 = 0.27$ ,  $P = 0.084$ ; Figure 8). Beyond these general trends, we also found a strong negative correlation between the annual count of nests on the Y-K Delta and the number of molting adults without young in our survey area (Pearson  $r = -0.85$ ,  $n = 12$ ,  $P < 0.01$ ; Figure 9).

Based on the numbers of goslings, annual productivity for Brant in our study area was highest in 1999, 2004, 2005, 2006 and 2008; lowest in 1997, 2001, 2002, and 2003; and near average in other years (Figure 7). Overall, 1997, 2001, and 2002 appeared to be years of low productivity for Brant in other parts of their range as well (S. Boyd, CWS [Canadian Wildlife Service], pers. comm.; C. Nicolai, Univ. of Nevada Reno, pers. comm.; J. Hines, CWS, pers. comm.). Summing thawing degree-days for May through July at Barrow, the coldest years were 2001, 2002, and 1994 (<125 thawing degree-days) and the warmest years were 2007, 1996, and 1998 (>225 thawing degree-days). At Kuparuk, the coldest years were 2005, 1999,



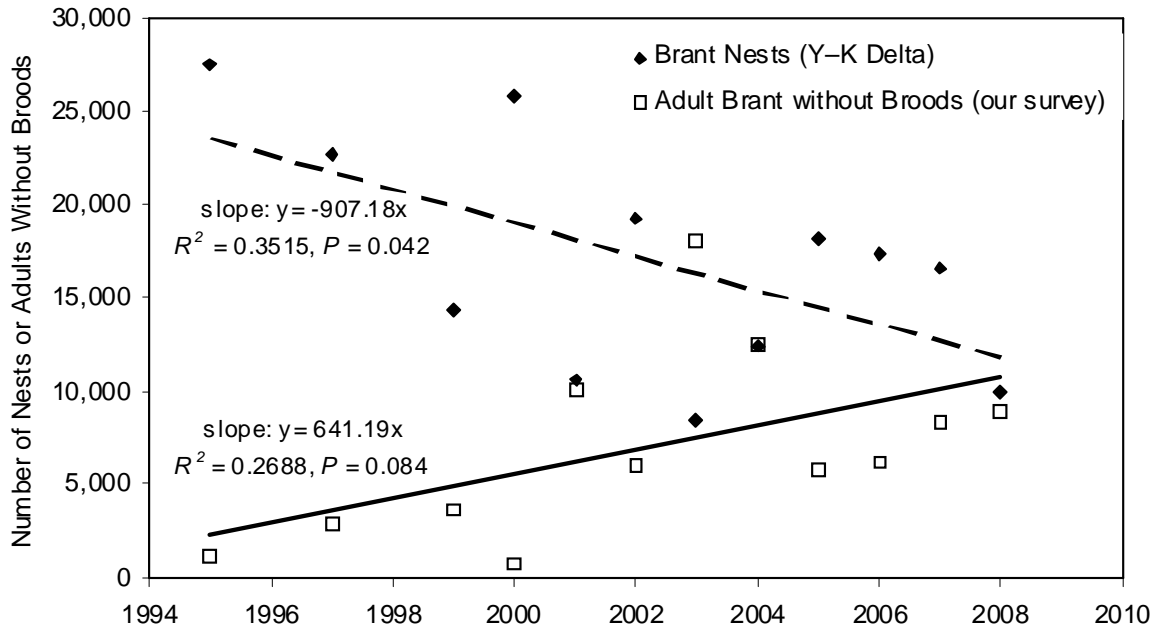


Figure 8. Trends in: A) the estimated total number of Brant nests in 5 nesting colonies on the Yukon-Kuskokwim (Y-K) Delta (dashed line; from Wilson 2008) and B) the number of adult Brant in groups without broods between Barrow and Fish Creek, Alaska, (solid line) in 1995, 1997, and 1999–2008 (years in which data were available from both areas).

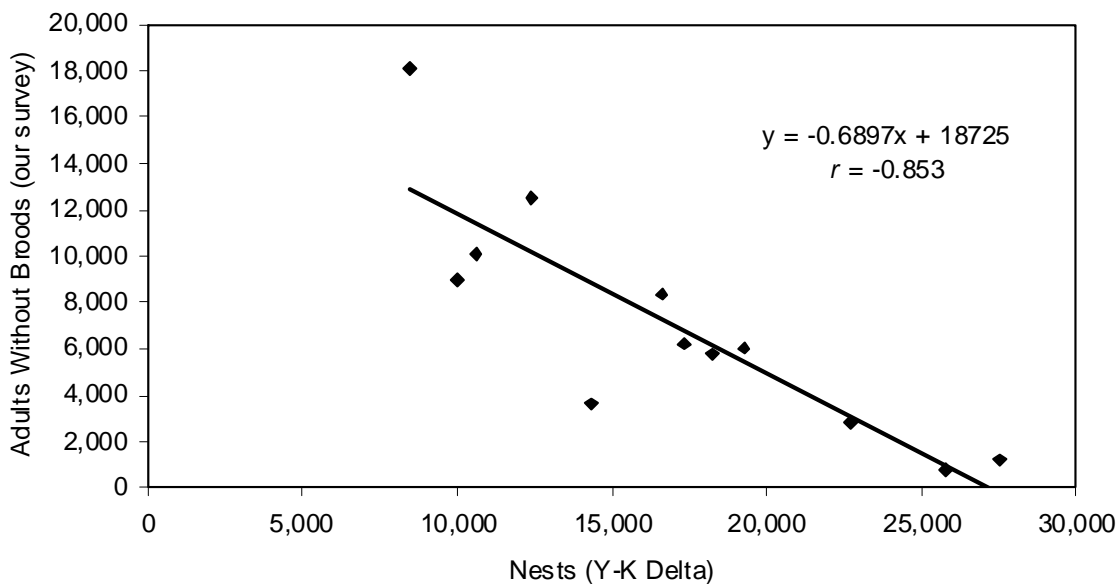


Figure 9. Correlation between the estimated total number of Brant nests in 5 nesting colonies on the Yukon-Kuskokwim Delta (Wilson 2008) and the number of adult Brant in groups without broods between Barrow and Fish Creek, Alaska, in 1995, 1997, and 1999–2008 (years in which data were available from both areas).

and 2007 and the warmest years were 1998, 1996, and 2008. Thawing degree-days in both Barrow and Kuparuk appear to correlate poorly with overall productivity of Brant in this region.

The 3 years with both the largest numbers of goslings and the largest number of adults in brood groups were 2005, 2006, and 2008, and the brood-rearing data suggest an increasing trend in the breeding population and productivity of Brant in the region since 1994, particularly since 2002 (Figure 6). The apparent increase in Brant productivity since 2002 is correlated with a concurrent increase in Snow Goose numbers, especially in the Smith Bay region, which could suggest a benefit to Brant from “predator swamping” in nesting and brood rearing areas (i.e., more geese reduces the overall proportion of the goose population susceptible to predators). Prior studies have demonstrated higher nest success in larger Brant colonies compared to smaller colonies (Raveling 1989) and have linked increased predation rates on Brant nests to reduced populations of alternative prey species (Anthony et al. 1991), generally supporting the hypothesis that Brant may benefit from greater numbers of Snow Geese. However, few monitored Brant colonies in the Smith Bay region are co-located with Snow Goose colonies (although some unmonitored colonies may exist in the vicinity of nesting Snow Geese) and it would be difficult to demonstrate density-dependent benefit during the brood-rearing period.

In the long term, one might predict a negative impact on Brant from a substantial increase in Snow Goose numbers due to degradation of salt marsh habitats used by both species during brood rearing (see Snow Goose section). Intense grazing by Brant, focused exclusively on above-ground biomass, appears to have no lasting deleterious effects on salt marsh grazing lawns (Person et al. 1998). In contrast, Snow Geese remove rhizomes and meristematic tissue by grubbing in the spring, which can result in long-term degradation of these plant communities in the vicinity of nesting colonies (e.g., Kerbes et al. 1990, Abraham and Jefferies 1997).

#### Photo Counts and Population Estimate Adjustments

Previous analyses indicate that aerial counts are accurate for group sizes up to about 50 birds and we attempted, therefore, to photograph all brood-rearing groups larger than 50 total birds. We obtained photos of 34 of 47 Brant brood groups in 2008 to assess the accuracy of our aerial estimates of group size and improve the precision of our counts (Appendices C, F). From visual estimates, photographed groups ranged in size from 27 to 200 Brant. All 13 brood groups without photographs had <50 estimated Brant (range 4–48 total birds). As in past years, photo counts were almost always higher than visual estimates. Overall, we detected 21% more adults and 41% more young on photographs than we estimated from the air. After replacing visual estimates with photo counts for the 34 photographed groups, the 2008 population estimates increased from 2,163 to 2,590 adults with broods and from 1,320 to 1,814 goslings (with 8,946 adults without broods, 13,350 total birds).

Since 2002, photo counts have revealed that our aerial estimates are accurate for group sizes up to about 50 Brant, but that we usually underestimated numbers of adults and young for larger group sizes (Ritchie and Shook 2005, Appendix G). We also have found that the accuracy of aerial estimates varies among observers. We conclude, therefore, that aerial photos are a valuable tool for improving counts of groups larger than 50 total birds (>50) but that aerial counts are adequate for smaller groups. Despite this bias, efforts still should be made to accurately enumerate birds in large groups from the aircraft to protect against data loss through operator error or equipment malfunction. Finally, because the accuracy of aerial estimates of large groups varies among observers, and because we have used different observers over the course of this multiyear project, the photo census results can be used only to correct estimates for the year in which they were taken (2001–2008).

**SNOW GEESE**

**COLONY MONITORING AERIAL AND GROUND SURVEYS**

From our aerial survey and the results of surveys by NSB at Kasegaluk Lagoon, Snow Geese were confirmed nesting at 4 locations west of the Colville River delta in 2008: 1) the traditionally used islands on the Ikpikpuk River delta, 2) a traditionally used island in the Kukpowruk River delta, Kasegaluk Lagoon (R. Suydam, NSB, pers. comm.), 3) a small colony near the Fish Creek mouth, and 4) a small colony near Garry Creek (Figure 10). Since our colony searches began in 1991, we have located Snow Geese nesting at >20 sites (Ritchie et al. 2000, 2002; Ritchie 2001; Ritchie and Shook 2003; this study), including at least 15 locations with multiple nest sites (Figure 10). Because nesting Snow Geese are surveyed opportunistically during efforts focused on 45 specific Brant colonies, these

numbers cannot be considered accurate totals for the study area, although clearly the vast majority of nesting Snow Geese in the region are located in the Ikpikpuk River delta and the other large colonies on the Sagavanirktok River delta, the Colville River delta, and the Kukpowruk River delta.

Of these 4 Snow Goose colonies, only the small colony of 40 pairs at the mouth of Garry Creek had not been recorded in previous years. Snow Geese have nested previously in small numbers just south in the vicinity of the Kogru River mouth, particularly in years when the Ikpikpuk River delta was flooded during nest initiation (e.g., 1996, Ritchie and Rose 1996), and non-breeding flocks are observed frequently on upper Gary Creek. (At least 200 non-breeding Snow Geese were present in upper Gary Creek on 15 June 2008.) The small colony near the mouth of Fish Creek had 20 nests in 2008 and has been occupied (by fewer pairs) in previous years (Ritchie and Burgess 1993, Ritchie and Rose 1996,

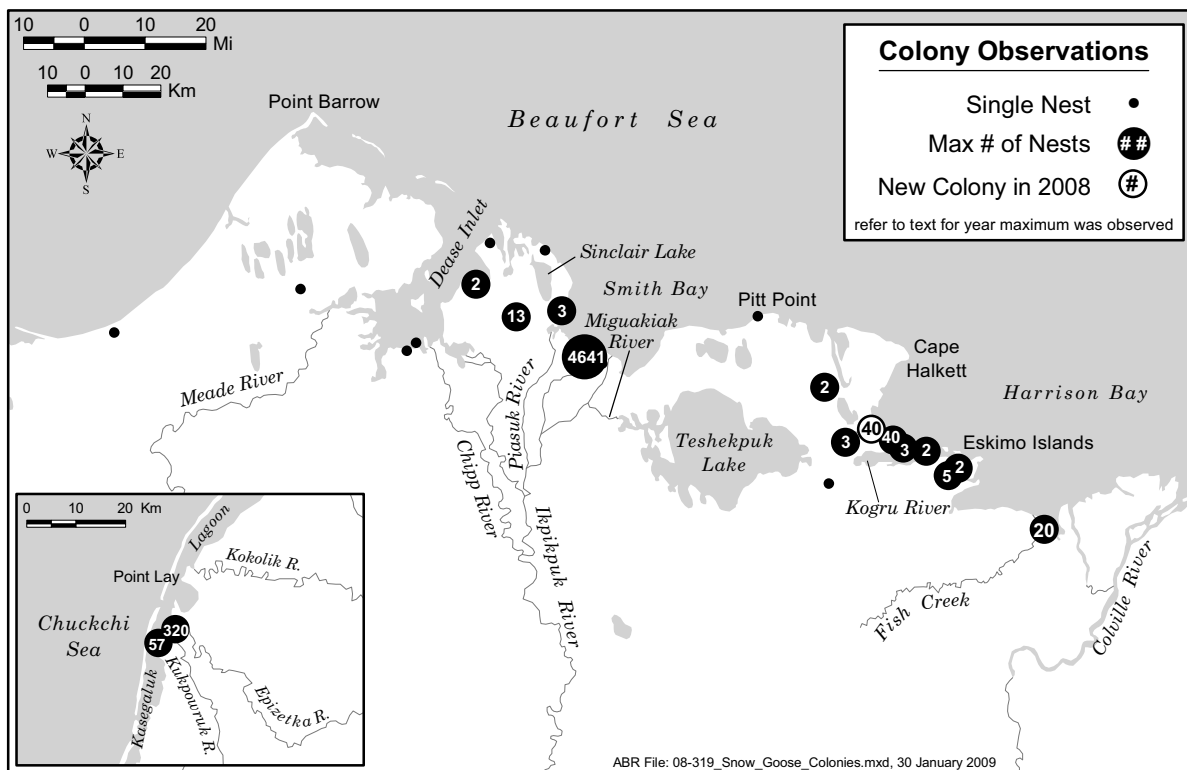


Figure 10. Maximum number of nests (over all survey years) at each location where Snow Geese have been recorded nesting, Barrow to Fish Creek, Alaska, 1992–2008.

Ritchie et al. 2007). The colony near Pt. Lay on the Kukpowruk River delta was visited by NSB personnel after hatch on 7 July 2008 and 320 nests were counted (R. Suydam, NSB, pers. comm.). No effort was made in 2008 to determine the presence of nesting Snow Geese at the mouth of the Epitzeka River, or other areas that have been used by Snow Geese in Kasegaluk Lagoon.

Often single Snow Geese nests also are recorded between Barrow and the western channel of the Colville River (Ritchie et al. 2000, 2004). In 2008, however, no single Snow Goose nests were reported at Brant colonies in this region.

Outside of our survey area, ~310 Snow Goose nests were observed on the Colville River delta in 2008 (~200 nests in the north eastern portion and ~110 nests in the central delta, plus a group of ~100 birds in flight; Tim Obritschkewitsch unpubl. data). And a record number of 1,060 nests was reported in the Sagavanirktok River delta on Howe and Duck islands (Streever et al. 2009).

In 2008, nesting Snow Geese again were widely distributed across the Ikpikpuk River delta as they have been since 2006, including islands in the eastern delta (Figure 11). Nearly 15,000 Snow Geese (Table 3), comprising ~3,500 possible nesting pairs and an additional ~8,000 flying birds, were recorded on numerous islands on the Ikpikpuk River delta during the 15 June aerial survey. Our 2008 estimate, albeit a rough calculation, suggests a substantial increase in abundance since 2007, a >60% increase in total birds and a near doubling of numbers of nesting pairs.

Survey conditions were good (clear, good visibility) and the estimated number of nesting pairs from 2008 aerial surveys (3,473) was higher than reported in all previous years (Ritchie et al. 2007, 2008a). As usual, the estimate of nest numbers increased following the ground surveys of specific nesting islands and the helicopter-assisted surveys of other islands later in the summer (Table

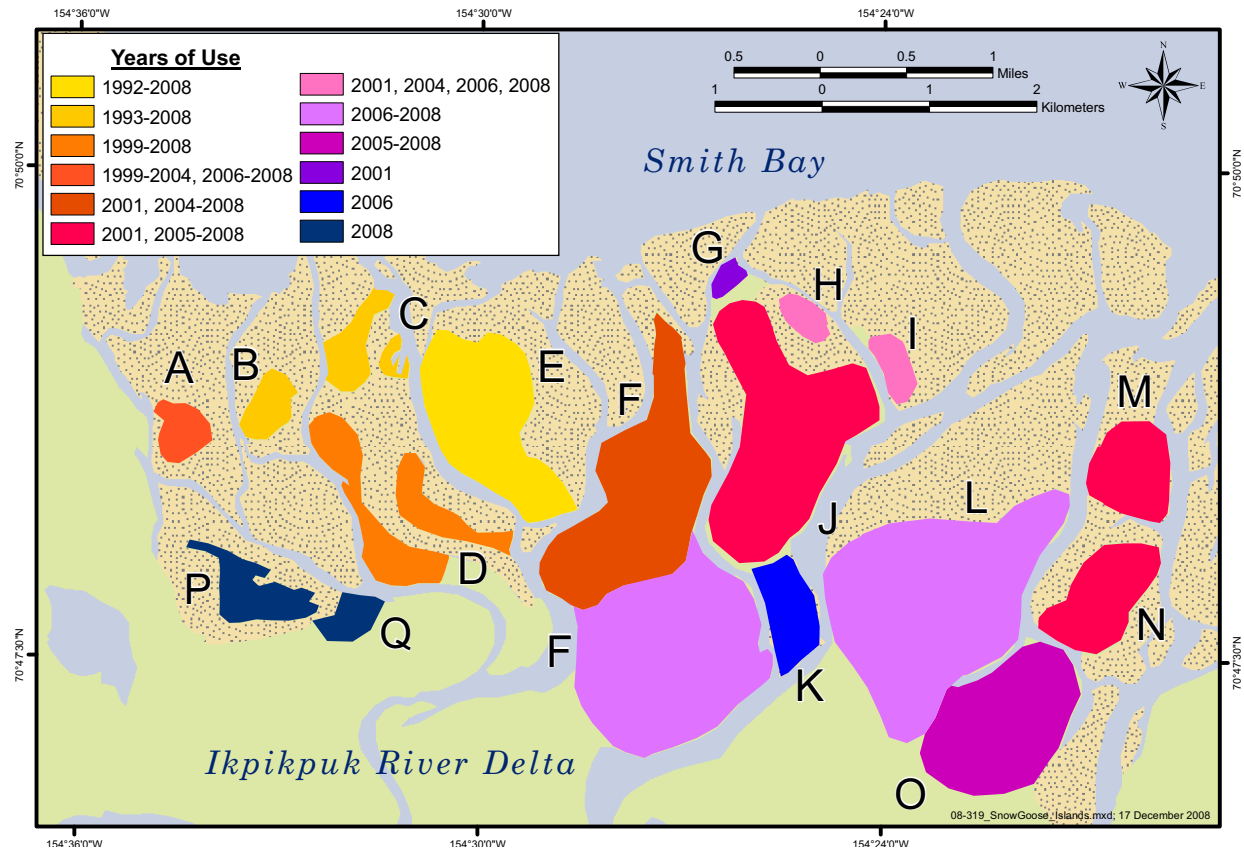


Figure 11. Islands on the Ikpikpuk River delta used for nesting by Snow Geese each year 1992–2008.

Table 3. Number of adults, minimum number of nests, and estimated nesting success of Snow Geese at the Kukpowruk River delta and Ikpikpuk River delta colonies, 1991–2008.

Year	Kukpowruk			Ikpikpuk		
	Adults <sup>a</sup>	Nests <sup>b</sup>	Nesting Success	Adults <sup>a</sup>	Nests <sup>b</sup>	Nesting Success
1991	185	55	nd	nd	nd	nd
1992	130	26	8%	200	~60 <sup>c</sup>	7%
1993	135	44	89%	140	42	21%
1994	10	0	nd	20	5	nd
1995	68	36	11%	200	55	nd
1996	nd	57	65%	0	0	nd
1997	nd	35	0%	160	50	nd
1998	nd	46	4%	195	nd	nd
1999	45	5 <sup>d</sup>	nd	552 <sup>e</sup>	176	nd
2000	nd	13	0%	1,500 <sup>e</sup>	250 <sup>e</sup>	nd
2001	nd	9 <sup>d</sup>	nd	1,230	335 <sup>f</sup>	48% <sup>c</sup>
2002	147	41 <sup>d</sup>	nd	1,232	918 <sup>f</sup>	63%
2003	nd	18	≥44%	1,364	1,149 <sup>f</sup>	97%
2004	nd	nd	nd	2,900	1,436 <sup>g</sup>	90%
2005	nd	nd	nd	2,390	1,116 <sup>g</sup>	70%
2006	nd	nd	nd	4,421	2,386 <sup>g</sup>	86%
2007	nd	204	61%	9,300	2,505 <sup>g</sup>	85%
2008	nd	320	nd	14,398	4,641 <sup>g</sup>	89%

<sup>a</sup> Estimate of adults from aerial survey only, number of adults equals all adults in flight and associated with nest sites

<sup>b</sup> Number of nests determined from aerial surveys, except at Kukpowruk from North Slope Borough ground searches in 1996–1998, 2000–2001, 2003, and 2007–2008 (R. Suydam, NSB, pers. comm.), and at Ikpikpuk from ground counts or combined aerial and ground counts, as footnoted below in 2001–2008

<sup>c</sup> ~60 nests were recorded during aerial survey, 43 nests were recorded during incomplete ground search (only one of 3 islands was searched)

<sup>d</sup> Aerial surveys in 1999, 2001, and 2002 included the Epizetka River mouth, 2 miles north of Kukpowruk River. In 1999, all nests were located near the Epizetka River mouth and none were found at the Kukpowruk River.

<sup>e</sup> Transcription errors: 1999: previously reported as 452 adults; 2000: previously reported as 1,450 adults and 225 pairs; 2001: previously reported as 45%

<sup>f</sup> Ground count (aerial counts were ~245 nests in 2001, 446 nests in 2002, and 532 nests in 2003)

<sup>g</sup> Combined data from ground counts (conducted only a sample of the colony) and aerial estimates (minimum values of 52, 9, 627, 645, and 1,999 additional nests estimated from the air in 2004–2008, respectively; total aerial estimates for the same years were 1,212, 695, 1,023, 1,065, and 3,423 nests)

3). As noted in 2006 and 2007, we consider these numbers to be rough estimates because the large size of the colony and high density of nests no longer allow accurate estimates from simple aerial survey. We recommend that future census efforts focus on aerial photo-census of the colony to obtain more accurate counts of nesting pairs (e.g., Kerbes 1982). Standard methods for aerial photo-census of large Snow Goose colonies have

been established (Kerbes 1982) and protocols include timing the census during mid-incubation and conducting the photo flight at altitudes >300 m to prevent disturbance to nesting pairs. Similarly-timed photo-surveys on the Kukpowruk River (Ritchie and Burgess 1993) and on Howe Island on the Sagavanirktok River delta (e.g., Burgess and Ritchie 1993) have proven very effective for mapping nest distribution and

accurately estimating nest numbers, and also assisted in subsequent ground-based assessments of nesting success.

Time constraints, poor accessibility, and high numbers of nests limited the ground search effort in July to most of the 4 major nesting islands on the western delta in 2008 (Islands C, D, E, and F; Figure 11). Location and nest fate data were collected on 2,642 nests during that July ground census (Figure 12). During banding in August, we attempted to enumerate the remaining nests on foot and by low-level (<20 m) helicopter survey, but many nests had been washed away by a storm in late July. From the June aerial survey, we conservatively estimate an additional 1,999 nests in areas not searched on the ground. Combined, these efforts indicate 4,641 nests or an 85% increase from the number of nesting pairs estimated in 2007 (Table 3).

The distribution of Snow Goose nests at the Ikpikpuk River delta in 2008 was similar to that observed in 2006 and 2007, in that nests were distributed extensively across the entire delta (Appendix H, Figure 11). Only 40% of Snow Goose nests in 2008 were located on the 5 islands with the longest history of use (i.e., Islands A–E) in the western part of the colony (Table 4). In 2008, the largest number of nests (1,673; 36%) was located on Island F, centrally located in the Ikpikpuk River delta. With increases in use in recent years, Island F now comprises the main nesting area of the colony, and increasing numbers of Snow Geese recently have nested farther inland on Island F, in wet sedge tundra habitats that previously were uncharacteristic of Snow Goose nesting habitats in the region. Only 24% of nests occurred in the eastern delta in 2008, although we believe that the aerial survey estimates used on the eastern delta undoubtedly were low.

Of 2,625 nests of known fate (fate was determined only for nests examined during the ground-search, excluding 1,999 nests estimated from the air), 89% were successful (at least 1 egg hatched) (Table 4, Figure 12). Between 2001 and 2008, nesting success ranged from 48% (2001) to 97% (2003) (Table 3). Data collected from smaller samples of nests during shorter visits to the colony in 1992 and 1993 suggested much lower productivity in those years: 7% in 1992 (Ritchie

and Burgess 1992) and 21% in 1993 (Ritchie and Burgess 1993).

A smaller Snow Goose nest colony in the Sagavanirktok River delta (east of Prudhoe Bay) has been monitored since 1984 and provides an interesting comparison with the Ikpikpuk River delta colony. Between 1984 and 2008, nesting success of Snow Geese in the Sagavanirktok River delta has ranged widely from 0–97% (not including 1992 when only 2 pairs nested [both successfully], and 2003 when data were not collected [Johnson 2000; Noel et al. 2004; Burgess and Ritchie 1993; Rodrigues et al. 2006, 2007]). Between 1984 and 2002, the number of Snow Goose nests in the Sagavanirktok River delta fluctuated wildly, with no known nests in some years and up to 455 nests in 1993. Major nesting failures (when most or all pairs in the colony failed) occurred at Howe Island during 1991, 1992 (Johnson 2000), 1994, 1997, 1998, 2000, and 2001. These failures were attributed to mammalian nest predators (arctic foxes and/or brown bears) in all years (see Burgess and Ritchie 1993, Johnson 2000, Noel et al. 2004, and summary information in Burgess and Ritchie 1993). Since 2004, the number of nests on the Sagavanirktok River delta has increased annually from 324 in 2004 to 1,060 in 2008, with high nesting success between 64% and 94% (91% in 2008).

Snow Goose breeding populations have been expanding in North America since at least the 1960's (Kerbes 1983, Kerbes et al. 1983, McCormick and Poston 1988, Alisauskas and Boyd 1994) perhaps due to increased winter survival due to the availability of increased agricultural resources in wintering areas (Davis et al. 1989). Snow Geese forage by grubbing for roots and rhizomes during spring prior to emergence of above-ground vegetation (Kerbes et al. 1990). This behavior, coupled with high fidelity to breeding areas (Ganter and Cooke 1998) has resulted in long-term degradation of some nesting areas and arctic coastal salt marshes used for brood-rearing (Kerbes et al. 1990, Ganter et al. 1995, Srivastava and Jefferies 1996). Over-population of breeding colonies has led to decreased growth and survival of goslings (Cooch et al. 1991, Williams et al. 1993, Gadallah and Jefferies 1995), and dispersal of young breeders to higher quality breeding areas (Ganter and Cooke 1998).

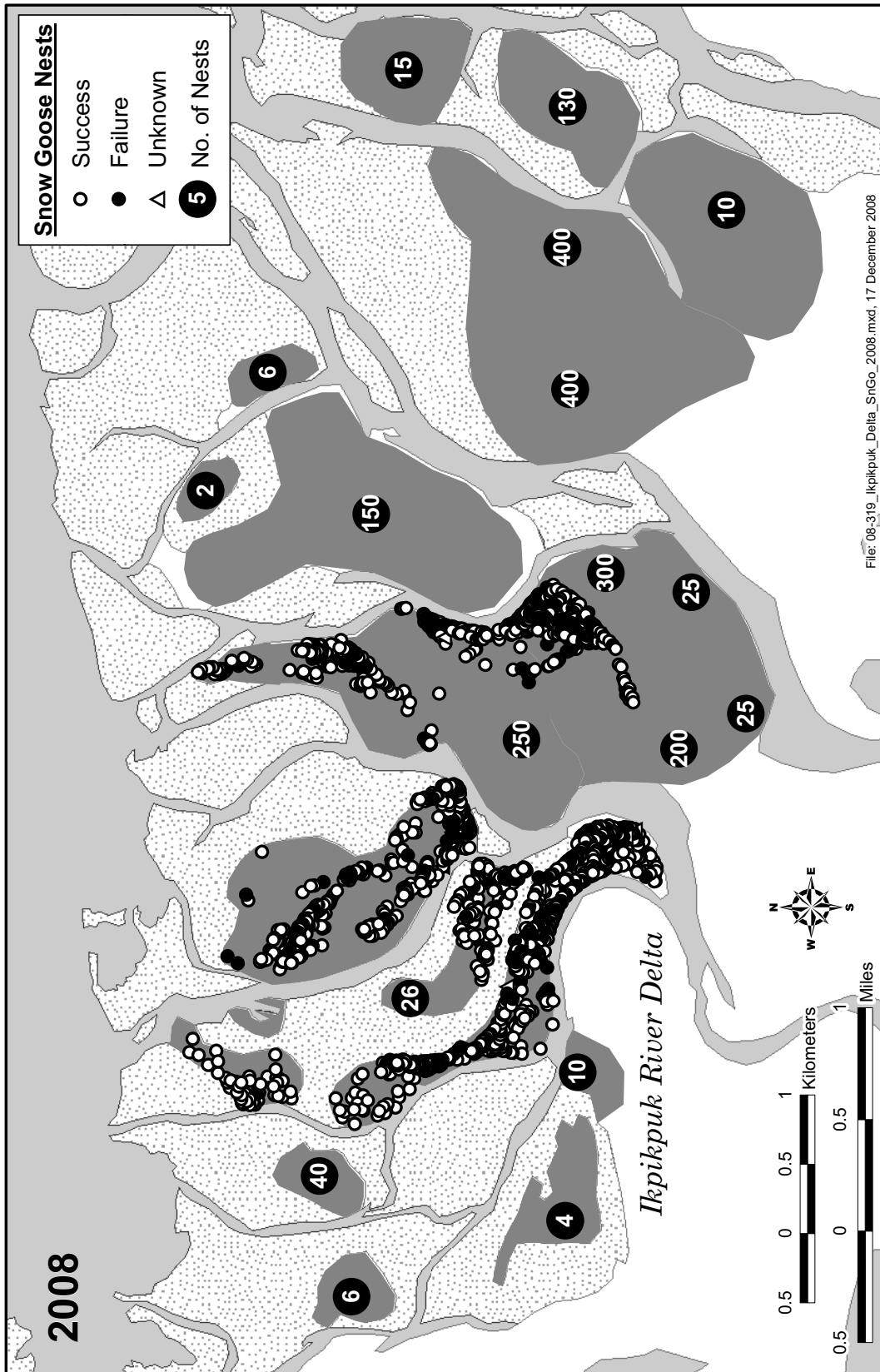


Figure 12. Locations and fates of Snow Goose nests on the Ikpikpuk River delta, 2008.

Table 4. Number of Snow Goose nests (from ground searches in most of Islands C–F combined with minimal estimates from aerial surveys in other areas) and nest fate by nesting island, Ikpikpuk River delta, Alaska, July–August 2008.

Island <sup>a</sup>	Nest Fate			Total
	Failed	Successful	Unknown	
A			6	6
B			40	40
C	3	92	0	95
D	161	936	35	1,132
E	60	503	5	568
F	73	797	803	1,673
G			0	0
H			2	2
I			6	6
J			150	150
K			0	0
L			800	800
M			15	15
N			130	130
O			10	10
P			4	4
Q			10	10
Total	297	2,328	2,016	4,641

<sup>a</sup> See Figure 11

Currently, visible evidence of grazing and grubbing by Snow Geese in the Ikpikpuk delta is limited to a small area of polygonal tundra near nesting areas and an apparently vast areal extent and standing crop biomass in the area appears capable of sustaining continued colony growth (B. Person, NSB, pers. comm.). There are indications, however, that numbers of Snow Geese are increasing across much of the North Slope, consistent with patterns of population growth and colony expansion throughout North America. The sudden increase in the number of nests reported on the Sagavanirktok River delta, in 2006 and again in 2008 also suggests a potential for rapid expansion of numbers in the central Beaufort Sea area, as do observations of an expanding colony on islands on the Colville River delta where ~310 nests were observed in 2008 (Tim Obritschkewitsch, ABR, unpubl. data), and recent reports of moderately large numbers of nesting or molting Snow Geese at other locations on the Colville River delta and in the Kuparuk oilfield.

## BROOD-REARING SURVEYS

### Aerial Estimates

The number of Snow Geese in the Barrow–Fish Creek region during brood-rearing surveys in 2008 was higher than in any previous year: 15,935 Snow Geese were estimated in 279 groups prior to photo analysis (Table 5, Figure 13, Appendices I and J). Of 279 total groups, 206 (74%) included broods and 73 were adults only. Brood-rearing groups comprised 6,014 adults and 6,508 young. The total number of young was higher than in any previous year except 2006. The ratio of goslings to adults in brood rearing groups was 52% in 2008, which was equal to the average for 1995–2008 (range 40.6–59.4%, Table 5, Figure 14).

As in previous years, most Snow Geese (90%), including goslings, were located in the Smith Bay section (Figure 15, Appendix J). Most of the remaining Snow Geese were found in the Harrison Bay section, with approximately 0.3% in the Dease Inlet section. Only 3.5% of goslings



Table 5. Composition of Snow Geese groups based on visual estimates during brood-rearing surveys, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Year	Total Groups	Brood Groups	Adults Without Broods	Adults With Broods	Total Adults	Goslings	Total Birds in Brood Groups	% Goslings in Brood Groups	Total Birds
1995	13	13	0	198	198	232	430	54.0	430
1996	7	4	107	63	170	85	148	57.4	255
1997	22	10	384	98	482	138	236	58.5	620
1999	31	23	278	515	793	624	1,139	54.8	1,417
2000	42	29	485	623	1,108	910	1,533	59.4	2,018
2001	31	19	422	352	774	241	593	40.6	1,015
2002	37	27	110	1,013	1,123	863	1,876	46.0	1,986
2003	48	44	38	1,511	1,549	1,816	3,327	54.6	3,365
2004	69	50	891	2,382	3,273	2,005	4,387	45.7	5,278
2005	74	43	2,995	1,916	4,911	1,521	3,437	44.3	6,432
2006	152	143	211	5,527	5,738	6,672	12,199	54.7	12,410
2007	118	82	2,095	2,635	4,730	2,645	5,280	50.1	7,375
2008	279	206	3,413	6,014	9,427	6,508	12,522	52.0	15,935
Mean	71	53	879	1,757	2,637	1,866	3,624	51.7	4,503
SD	75	59	1,171	1,979	2,814	2,242	4,210	5.9	4,924

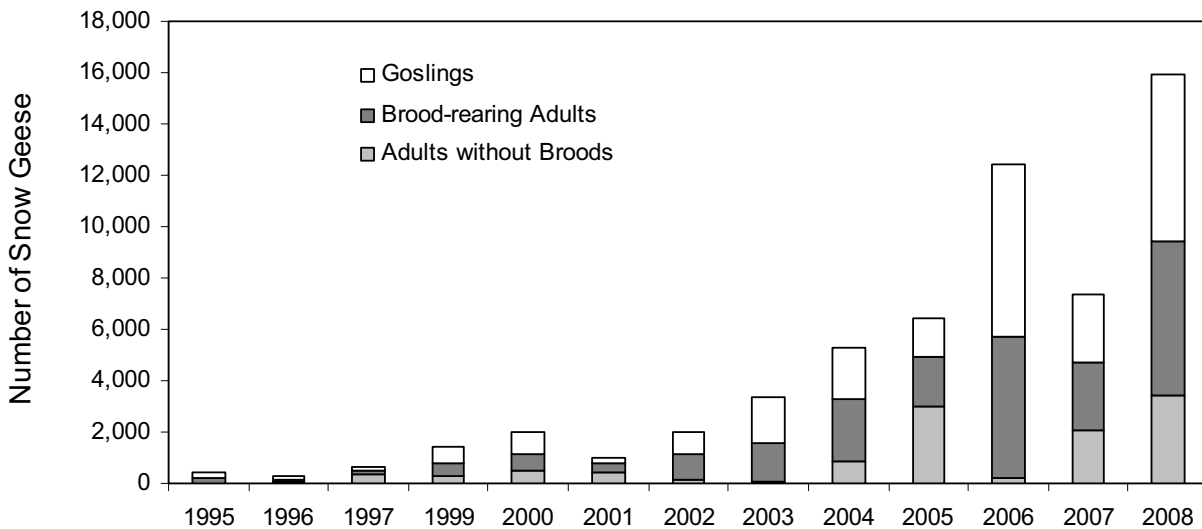


Figure 13. Numbers of adult Snow Geese without broods, brood-rearing adult Snow Geese, and goslings based on visual estimates during aerial surveys, Barrow to Fish Creek, Alaska, July 1995–1997 and 1999–2008.

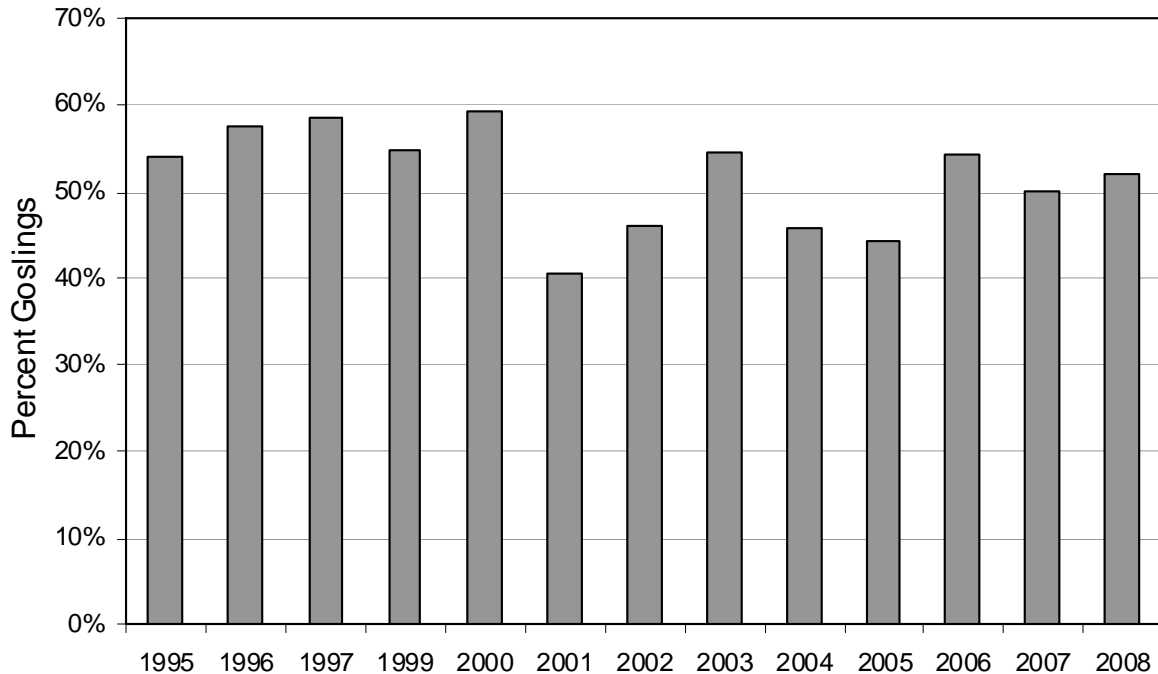


Figure 14. Percent goslings in Snow Goose brood-rearing groups, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

were located in Dease Inlet and Harrison Bay combined. Observations during June surveys and records of nesting in the past (Ritchie et al. 2000) suggest that although birds in all 3 sections could have originated from the nesting colony on the Ikpikpuk River delta (in the Smith Bay section), it is likely that many of the broods recorded in the Harrison Bay section originated from small colonies between Cape Halkett and Fish Creek, including those documented in 2008 near the Kogru River mouth and Garry Creek.

As previously mentioned, the Teshekpuk Lake area molting goose survey was conducted about 2 weeks prior to our brood-rearing survey in 2008; their count of Snow Geese was 4,072 adults and 570 goslings (Mallek 2009). Again, our surveys primarily are restricted to coastal environments, while the Teshekpuk Lake molting goose survey covers coastal and inland lakes north and east of Teshekpuk Lake, including about half of our coastal survey in Section 4 (east from the eastern coast of Smith Bay) and about 1/3 of our coastal survey in Section 5 (west as far as Garry Creek). In the overlapping area (approximated), the molting

goose survey in mid-July enumerated 375 adult Snow Geese and 262 goslings, while we recorded 1,637 adult Snow Geese and 461 goslings in late July in lakes that probably were included in both surveys. Of the 4,072 total adult Snow Geese recorded by the molting survey, 2,913 adults and 7 goslings were located in the Garry Creek area, nearly all of which (2,814 adults and 7 goslings) were in the inland section of the creek where we did not survey. In contrast, the molting goose survey recorded only 99 adults (and no goslings) in Lake 149 (the salt slough at the mouth of Garry Creek), where we observed 887 adults and 5 goslings about 2 weeks later. Variable use of Lake 149 by Snow Geese accounted for a large shift in distribution between coastal and inland habitats during the molting/brood-rearing season in 2007 as well (Lewis et al. no publication date; report for 2007). Movements of geese during the last half of July along Garry Creek and possibly farther west into inland lakes (as suggested by 2007 results [Ritchie et al. 2008a]) likely account for much of the difference between the 2 surveys in the area of overlap.

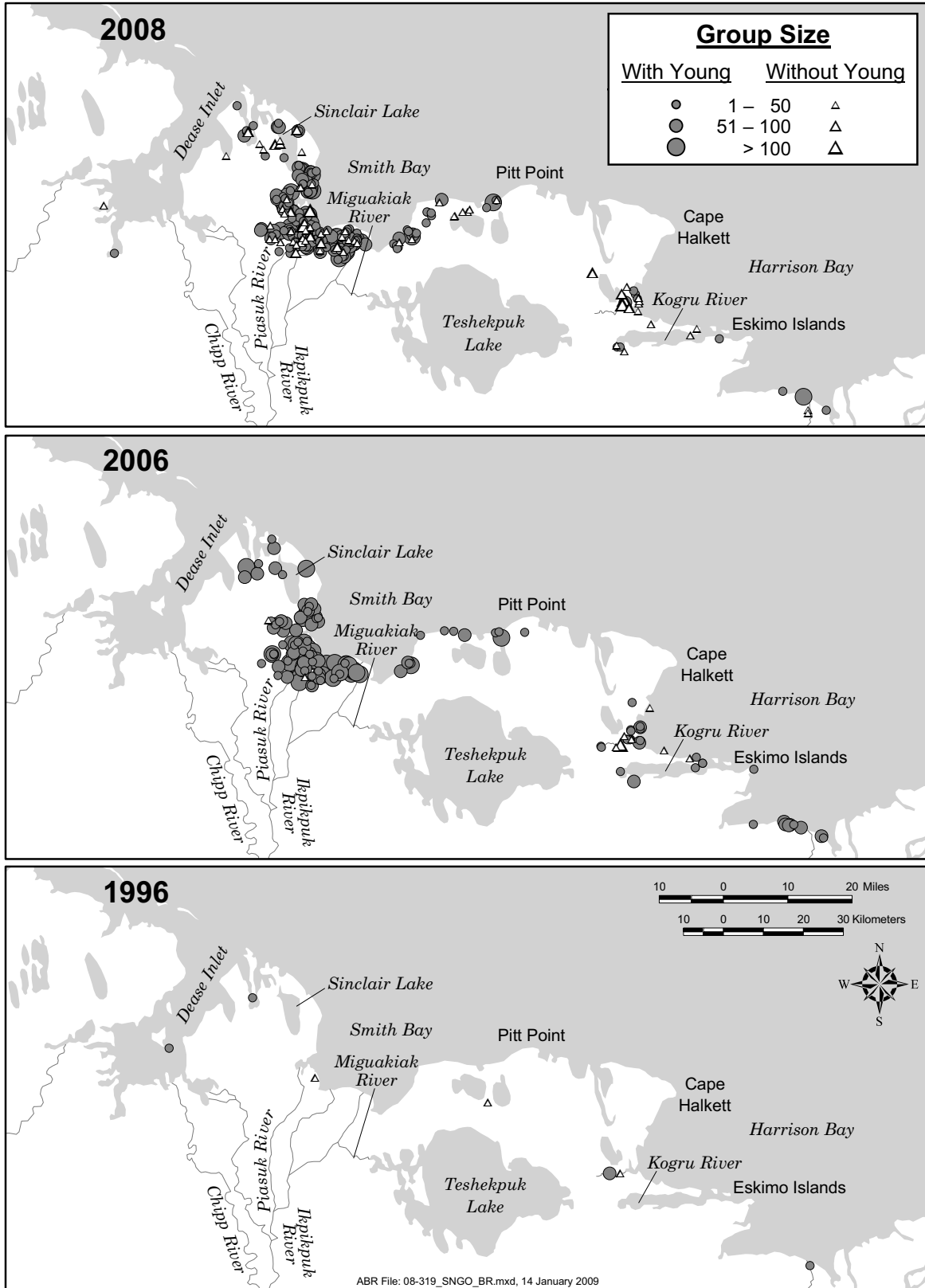


Figure 15. Distribution of Snow Goose brood-rearing groups and groups without young, Barrow to Fish Creek, Alaska, 1996, 2006, and 2008.

The rapidly increasing population of Snow Geese in the region also has been documented by the Teshekpuk Lake molting goose surveys, which have been conducted annually since 1982 (Mallek 2009). Numbers of molting Snow Geese (gosling not included) first exceeded 500 geese in 1997, 1,000 in 1999, and 2,000 in 2001. Numbers continued to increase from 2003–2007, breaking 4,000 in 2006, and exceeding 6,000 in 2007 before dropping to just over 4,000 in 2008 (Mallek 2009). While these numbers parallel increases in the number of breeding Snow Geese in local colonies, it is not certain that these large numbers of molting Snow Geese are associated with the local breeding colonies and evidence suggests that unknown numbers of failed breeders or non-breeding Snow Geese may migrate into the Teshekpuk area from colonies farther afield, as has been demonstrated for Brant and other geese in the region, perhaps including birds associated with Canadian or Russian nesting areas. It is clear from the rate of colony growth that emigration from breeding and molting areas outside of the State of Alaska is largely responsible for the rapid increase in abundance of Snow Geese in the region. Previously, Snow Geese have been relatively uncommon in Alaska outside of fall and spring migrations, and the rate of growth in numbers of both breeding and molting Snow Geese in the Teshekpuk Lake region (including the Ikpikpuk River delta and the Teshekpuk Lake molting lakes) clearly exceeds what could be accounted for by production and survival in the handful of small Alaskan colonies. Observations both west and east of our survey coverage on the North Slope of Alaska indicate a regional increase in the abundance of breeding Snow Geese, including the Kasegaluk Lagoon area to the west (Robert Suydam, NSB, pers. comm.), the Colville River delta (R. Johnson, ABR, pers. comm.), and the Sagavanirktok River delta to the east (Streever et al. 2009).

#### Photo Counts and Population Estimate Adjustments

Previous analyses indicated that aerial counts are accurate for group sizes up to about 50 birds and we attempted, therefore, at a minimum to

photograph all groups larger than 50. We obtained photos of 149 of 206 Snow Goose brood-rearing groups in 2008 (Appendix K) to assess the accuracy of our aerial estimates of group size and improve the precision of our population estimates. From visual estimates, we photographed brood-rearing groups that ranged from 14 to 340 Snow Geese (adults plus young) (Appendix K). All 57 brood groups without photographs had 50 or fewer Snow Geese (range 5–50 total birds). We detected 61% more adults and 46% more young on photos than in our aerial estimates. When visual estimates were replaced with photo counts for the 149 photographed groups, the total number of adults in brood groups increased from 6,014 to 9,355, the number of goslings increased from 6,508 to 8,306, and the total number of Snow Geese increased from 15,935 to 21,074.

Photos also provide a more accurate determination than aerial counts of the proportion of blue-phase geese in the population. We identified 232 adult blue-phase geese on photos of brood-rearing Snow Geese in 2008, equaling 2.6% of all adult Snow Geese in these photos. Blue-phase Snow Geese in the groups we have captured for banding have ranged from 1–5% of total birds since 2000 (Ritchie 2001; Ritchie et al. 2002, 2004, 2006, 2007, 2008a; Ritchie and Shook 2003, 2005). Prior to rapid growth of the Ikpikpuk colony, blue-phase Snow Geese rarely were observed in northern Alaska (<1% on Howe Island, Johnson and Troy 1987; also Ritchie et al. 2000) and blue-phase geese represent only a small percentage (<0.5%) of the nearest mainland Snow Goose colonies in western Canada (J. Hines, CWS, pers. comm.). In contrast, blue-phase Snow Geese are much more common in nesting colonies in the eastern Canadian arctic (Dzubin 1979). The higher percentage of blue-phase geese in our study area suggests the possibility of immigration from such colonies in eastern Canada or a “founder effect” (e.g., resulting from a handful of blue-phase individuals being present during the founding of the Ikpikpuk colony). A blue-phase goose was recorded in Smith Bay as early as 1981 when the Ikpikpuk colony probably comprised fewer than 50 pairs (Johnson and Troy 1987).

## SNOW GOOSE BANDING AND BAND RETURNS

Birds were banded at 3 sites across the Beaufort Sea coast in 2008: the Ikpikpuk River delta, the Colville River delta, and the Sagavanirktok River delta. In total, 2,772 birds were banded in 2008, including 1,143 adults or subadults and 1,629 goslings (59%). Efforts at a fourth site on the Kukpowruk River delta were unsuccessful at capturing birds due to logistical constraints, but the reconnaissance there and at the nearby village of Point Lay should facilitate future efforts. Recaptures in 2008 totaled 195 birds, 176 of which were originally banded on the Ikpikpuk River delta in previous years. Other recaptured birds were originally banded (in previous years) in the Sagavanirktok River delta (including Foggy Island Bay) (8 birds), the Colville River delta (5 birds), in northern Canada (Nunavut and Northwest Territories, 4 birds), and Russia (Wrangel Island, 2 birds). Over all banding sites, 58 blue-phase Snow Geese were captured (2.1%), 26 adults and 32 goslings.

Since the inception of banding at the Ikpikpuk and through 7 March 2009, band returns have been reported by the USFWS Banding Laboratory from 25 of the lower 48 states (562), from 7 Canadian provinces (204), from Alaska (20), from 5 states of Mexico (13), and from Russia (2) (Table 6). (Please note that these details need to be confirmed further, as discrepancies in location information have been noted for a number of records reported to us by the Banding Laboratory.) The distribution of returns and recaptures suggests wide-ranging wintering areas and migratory routes generally similar to those reported for Snow Geese banded 1980–1990 in the Sagavanirktok River delta (Johnson 1996) and Western Arctic Snow Geese in Canada (Kerbes et al. 1999). However, a fairly large number of band returns from Snow Geese banded since 2000 on the Ikpikpuk River delta (Figure 16) were peripheral to the main loci for wintering and spring use areas of the earlier Sagavanirktok River delta birds and the Western Arctic Snow Goose Population, including Arkansas (19 total, including 15 banded as goslings and 4 females banded as adults), Illinois (1 male banded as an adult and 1 female banded as a gosling), Kansas (19 total, including 13 banded

as goslings and 3 females banded as adults), Kentucky (1 female banded as a gosling), Louisiana (6 total, 4 banded as goslings, 1 adult male, and 1 adult female), Mississippi (a male and a female banded as goslings), eastern Nebraska (of 15 returns from Nebraska, 4 were in eastern Nebraska, 3 banded as goslings and 1 adult male), eastern Texas (of 46 returns from Texas, 9 were in eastern Texas: 3 from the Dallas area and 6 from the Gulf Coast, including 5 birds banded as goslings and 3 adult females), Manitoba (a male and a female banded as goslings), and Nunavut (3). Although there is a fair amount of mixing between populations, particularly for male birds, these eastern states and provinces are in the primary migration routes and winter areas of the Central Arctic and Eastern Arctic populations of Lesser Snow Geese, breeding in the eastern Canadian arctic (Bellrose 1976, Francis and Cooke 1992). Banding results and returns through 7 March 2009 are presented separately for each banding area in the following sections.

### Ikpikpuk River Delta

In 2008, we captured 1,393 Snow Geese in 7 groups on the western Ikpikpuk River delta. Of these, 1,212 were newly banded prior to release: 429 adults or subadults (after hatching year or AHY; 35%) and 783 goslings (65%). Recaptures totaled 178 adult and subadult geese in 2008 (39% of total adults and subadults). Females comprised 39.2% of adults and 54.4% of goslings. As in most previous years, most of the geese we banded were white-phase (96%). In 2008, 47 blue-phase geese were banded on the Ikpikpuk River delta (3.8% of all geese captured), including 28 goslings. Since 2000, we have banded 8,197 Snow Geese (3,230 adults and 4,962 goslings) and processed 8,953 birds (including recaptures) on the Ikpikpuk River delta.

From the Ikpikpuk banding sites, a total of 746 bands have been returned since 2000 (through 7 March 2009) approximately 9.1% of the 8,197 birds banded (Table 7). All but 3 returns have been hunter killed or otherwise reported dead. Three returns were of birds banded in 2003 that were recaptured and released alive during banding operations at other colonies (see below). The largest number of band returns occurred in 2007 (162) and the smallest number in 2001 (12). Over

Table 6. Band returns of Snow Geese (through 6 December 2008) by season, region, and state. Snow Geese were banded at the Ikpikpuk River delta, 2000–2008, and at the Colville River delta and Sagavanirktok River delta/Foggy Island Bay areas, 2008.

Region State/Province/District	Season					Total
	Fall	Winter	Spring	Summer	Unknown <sup>a</sup>	
Alaska			15	4	1	20
Canada						
Alberta	101	11		1	1	114
Manitoba	1		1			2
Northwest Territories	1		6	3		10
Nunavut			2	1		3
Saskatchewan	70	3	2			75
Lower 48						
Arizona		2				2
Arkansas		18	3			21
California	3	345	2		3	353
Colorado		12	27		1	40
Idaho		3			2	5
Illinois		1				1
Iowa			1			1
Kansas		12	1			13
Kentucky		2				2
Louisiana		6				6
Mississippi		1				1
Missouri		6	3			9
Montana		9				9
Nebraska			18			18
Nevada		2				2
New Mexico		7				7
North Dakota			4			4
Oklahoma		1	1			2
Oregon		3				3
South Dakota			14			14
Texas		41	3			44
Washington		1				1
Wyoming		2	2			4
Mexico						
Baja California (Norte)			1			1
Chihuahua		1				1
Durango		3				3
Sonora		4				4
Tamaulipas		4				4
Russia						
Chukotka (Wrangel Island)				2		2
Total	176	500	106	11	8	801

<sup>a</sup> Date unknown, reported by the Banding Lab as “hunting season” because return was from a hunter

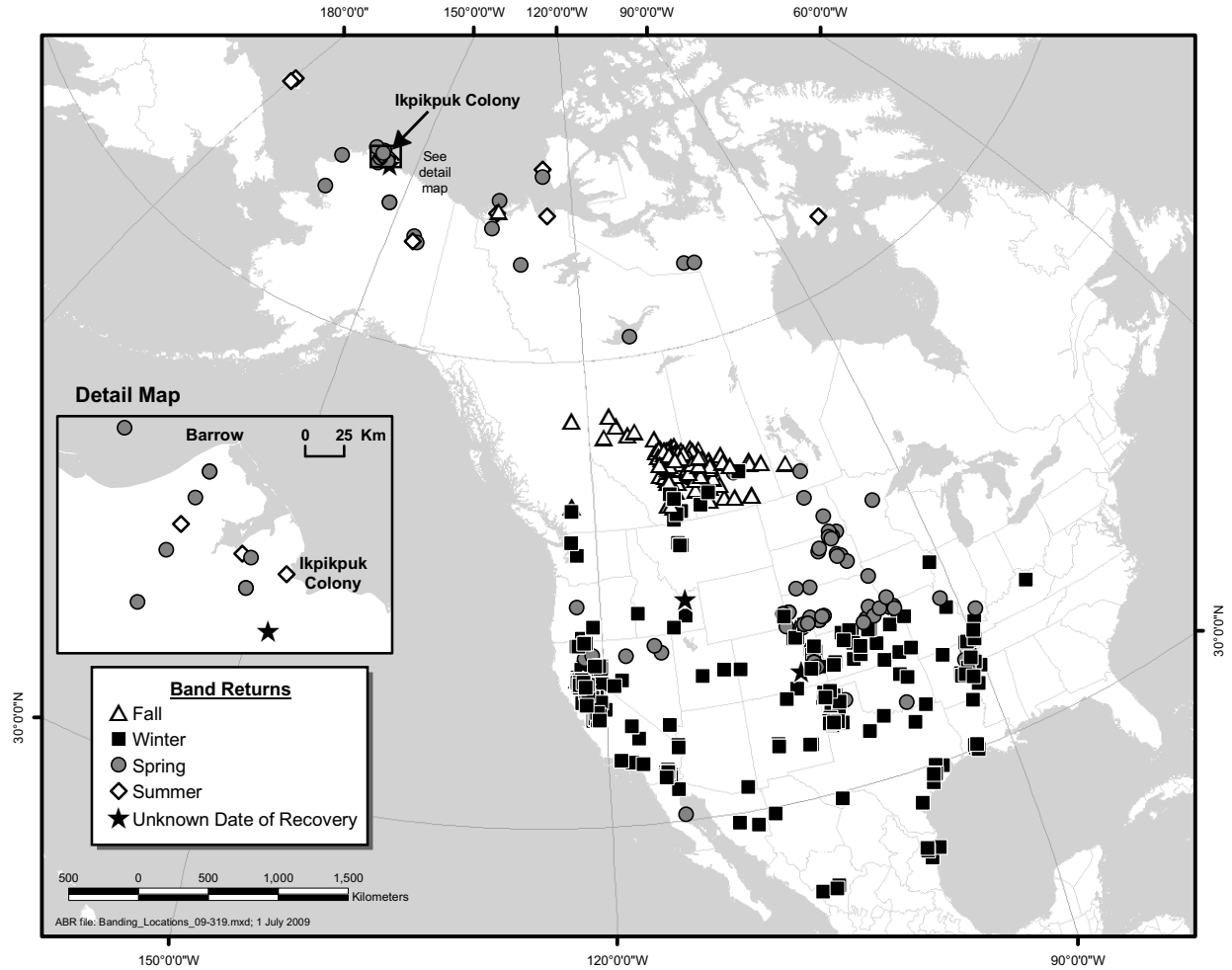


Figure 16. Locations of band recoveries by season from Snow Geese banded on the Ikpikpuk River delta, 2000–2008.

all years, 61% of banded birds were known-age, or captured as goslings; 41% of all returns are known-age birds <1 year old, and 6% of birds banded as goslings were reported dead within 1 year of banding (Table 8).

Most band returns are from fall migration and wintering areas (Table 6). Of 746 total band returns from the Ikpikpuk River delta, 64% were in winter (480) and 19% in fall (141). All but 9 of these fall and winter recoveries were hunter returns; the remaining recoveries were described as “found dead,” “collected,” “car-killed,” or “dog-killed.” Fall and winter recoveries have come from Canada (151; Alberta, Saskatchewan, Manitoba, and Northwest Territories), Mexico (11), and 19 of the lower 48 states (459, Figure 16). Three-hundred

and eighteen (69%) of the 459 fall/winter returns from the United States have come from California.

There also have been 117 spring and summer recoveries of Snow Geese banded on the Ikpikpuk River delta. Nineteen of these spring and summer records were hunter kills from Alaska (10 from Barrow, 1 from Ikpikpuk River delta, and the rest from 6 other locations in northern Alaska). Fifteen of the spring and summer records were hunter kills from Canada (8 from Northwest Territories, 3 from Nunavut, 2 from Saskatchewan, 1 from Manitoba, and 1 from Alberta). Seventy-nine of the spring/summer recoveries came from the lower 48 states and 1 from Mexico. In addition, 3 Snow Geese banded on the Ikpikpuk River delta in 2003 were recaptured (and released alive) at other

Table 7. Band returns by season, region, and year, from Snow Geese banded on the Ikpikpak and Piasuk River deltas, Alaska, 2000–2008.<sup>a</sup>

Season Region	Year of Band Return										Total	
	2000	2001	2002	2003	2004 <sup>b</sup>	2005	2006	2007	2008	2009		
Fall <sup>c</sup>												
Canada	6	2	7	23	4	13	24	21	38		138	
Lower 48				1	1				1		3	
Subtotal	6	2	7	24	5	13	24	21	39		141	
Winter <sup>c</sup>												
Canada	1					3		6	3		13	
Lower 48	9	4	24	44	29	61	99	103	83		456	
Mexico		2		3		1	2	3			11	
Subtotal	10	6	24	47	29	65	101	112	86		480	
Spring <sup>c</sup>												
Alaska				2		6		4	3		15	
Canada				1	2	1	3	3	1		11	
Lower 48		3	3	6	4	2	15	18	24	4	79	
Mexico						1					1	
Subtotal		3	3	9	6	10	18	25	28	4	106	
Summer <sup>c</sup>												
Alaska		1			1			1	1		4	
Canada					1 <sup>d</sup>	1		2	1		5	
Russia					1 <sup>d</sup>	1 <sup>d</sup>					2	
Subtotal		1			3	2		3	2		11	
Season unknown <sup>c</sup>												
Alaska					1						1	
Canada							1				1	
Lower 48				1			4	1			6	
Subtotal				1	1		5	1			8	
Total	16	12	34	81	44	90	148	162	155	4	746	

<sup>a</sup> Data are current through 7 March 2009



Table 8. Summary of band returns, by age for birds banded as goslings and by years between banding and return (equals 1 less than minimum age) for birds banded as adults, for Snow Geese banded on the Ikpikpuk and Piasuk River deltas, Alaska, 2000–2008.<sup>a</sup>

	Year of Banding										Total
	2000	2001	2002	2003	2005	2006	2007	2008	2008	Total	
Total birds banded	227	160	822	1,075	1,252 <sup>c</sup>	1,755 <sup>c</sup>	1,694	1,212	1,212	8,197	
Goslings banded	142	69	414	682	700	1,135	1,037	783	783	4,962	
% Goslings	62.6	43.1	50.4	63.4	55.9	64.7	61.2	64.6	64.6	60.5	
Age at return for birds banded as goslings <sup>a</sup>											
0	13	6	23	43	49	79	60	36	36	309	
1	3	4	7	22 <sup>c</sup>	23	22	12	–	–	93	
2	1	2	7	15	12	18	–	–	–	55	
3	1	1	3	10	6	–	–	–	–	21	
4	1	–	4	8	–	–	–	–	–	13	
5	1	–	9	10	–	–	–	–	–	20	
6	–	–	4	–	–	–	–	–	–	4	
7	2	–	–	–	–	–	–	–	–	2	
Total returns for birds banded as goslings	22	13	57	108 <sup>st,e</sup>	90	119	72	36 <sup>f</sup>	36 <sup>f</sup>	517	
% of goslings returned at age zero	9.2	8.7	5.6	6.3 <sup>de</sup>	7.0	7.0	5.8	4.6 <sup>f</sup>	4.6 <sup>f</sup>	6.2	
% of returns at age zero	33.3	28.6	22.3	28.9 <sup>de</sup>	36.5	51.9	60.0	75.0 <sup>f</sup>	75.0 <sup>f</sup>	41.4	
Adults banded	85	91	408	393	551	619	657	429	429	3,233	
% Adults	37.4	56.9	49.6	36.6	44.0	35.3	38.8	35.4	35.4	39.4	
Age of band at return for birds banded as adults <sup>b</sup>											
0	7	1	8	17	13	20	21	12	12	99	
1	1	1	8	8	15	4	7	–	–	44	
2	3	1	7	7	8	8	–	–	–	34	
3	1	1	5	1	7	–	–	–	–	15	
4	1	2	6	3	–	–	–	–	–	12	
5	1	–	8	5	–	–	–	–	–	14	
6	–	2	4	–	–	–	–	–	–	6	
7	2	–	–	–	–	–	–	–	–	2	
8	1	–	–	–	–	–	–	–	–	1	
Total returns for birds banded as adults	17	8	46	41 <sup>e</sup>	43	32	28	12 <sup>f</sup>	12 <sup>f</sup>	227	
Total returns (all ages)	39	21	103	149 <sup>st,e</sup>	134	152	100	48 <sup>f</sup>	48 <sup>f</sup>	746	
% of bands returned to date <sup>a</sup>	17.2	13.1	12.5	13.9 <sup>de</sup>	10.7	8.7	5.9	4.0 <sup>f</sup>	4.0 <sup>f</sup>	9.1	

<sup>a</sup> Band returns through 7 March 2009

<sup>b</sup> Equals bird age for birds banded as goslings and 1 less than minimum age for birds banded as adults

<sup>c</sup> Includes 1 bird of unknown age

<sup>d</sup> Includes 1 bird captured and released alive at Banks Island, NWT, Canada

<sup>e</sup> Includes 1 bird captured and released alive at Wrangel Island, Russia

<sup>f</sup> Value is preliminary as <1 year has transpired since the 2008 banding effort

colonies: 1 on Banks Island (a male banded as a gosling) in 2004 and 2 on Wrangel Island, Russia (a female banded as a gosling and a male banded as an adult) in 2004 and 2005.

Since banding began in 2000, we have recaptured 794 geese (8.9% of 8,953 Snow Geese processed during banding) on the Ikpikpuk River delta. These recaptures included 22 birds originally banded in Northwest Territories, 2 banded in Nunavut, 1 banded in Manitoba, 2 banded near the Sagavanirktok River delta, 8 banded in Russia, and over 759 birds banded by us on the Ikpikpuk River delta (Figure 17, Appendix L).

#### Colville River Delta

In 2008, we captured 707 Snow Geese in 5 groups on the Colville River delta. Of these, 704 were newly banded prior to release: 313 adults or subadults (after hatching year or AHY; 44%) and 391 goslings (56%). Six of the birds handled on the Colville River delta in 2008 were recaptures (Figure 17): 5 were previously banded in 2001 on the Colville River delta (on Anachlik Island), 4 female goslings and 1 adult of unknown sex. One male was previously banded by ABR on the Ikpikpuk River delta as a gosling in 2005. Females comprised 50.1% of adults and 51.4 % of goslings. Only 4 Snow Geese captured on the Colville River delta were blue-phase (0.6%).

From the Colville River delta banding sites, a total of 25 bands have been returned (through 7 March 2009) approximately 4% of the 704 birds banded. All were reported as hunter killed. Nineteen of 25 returned bands were from birds that were banded as goslings.

Seventeen of 25 returns from birds that were banded on the Colville River delta were from Saskatchewan and Alberta during fall hunting season (Figure 18). (All were designated as fall season returns except 1 from Saskatchewan in November that was designated a winter season return.) Subsequent winter band returns have been from California (5), Durango (1), and Texas (2)

Returns are too few and too little time has passed to provide further interpretation of movements or wintering areas of the Colville River Snow Goose population. None of the information obtained from banded birds so far suggests any remarkable differences from Snow Geese on the Ikpikpuk River delta. It is perhaps somewhat

remarkable that 5 of the recaptures (4 females and 1 unknown sex) were birds originally banded on the Colville River in 2001. The sixth recapture, a male originally banded on the Ikpikpuk River delta, does suggest some exchange between those breeding populations, at least for males.

#### Sagavanirktok River Delta

In 2008, we captured 881 Snow Geese in 6 groups on the Sagavanirktok River delta. Of these, 856 were newly banded prior to release: 401 adults or subadults (after hatching year or AHY; 47%) and 455 goslings (53%). Eleven of the birds handled on the Sagavanirktok River delta in 2008 were recaptures (Figure 17). Eight of these recaptures were previously banded on the Sagavanirktok River delta or in the adjacent Foggy Island Bay area: 7 female goslings, and 1 adult (sex unknown). The other 3 recaptures included 1 female banded on the Ikpikpuk River delta as a gosling in 2006, 1 female banded on Banks Island as an adult in 2002, and another female banded on Wrangel Island, Russia, as an adult in 2007. Females comprised 51.3% of adults and 49.7% of goslings. Only 7 Snow Geese captured on the Sagavanirktok River delta were blue-phase (0.8%).

From the Sagavanirktok River delta banding sites, a total of 30 bands have been returned (through 7 March 2009) approximately 4% of the 856 birds banded. All were reported as hunter killed. Twenty-six of 30 returned bands were from birds that were banded as goslings.

Nineteen of the 30 returns from birds that were banded on the Colville River delta were from Saskatchewan and Alberta (Figure 18) and were designated as fall season returns. Subsequent winter returns have come from Montana (1) and California (10).

Returns are too few and too little time has passed to provide further interpretation of movements or wintering areas of the Sagavanirktok River Snow Goose population. None of the information obtained from banded birds so far suggests any remarkable differences from Snow Geese on the Ikpikpuk River delta or from earlier analyses of banded birds from the Sagavanirktok River delta (Johnson 1996). As with the Colville River birds, it is perhaps somewhat remarkable that 8 of 11 recaptures (7 females and 1 unknown sex) were birds that were previously

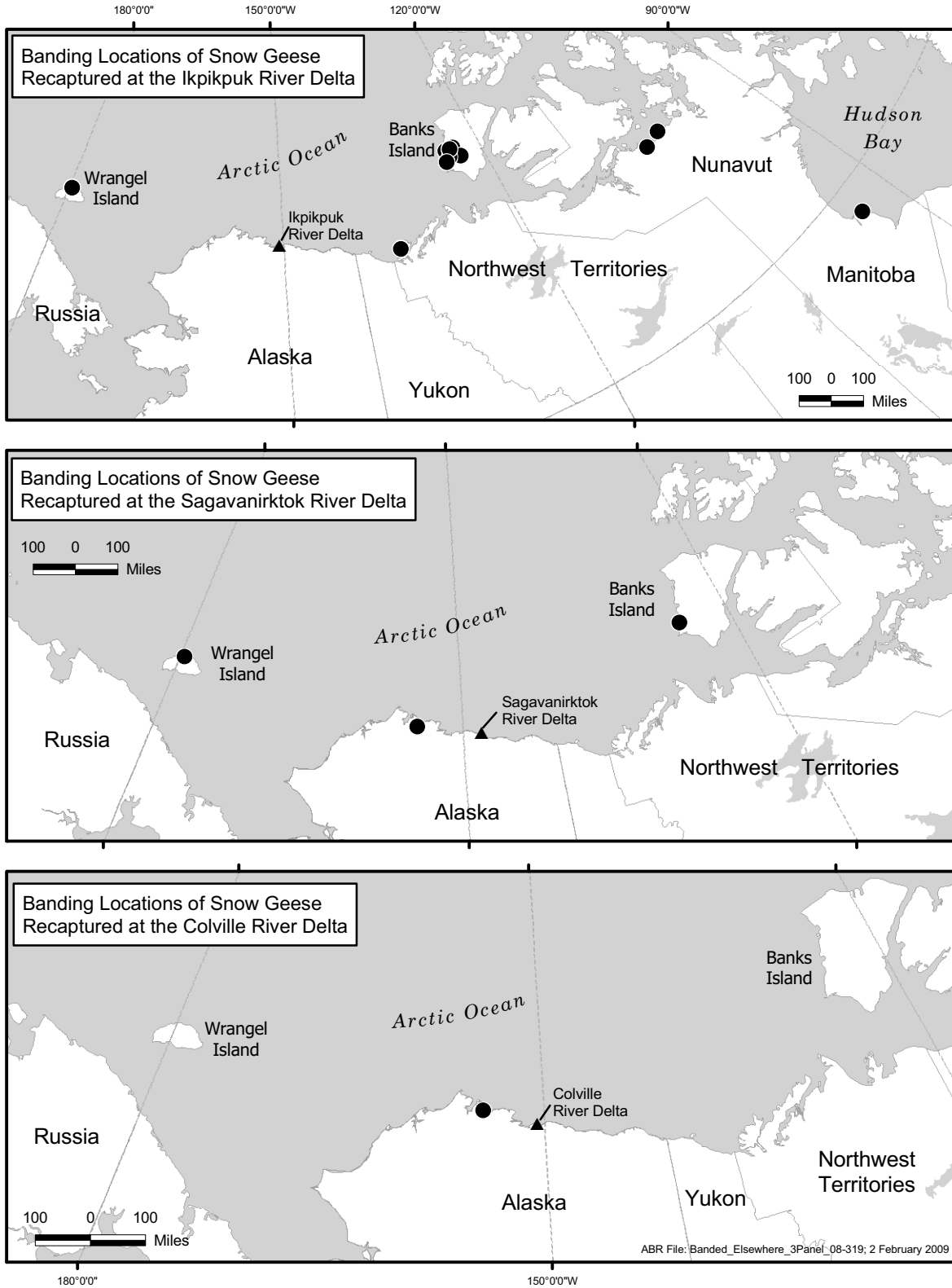


Figure 17. Original banding locations of Snow Geese recaptured on the Ikpikpuk River delta, Colville River delta, and Sagavanirktok River delta, 2000–2008. Excludes recaptures at the original banding site.

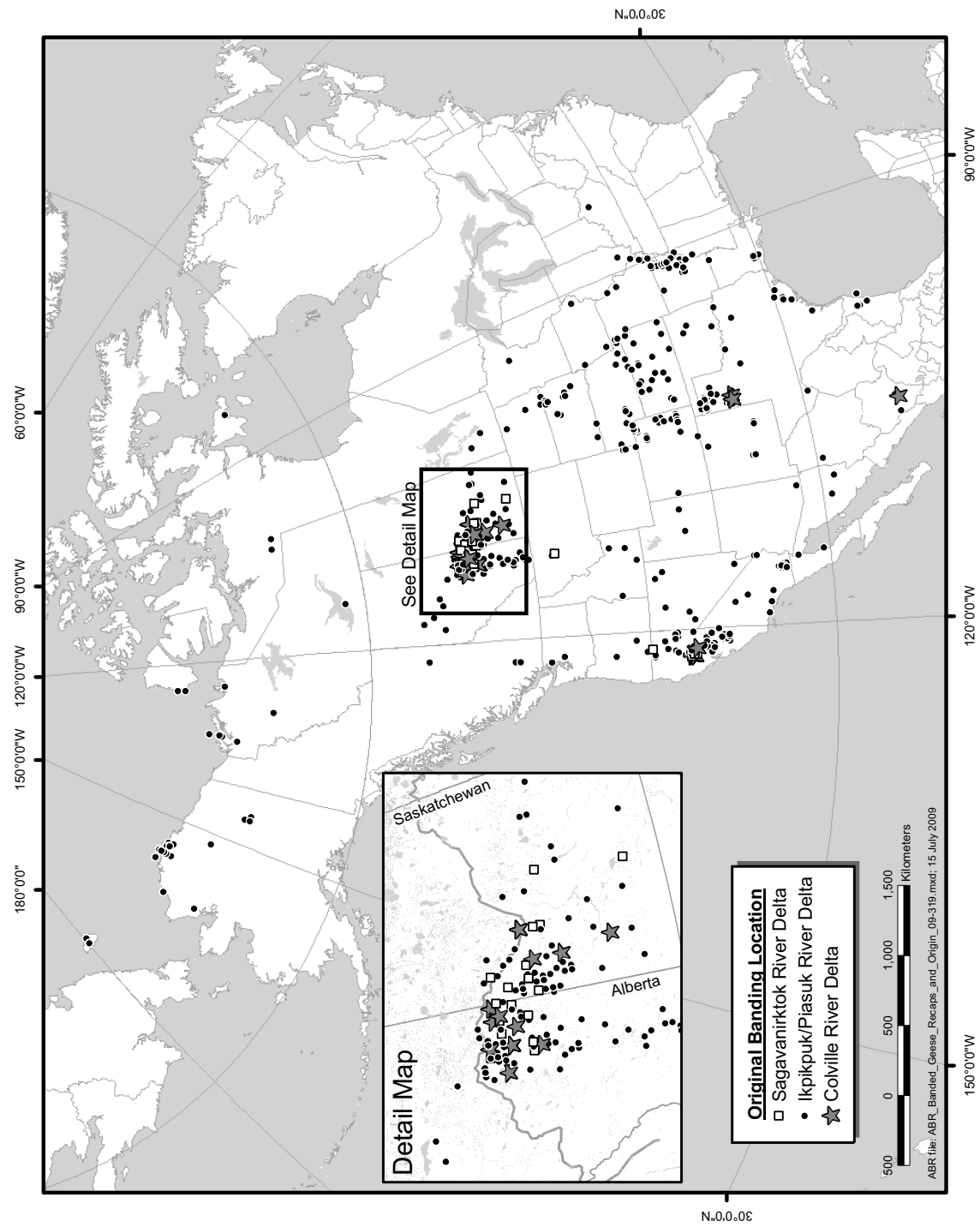


Figure 18. Locations of band recoveries from Snow Geese banded on the Colville River delta and the Sagavanirktok River delta in 2008, and the Ikpiukpuk River delta, 2000–2008.

captured on the Sagavanirktok River delta. Also similar to the Colville River birds, the recapture of a bird originally banded on the Ikpikpuk River delta suggests some exchange between those breeding populations.

### SUMMARY AND CONCLUSIONS

In 2008, we conducted surveys of 45 Brant monitoring colonies and visited 1 traditionally used Snow Goose colony, as we have for the previous 14 and 17 years, respectively. Brant occupied 82% of 45 monitored colonies in 2008, with an estimated 482 nests at these colonies. Brant colony occupancy and total number of nests have averaged 76% and 319 nests, respectively, for all 15 survey years. Colony occupancy was above average and the number of nests was the highest observed among all years in 2008. Visual estimates of Brant numbers during brood-rearing surveys in 2008 indicated 12,429 Brant in 147 groups (11,109 adults and 1,320 goslings). Photo counts increased the estimate of brood-rearing adult Brant by 21%, to 2,590 adults with broods and increased the estimate of goslings by 41%, to 1,814 goslings.

Snow Geese again nested at the traditional colony at the mouth of the Ikpikpuk River delta in 2008. The number of nests (4,641) was the highest number recorded and an 85% increase from 2007. Snow Goose colonies also were observed near the mouth of Fish Creek (20 nests), near Garry Creek (40 nests), and on the Kukpowruk River delta (320 nests; R, Suydam, NSB, pers. comm.). The Ikpikpuk colony continues to grow at a remarkable rate. Nesting success for the Ikpikpuk colony was 89%. Nesting success has ranged annually from 48–97% since 2001. During brood-rearing surveys in 2008, 15,935 Snow Geese were recorded, 28% more than in any previous year (the previous record being 12,410 in 2006), including 9,427 adults and 6,508 goslings (slightly fewer than in 2006). Photo counts increased the estimate of brood-rearing adult Snow Geese by 61%, to 9,355 adults with broods, and increased the number of goslings 46%, to 8,306.

In 2008, we conducted banding activities at 3 sites across the Beaufort Sea coast: on the Ikpikpuk River delta (the 8th year of banding since 2000), on the Colville River delta, and on the Sagavanirktok River delta. Since banding began in 2000, ~8% of

banded Snow Geese have been recovered. Through 6 December 2008, most of 684 fall and winter recoveries have come from California (336), Alberta (108), Saskatchewan (75), Texas (42), and Arkansas (17), with additional fall and winter recoveries from British Columbia (3), Manitoba (1), Northwest Territories (1), Alaska (1), Mexico (12), and another 19 of the lower 48 states (88). Spring and summer recoveries have come from mainly from Colorado (21), Alaska (19), Nebraska (15), and South Dakota (12), with additional recoveries from Northwest Territories (8) and Nunavut (3), the prairie provinces (Alberta, Saskatchewan, and Manitoba; 4), Russia (2), Mexico (1), and another 13 of the lower 48 states (31). Since banding began, 794 recaptures on the Ikpikpuk River delta (9% of all Snow Geese processed during banding) have included birds banded in Northwest Territories (22), Nunavut (2), Manitoba (1), the Sagavanirktok River delta (2), Russia (8), and over 759 birds banded on the Ikpikpuk River delta. The distribution of wintering birds and returns continues to suggest wide-ranging wintering areas and migratory routes similar to those used by Snow Geese in Sagavanirktok River delta colony and other Western Arctic Snow Geese. Some band returns and recaptures, as well as the relatively high incidence of blue-phase Snow Geese in the Ikpikpuk delta, also suggests the possibility of immigration from colonies in eastern portions of the breeding range in Canada.

### LITERATURE CITED

- Abraham, K. F., and R. L. Jefferies. 1997. High goose populations: causes, impacts and complications. Pages 7–72 in B. D. J. Batt, ed. *Arctic Ecosystems in Peril: Report of the Arctic Goose Habitat Working Group*. Arctic Goose Joint Venture Special Publication. U.S. Fish and Wildlife Service, Washington, D.C. and Canadian Wildlife Service, Ottawa, Ontario. 120 pp.
- Alisauskas, R. T. 2002. Arctic climate, spring nutrition, and recruitment in midcontinent Lesser Snow Geese. *Journal of Wildlife Management* 66: 181–193.

- Alisauskas, R. T., and H. Boyd. 1994. Previously unrecorded colonies of Ross' and Lesser Snow Geese in the Queen Maud Gulf Bird Sanctuary. *Arctic* 47: 69–73.
- Anthony, R. M., P. L. Flint, and J. S. Sedinger. 1991. Arctic fox removal improves nest success of Black Brant. *Wildlife Society Bulletin* 19: 176–184.
- Bellrose, F. C. 1976. Ducks, geese and swans of North America. Stackpole Books, Harrisburg, PA. 540 pp.
- Boyd, H., G. E. J. Smith, and F. G. Cooch. 1982. The Lesser Snow Goose of the eastern Canadian Arctic. Canadian Wildlife Service Occasional Paper Number 46.
- Burgess, R. M., and R. J. Ritchie. 1993. Snow Goose. 1988 Endicott Environmental Monitoring Program Volume V. Report for U.S. Army Corps of Engineers, Alaska District, Anchorage AK, by Science Applications International Corp., Anchorage, AK.
- Cotter, R. C., and J. E. Hines. 2000. Breeding biology of Brant on Banks Island, Northwest Territories, Canada. *Arctic* 54: 357–366.
- Cooch, E. G., D. B. Lank, R. F. Rockwell, and F. Cooke. 1991. Long-term decline in body size in a Snow Goose population: evidence of environmental degradation? *Journal of Animal Ecology* 60: 483–496.
- Davis, S. E., E. E. Klaas, and K. J. Koehler. 1989. Diurnal time-activity budgets and habitat use of Lesser Snow Geese *Anser caerulescens* in the middle Missouri River Valley during winter and spring. *Wildfowl* 40: 45–54.
- Derksen, D., M. Weller, and W. Eldridge. 1979. Distributional ecology of geese molting near Teshekpuk Lake, National Petroleum Reserve—Alaska. Pages 189–207 in R. Jarvis and J. Bartonek, eds. Management and biology of Pacific Flyway geese. OSU Book Stores, Inc., Corvallis, OR. 346 pp.
- Downing, R. L. 1980. Vital statistics of animal populations. Pages 247–258 in S. D. Schemnitz, ed. Wildlife management techniques manual. The Wildlife Society. Washington, DC.
- Dzubin, A. 1979. Recent increases of blue geese in western North America. In R. L. Jarvis and J. C. Bartonek, eds. Management and biology of Pacific Flyway geese. OSU Book Stores, Corvallis, OR.
- Flint, P. F., E. J. Mallek, R. J. King, J. A. Schmutz, K. S. Bollinger, and D. V. Derksen. 2008. Changes in abundance and spatial distribution of geese molting near Teshekpuk Lake, Alaska: Interspecific competition or ecological change? *Polar Biology* 31:549–556
- Francis, C. M., and F. Cooke. 1992. Migration routes and recovery rates of Lesser Snow Geese from southwestern Hudson Bay. *Journal of Wildlife Management* 56: 279–286.
- Gadallah, F. L., and R. L. Jefferies. 1995. Forage quality in brood rearing areas of the Lesser Snow Goose and the growth of captive goslings. *Journal of Applied Ecology* 32: 276–287.
- Gallant, A. L., E. F. Binnian, J. M. Omernik, and M. B. Shasby. 1995. Ecoregions of Alaska. U.S. Geological Survey Professional Paper 1567, Washington, DC.
- Ganter, B., and F. Cooke. 1998. Colonial nesters in deteriorating habitat: site fidelity and colony dynamics of Lesser Snow Geese. *Auk* 115: 642–652.
- Ganter, B., F. Cooke, and P. Mineau. 1995. Long-term vegetation changes in a Snow Goose nesting habitat. *Canadian Journal of Zoology* 74: 965–969.
- Johnson, C. B., R. M. Burgess, A. M. Wildman, A. A. Stickney, P. E. Seiser, B. E. Lawhead, T. J. Mabee, A. K. Prichard, and J. R. Rose. 2005. Wildlife studies for the Alpine Satellite Development Project, 2004. Second annual report for ConocoPhillips Alaska, Inc., and Anadarko Petroleum Corporation, Anchorage, by ABR, Inc., Fairbanks, AK. 129 pp.

- Johnson, S. R. 1993. An important early-autumn staging area for Pacific Flyway Brant: Kasegaluk Lagoon, Chukchi Sea, Alaska. *Journal of Field Ornithology* 64: 539–548.
- Johnson, S. R. 1996. Staging and wintering areas of Snow Geese nesting on Howe Island, Alaska. *Arctic* 49: 86–93.
- Johnson, S. R. 2000. Lesser Snow Geese. Pages 233–258 in J. Truett and S. Johnson, eds. *The natural history of an Arctic oil field*. Academic Press, New York. 422 pp.
- Johnson, S. R., and D. M. Troy. 1987. Nesting of the Ross' Goose and blue-phase Snow Goose in the Sagavanirktok River delta, Alaska. *Condor* 89: 665–667.
- Kerbes, R. H. 1982. Nesting Snow and Ross' geese. Pages 285–287 in D. E. Davis, ed. *CRC handbook of census methods for terrestrial vertebrates*. CRC Press, Inc. Boca Raton, FL.
- Kerbes, R. H. 1983. Lesser Snow Goose colonies in the western Canadian Arctic. *Journal of Wildlife Management* 47: 523–526.
- Kerbes, R. H., M. R. McLandress, G. E. J. Smith, G. W. Beyersbergen, and B. Godwin. 1983. Ross' Goose and Lesser Snow Goose colonies in the central Canadian Arctic. *Canadian Journal of Zoology* 61: 168–173.
- Kerbes, R. H., P. M. Kotanen, and R. L. Jefferies. 1990. Destruction of wetland habitats by Lesser Snow Geese: a keystone species on the west coast of Hudson Bay. *Journal of Applied Ecology* 27: 242–258.
- Kerbes, R. H., K. M. Meeres, and J. E. Hines, eds. 1999. *Distribution, survival, and numbers of Lesser Snow Geese of the western Canadian Arctic and Wrangel Island, Russia*. Canadian Wildlife Service Occasional Paper No. 98. 120 pp.
- King, J., and J. Hodges. 1979. A preliminary analysis of goose banding on Alaska's Arctic Slope. Pages 176–188 in R. Jarvis and J. Bartonek, eds. *Management and biology of Pacific Flyway geese*. OSU Book Stores, Inc., Corvallis, OR. 346 pp.
- Lewis, T. L., P. L. Flint, J. A. Schmutz, and D. V. Derksen. No date. *Temporal distributions and patterns of habitat use by Black Brant molting in the Teshekpuk Lake Special Area—2007 Annual Progress Report*. Unpublished report, U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska. 21 pp.
- Lewis, T. L., P. L. Flint, J. A. Schmutz, and D. V. Derksen. No date. *Temporal and spatial patterns of habitat use by Black Brant molting in the Teshekpuk Lake Special Area, Alaska—2008 Annual Progress Report*. Unpublished report, U.S. Geological Survey, Alaska Science Center, Anchorage, Alaska. 23 pp.
- Mallek, E. J. 2009. *Teshekpuk Lake area molting goose survey—2008*. Unpublished report, U.S. Fish and Wildlife Service, Fairbanks, Alaska. 13 pp.
- McCormick, K. J., and B. Poston. 1988. Lesser Snow Geese, *Anser c. caerulescens*, nesting on Jenny Lind Island, Northwest Territories. *Canadian Field-Naturalist* 102: 530–532.
- Noel, L. E., S. R. Johnson, and M. K. Butcher. 2004. Snow Goose nesting and brood-rearing distributions in the Sagavanirktok River delta, 1980–2002. *Waterbirds* 27: 388–395.
- Person, B. T., C. A. Babcock, and R. W. Ruess. 1998. Forage variation in brood-rearing areas used by Pacific Black Brant geese on the Yukon-Kuskokwim Delta, Alaska. *Journal of Ecology* 86: 243–259.
- Raveling, D. G. 1989. Nest predation rates in relation to colony size of Black Brant. *Journal of Wildlife Management* 53: 87–90.
- Ritchie, R. J. 1996. *Aerial surveys for nesting and brood-rearing Brant, Barrow to Fish Creek, Alaska, 1995*. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 28 pp.

- Ritchie, R. J. 1998a. Aerial surveys for nesting and brood-rearing Brant, Barrow to Fish Creek, Alaska, 1997. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 26 pp.
- Ritchie, R. J. 1998b. Aerial surveys for nesting Brant, Barrow to Fish Creek delta, Alaska, 1998. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 12 pp.
- Ritchie, R. J. 2001. Aerial surveys for Brant and Snow Geese, Barrow to Fish Creek delta and Snow Goose banding near the Ikpikpuk River delta, Alaska, 2000. Annual report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 22 pp.
- Ritchie, R. J., P. W. Banyas, A. A. Stickney, R. M. Burgess, and J. G. King. 1990. Tundra Swan and Brant surveys on the Arctic Coastal Plain, Colville River to Staines River, 1989. Report for ARCO Alaska, Inc., and BP Exploration (Alaska) Inc., Anchorage, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 138 pp.
- Ritchie, R. J., and R. M. Burgess. 1992. Aerial surveys for Snow Geese on the Arctic Coastal Plain of Northwest Alaska, 1992. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 14 pp.
- Ritchie, R. J., and R. M. Burgess. 1993. Aerial surveys for Snow Geese on the Arctic Coastal Plain of Northwest Alaska, 1993. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by Alaska Biological Research, Inc., Fairbanks, AK. 13 pp.
- Ritchie, R. J., R. M. Burgess, J. E. Shook, and T. Obritschkewitsch. 2008a. Surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River Delta, Alaska, 2007. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 63 pp.
- Ritchie, R. J., R. M. Burgess, and R. S. Suydam. 2000. Status and nesting distribution of Lesser Snow Geese, *Chen caerulescens caerulescens*, and Brant, *Branta bernicla nigricans*, on the western Arctic Coastal Plain, Alaska. Canadian Field-Naturalist 114: 395–404.
- Ritchie, R. J., and D. A. Flint. 1994. Aerial surveys of nesting and brood-rearing Brant, Cape Sabine to Smith Bay, Alaska, 1994. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 11 pp.
- Ritchie, R. J., and J. King. 2004. Steller's Eider surveys near Barrow, Alaska, 2004. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK; U.S. Bureau of Land Management, Fairbanks, AK; and Alaska Army National Guard, Fort Richardson, AK; by ABR, Inc., Fairbanks, AK. 15 pp.
- Ritchie, R. J., P. Lovely, and M. J. Knoche. 2002. Aerial surveys for nesting and brood-rearing Brant and Snow Geese, Barrow to Fish Creek delta, and Snow Goose banding near the Ikpikpuk River delta, Alaska, 2001. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 31 pp.
- Ritchie, R. J., T. Obritschkewitsch, J. E. Shook, R. M. Burgess, and J. R. Rose. 2007. Surveys for nesting and brood-rearing Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River delta, Alaska, 2006. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 45 pp.
- Ritchie, R. J., J. Parrett, and R. M. Burgess. 2008b. Snow Goose banding on the Colville River delta, Alaska, 2008. Draft field report for ConocoPhillips Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK.



- Ritchie, R. J., and J. R. Rose. 1996. Aerial surveys for nesting and brood-rearing Brant, Barrow to Fish Creek delta, Alaska, 1996. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 19 pp.
- Ritchie, R. J., and J. R. Rose. 2008. Results of Snow Goose surveys and a pilot study to band Snow Geese near Pt. Lay, Kasegaluk Lagoon, Alaska. Draft field report for ConocoPhillips Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK.
- Ritchie, R. J., P. Seiser, R. M. Burgess, and A. A. Stickney. 2008c. Results of Snow Goose banding on the Sagavanirktok River delta, Alaska, 2008. Field report for BP Exploration Alaska, Inc., Anchorage, AK, by ABR, Inc., Fairbanks, AK.
- Ritchie, R. J., and J. E. Shook. 2003. Aerial surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River delta, Alaska, 2002. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 36 pp.
- Ritchie, R. J., and J. E. Shook. 2005. Aerial surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River delta, Alaska, 2004. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 36 pp.
- Ritchie, R. J., J. E. Shook, and J. R. Rose. 2004. Aerial surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River delta, Alaska, 2003. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 35 pp.
- Ritchie, R. J., J. E. Shook, R. M. Burgess, and A. A. Stickney. 2006. Aerial surveys for nesting and brood-rearing Brant and Lesser Snow Geese, Barrow to Fish Creek delta, and Lesser Snow Goose banding near the Ikpikpuk River delta, Alaska, 2005. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 36 pp.
- Ritchie, R. J., and A. M. Wildman. 2000. Aerial surveys for nesting Brant and Snow Geese, Kasegaluk Lagoon to Fish Creek delta, Alaska, 1999. Report for North Slope Borough, Dept. Wildlife Management, Barrow, AK, by ABR, Inc., Fairbanks, AK. 18 pp.
- Rodrigues, R., S. McKendrick, and C. Reiser. 2006. Howe Island Snow Goose nest monitoring, Sagavanirktok River delta area, Alaska, 2006. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska, USA. 11 p.
- Rodrigues, R., S. McKendrick, M. Brees, and S. Johnson. 2007. Howe Island Snow Goose and Brant nest monitoring, Sagavanirktok River delta area, Alaska, 2007. Report for BP Exploration (Alaska) Inc. by LGL Alaska Research Associates, Inc., Anchorage, Alaska, USA.
- Sedinger, J. S., and A. A. Stickney. 2000. Black Brant. Pages 221–232 *in*: J. C. Truett and S. R. Johnson, eds. The natural history of an Arctic oil field. Academic Press, San Francisco. 422 pp.
- Srivastava, D. S., and R. L. Jefferies. 1996. A positive feedback: herbivory, plant growth, salinity and the desertification of an Arctic salt-marsh. *Journal of Ecology* 84: 31–42.
- Stickney, A. A., and R. J. Ritchie. 1996. Distribution and abundance of Brant on the Central Arctic Coastal Plain of Alaska. *Arctic* 49: 44–52.
- Streever, B., D. Sanzone, R. M. Burgess, and J. Lukin, eds. 2008. Long-term ecological monitoring in BP's North Slope oil fields: 2007 annual report. BP Exploration (Alaska) Inc., Anchorage, AK.

*Literature Cited*

- Streever, B., D. Sanzone, R. M. Burgess, and J. Lukin, eds. 2009 (in press). Long-term ecological monitoring in BP's North Slope oil fields: 2008 annual report. BP Exploration (Alaska) Inc., Anchorage, AK.
- Williams, T. D., E. G. Cooch, R. L. Jefferies, and F. Cooke. 1993. Environmental degradation, food limitation and reproductive output: juvenile survival in Lesser Snow Geese. *Journal of Animal Ecology* 62: 766–777.
- Wilson, H. M. 2008. Aerial photographic survey of Brant colonies on the Yukon-Kuskokwim Delta, Alaska, 2008. Unpubl. report, U.S. Fish and Wildlife Service, Migratory Bird management, Anchorage, AK. 8 pp. <[http://alaska.fws.gov/mbsp/mbm/water-fowl/surveys/pdf/brant\\_ykd.pdf](http://alaska.fws.gov/mbsp/mbm/water-fowl/surveys/pdf/brant_ykd.pdf)>

Appendix A. Summary of survey areas and types of surveys conducted for long-term monitoring of Snow Geese and Brant in northern Alaska, 1991–2008.

Year	Ikpikpuk River Delta Snow Goose Colony			Kukpowruk River Delta Snow Goose Colony			Regional Aerial Surveys <sup>a</sup>	
	Aerial Nesting Survey	Ground-based Nest Search	Banding	Aerial Nest Survey	Ground-based Nest Search	NSB Ground Search <sup>b</sup>	Nesting	Brood-rearing
1991	no	no	no	yes	no	no	none	none
1992	yes	yes	no	yes	yes	no	Area A <sup>a, c</sup>	none
1993	yes	yes	no	yes	yes	no	Area A <sup>c</sup>	none
1994	yes	no	no	yes	no	no	Area A	Area A <sup>d</sup>
1995	yes	no	no	yes	no	yes	Area A	Area A
1996	yes	no	no	no	no	yes	45 colonies <sup>e, f</sup>	Area B <sup>a</sup>
1997	yes	no	no	no	no	yes	45 colonies <sup>f</sup>	Area B
1998	yes	no	no	no	no	yes	45 colonies <sup>f</sup>	none
1999	yes	no	no	yes <sup>g</sup>	no	yes	45 colonies	Area A
2000	yes	no	yes	no	no	yes	45 colonies	Area B
2001	yes	yes	yes	no	no	yes	45 colonies	Area B
2002	yes	yes	yes	yes <sup>h</sup>	no	no	45 colonies	Area B
2003	yes	yes	yes	no	no	yes	45 colonies	Area B
2004	yes	yes	no	no	no	no	45 colonies	Area B
2005	yes	yes	yes	no	no	no	45 colonies	Area B
2006	yes	yes	yes	no	no	no	45 colonies	Area B
2007	yes	yes	yes	no	no	yes	45 colonies	Area B
2008	yes	yes	yes	no	no	yes	45 colonies	Area B

<sup>a</sup> Area A comprised parts of both the Chukchi and Beaufort Sea coasts between the southern end of Kasegaluk Lagoon in the west and the western edge of the Colville River delta; Area B comprised the western Beaufort Sea coast between Barrow in the west and the western edge of the Colville River delta.

<sup>b</sup> North Slope Borough (NSB) survey data provided by R. Suydam, NSB Dept. of Wildlife Management. Surveys were conducted only on the Kukpowruk River delta and did not include searches of the Epizetka River delta, where Snow Geese have been recorded nesting in some years.

<sup>c</sup> In 1992 and 1993, regional aerial surveys did not record Brant, only Snow Geese.

<sup>d</sup> In 1994, weather conditions prevented a complete brood-rearing survey and excluded that part of the Chukchi Sea coast between Franklin and Barrow.

<sup>e</sup> In 1996–2008, the nesting surveys focused on 45 known Brant colonies between Barrow and the western edge of the Colville River delta. Snow Goose nests/colonies observed in transit between Brant colonies also were recorded.

<sup>f</sup> In 1996–1998, in addition to the 45 known Brant colonies, additional inland areas were surveyed intensively for Brant and Snow Goose nests. In 1996, 3 inland areas were surveyed: an area south of Dease Inlet and west of the Chipp River, the area between the Ikpikpuk River and east to Teshekpuk Lake, and the Fish Creek delta (see Ritchie and Rose 1996). In 1997, the area east of Teshekpuk Lake and to Harrison Bay and south to Fish Creek was surveyed (see Ritchie 1998a). In 1998, the area north of Teshekpuk Lake (to the Beaufort Sea coast) and tundra immediately south of Teshekpuk Lake was surveyed (see Ritchie 1998b).

<sup>g</sup> In 1999, aerial surveys included nests located near the mouth of the Epizetka River in an area not included in previous surveys.

<sup>h</sup> In 2002, all nests were located near the mouth of the Epizetka River, none were found at the Kukpowruk River delta.

Appendix B. Location, size, and status of 45 Brant colonies monitored annually between Barrow and Fish Creek, Alaska, 1994–2008.

Colony No.	Survey Section <sup>a</sup>	Latitude	Longitude	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
9	3	70.8951667	-157.0330000	10	15	24	34	15	24	16	19	13	25	10	27	8	13	25
52	3	71.0243333	-157.0098333	0	6	4	13	3	11	13	12	21	23	23	12	6	25	40
7	3	71.0401667	-156.8920000	6	10	7	13	12	8	16	22	13	30	10	8	14	4	23
53	3	70.9465000	-156.5598333	0	12	5	6	0	6	3	nd	0	4	4	6	3	0	3
19	3	70.8340000	-156.4595000	3	1	0	3	0	5	0	0	0	0	0	0	1	2	2
18	3	70.9331667	-156.4236667	1	5	4	0	6	5	6	0	4	8	3	4	0	4	13
20	3	70.7590000	-156.3801667	2	0	0	1	1	0	1	4	2	1	2	0	2	3	2
35	3	71.0910000	-156.3690000	0	7	0	4	0	4	5	8	10	0	11	6	8	8	12
60	3	70.7865000	-156.3615000	0	5	2	1	0	1	1	0	1	1	2	3	0	1	0
36	3	71.0341667	-156.3418333	0	8	0	0	3	0	0	3	2	5	5	5	7	3	4
54	3	70.7776667	-156.2921667	0	1	5	2	0	1	4	0	2	2	6	0	2	3	4
51	3	71.0910000	-156.2663333	0	6	0	5	3	7	2	1	3	6	2	4	2	0	10
50	3	71.0255000	-156.2205000	0	2	3	3	6	8	8	8	5	8	10	1	7	4	13
49	3	71.1006667	-156.2141667	0	5	8	4	6	7	4	5	7	2	5	6	5	3	8
12	3	70.7851667	-155.9788333	10	6	0	3	2	3	2	4	2	0	2	0	2	3	3
11	3	70.8448333	-155.9426667	25	20	20	10	30	29	35	25	30	45	40	0	52	40	98
10	3	71.1525000	-155.9331667	6	10	4	11	7	13	4	15	9	15	0	4	10	6	4
14	3	70.8073333	-155.8265000	3	0	0	0	0	0	0	0	0	1	0	0	0	0	0
15	3	70.8233333	-155.7531667	5	1	0	0	0	13	0	0	2	0	0	2	0	1	2
64	3	71.0126670	-155.7270000	0	5	0	0	0	0	3	nd	1	nd	0	1	4	1	0
48	3	70.8121667	-155.7145000	0	4	9	0	7	2	4	0	8	4	6	3	2	3	3
25	3	71.0801667	-155.6948333	4	2	0	2	1	0	2	2	0	0	1	1	0	0	0
65	3	70.8433330	-155.6895000	0	3	0	0	0	3	0	6	0	2	0	0	0	0	0
44	3	71.0613333	-155.6521667	0	1	2	3	6	2	2	4	8	5	3	2	1	3	1
26	3	71.1083333	-155.6186667	5	3	0	6	2	3	5	6	1	3	1	3	0	0	0
17	3	70.8991667	-155.4236667	3	3	6	7	3	2	7	5	1	3	3	0	0	3	4
16	3	70.8546667	-155.3955000	5	0	1	3	0	3	1	2	0	2	1	0	0	0	4
23	3	70.9818333	-155.3365000	6	5	10	17	20	27	21	28	8	22	3	19	19	22	19
45	3	70.8866667	-155.2783333	0	4	0	0	3	2	4	5	1	5	5	1	0	3	3
24	3	70.9888333	-155.2753333	10	10	12	25	28	30	23	32	10	25	40	34	51	20	13
22	3	70.8396667	-155.2008333	3	5	0	1	4	1	5	6	2	3	6	4	0	0	3

Appendix B. Continued.

Colony No.	Survey Section <sup>a</sup>	Latitude	Longitude	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
27	3	71.0893333	-155.1798333	3	8	0	7	2	9	15	16	5	0	6	8	2	4	3
46	3	70.9333333	-155.1166667	0	0	0	0	0	3	8	3	0	2	2	12	3	7	10
43	3	71.1335000	-155.0073333	0	2	0	nd	0	0	2	0	10	20	12	7	4	2	12
47	3	70.9111667	-154.9843333	0	15	14	16	11	17	16	33	15	15	12	14	17	7	18
28	3	71.0626667	-154.9468333	4	8	10	2	1	15	2	5	2	10	8	5	4	7	10
29	3	71.0736667	-154.7853333	5	6	0	6	7	11	7	6	3	3	2	3	3	2	9
30	4	70.9270000	-154.6625000	3	0	0	0	0	0	0	0	0	0	nd	0	2	0	3
31	4	70.8006667	-154.4586667	5	5	5	8	4	15	6	2	6	0	nd	4	0	nd	0
34	4	70.7998333	-154.3751667	0	2	0	0	0	1	0	0	0	0	0	0	0	nd	0
32	4	70.6395000	-154.2016667	40	35	35	30	30	15	40	10	20	30	63	85	50	60	40
33	4	70.8393333	-153.9236667	4	2	3	5	5	3	7	12	3	18	12	3	12	9	9
56	4	70.9133333	-153.2755000	0	6	2	0	3	1	1	6	1	0	nd	0	2	2	2
57	5	70.7408333	-152.4080000	nd	15	35	28	25	6	27	26	9	11	23	3	6	13	17
58	5	70.4308333	-151.6450000	nd	25	29	45	47	55	50	45	34	10	30	17	35	12	33

<sup>a</sup> 3 = Dease Inlet, 4 = Smith Bay, 5 = Harrison Bay

Appendix C. Location and numbers of Brant (visual estimates and photo counts) during brood-rearing surveys, Barrow to Fish Creek, Alaska, 2008.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults	No. Young	Total
3	Christie Point	71.14773	-155.58532	170	0	170	na	na	
3	Christie Point	71.13636	-155.57534	40	8	48	42	9	51
3	Christie Point	71.13654	-155.56607	150	0	150	na	na	
3	Christie Point	71.13375	-155.56773	2	3	5	na	na	
3	Christie Point	71.13529	-155.56778	80	0	80	na	na	
3	Dease Inlet	71.08744	-155.50873	26	20	46	28	33	61
3	Dease Inlet	71.08702	-155.51284	12	0	12	na	na	
3	Dease Inlet	71.07561	-155.51515	2	4	6	na	na	
3	Dease Inlet	71.07561	-155.51515	6	0	6	na	na	
3	Dease Inlet	71.07024	-155.53022	4	2	6	na	na	
3	Dease Inlet	71.05674	-155.56933	2	2	4	na	na	
3	Dease Inlet	71.05513	-155.57922	30	13	43	33	21	54
3	Dease Inlet	71.03994	-155.63808	50	20	70	59	33	92
3	Dease Inlet	71.03984	-155.63944	50	22	72	87	29	116
3	Dease Inlet	71.02372	-155.66818	30	30	60	37	35	72
3	Dease Inlet	71.02132	-155.65791	8	6	14	na	na	
3	Dease Inlet	71.00472	-155.71222	30	0	30	na	na	
3	Dease Inlet	70.99381	-155.71124	18	0	18	na	na	
3	Admiralty Bay	70.92010	-155.98195	20	30	50	32	51	83
3	Admiralty Bay	70.85470	-155.92754	60	35	95	107	50	157
3	Kurgorak Bay	70.99363	-155.23350	22	5	27	21	5	26
3	Kurgorak Bay	70.99126	-155.22625	18	12	30	23	15	38
3	Kurgorak Bay	70.99351	-155.23344	35	0	35	na	na	
3	Kurgorak Bay	71.03765	-155.20074	3	0	3	na	na	
3	Kurgorak Bay	71.05368	-155.23154	32	0	32	na	na	
4	Smith River	70.87243	-153.32536	50	10	60	55	11	66
4	Smith River	70.89294	-153.31428	125	0	125	na	na	
4	Smith River	70.88804	-153.31582	60	0	60	na	na	
4	Smith River	70.88227	-153.30896	30	0	30	na	na	
4	Boat Creek	70.85901	-153.84879	12	7	19	na	na	
4	Imakruak Lake	70.79690	-153.97418	30	30	60	31	40	71
4	Ikpikpuk River	70.78504	-154.27792	0	0	0	2	0	2
4	Ikpikpuk River	70.80488	-154.52689	150	0	150	na	na	
4	Ikpikpuk River	70.79655	-154.55757	180	0	180	na	na	
4	Piasuk River	70.81185	-154.78121	0	0	0	1	0	1
4	Piasuk River	70.82610	-154.60752	30	0	30	na	na	
4	Piasuk River	70.83466	-154.63146	4	0	4	4	0	4
4	Piasuk River	70.85479	-154.76229	100	0	100	105	0	105
4	Piasuk River	70.85595	-154.68266	80	0	80	na	na	
4	Piasuk River	70.85675	-154.67668	20	0	20	na	na	
4	N. Piasuk River	70.88987	-154.82704	220	0	220	na	na	
4	SE Sinclair Lake	70.94491	-154.69229	60	0	60	na	na	

## Appendix C. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults	No. Young	Total
4	Sinclair Lake	71.06122	-154.86732	0	0	0	1	0	1
4	Sinclair Lake	71.05222	-154.87523	60	0	60	na	na	
4	McKay Inlet	71.03849	-155.03081	275	0	275	na	na	
4	McKay Inlet	71.04121	-155.03325	140	0	140	na	na	
4	McKay Inlet	71.07509	-155.06473	180	0	180	na	na	
4	Tangent Point	71.12608	-155.06571	320	0	320	na	na	
5	Fish Creek Delta	70.38463	-151.24959	45	50	95	52	65	117
5	Fish Creek Delta	70.39321	-151.26971	14	12	26	na	na	
5	Fish Creek Delta	70.40203	-151.32618	70	40	110	85	55	140
5	Fish Creek Delta	70.40059	-151.33781	60	50	110	66	79	145
5	Fish Creek Delta	70.40499	-151.33453	30	25	55	29	27	56
5	Fish Creek Delta	70.40594	-151.32385	55	20	75	69	43	112
5	Fish Creek Delta	70.40466	-151.3531	140	60	200	116	65	181
5	Fish Creek Delta	70.40061	-151.35695	32	0	32	na	na	
5	Fish Creek Delta	70.40342	-151.36168	70	42	112	68	62	130
5	Fish Creek Delta	70.41452	-151.38099	350	0	350	na	na	
5	Fish Creek Delta	70.41513	-151.38468	60	0	60	na	na	
5	Fish Creek Delta	70.41513	-151.38468	20	10	30	na	na	
5	Fish Creek Delta	70.41867	-151.40573	120	40	160	202	55	257
5	Fish Creek Delta	70.42114	-151.3984	32	0	32	na	na	
5	Fish Creek Delta	70.42154	-151.40855	80	60	140	87	57	144
5	Fish Creek Delta	70.41885	-151.42971	130	0	130	na	na	
5	Fish Creek Delta	70.4166	-151.44051	45	0	45	na	na	
5	Fish Creek Delta	70.42037	-151.44277	16	10	26	na	na	
5	Fish Creek Delta	70.42986	-151.5194	60	40	100	81	63	144
5	Fish Creek Delta	70.42949	-151.51127	90	50	140	88	97	185
5	Fish Creek Delta	70.40135	-151.38306	50	40	90	54	37	91
5	Fish Creek Delta	70.39619	-151.38487	40	20	60	35	25	60
5	Fish Creek Delta	70.39722	-151.38413	90	50	140	123	65	188
5	Fish Creek Delta	70.3964	-151.3881	130	60	190	144	77	221
5	Fish Creek Delta	70.39488	-151.39222	28	20	48	na	na	
5	Fish Creek Delta	70.39598	-151.35693	48	50	98	56	64	120
5	Fish Creek Delta	70.39184	-151.36625	30	30	60	41	28	69
5	Fish Creek Delta	70.38718	-151.28587	120	80	200	125	175	300
5	Fish Creek Delta	70.38977	-151.37069	12	8	20	na	na	
5	Fish Creek Delta	70.40397	-151.4835	70	45	115	89	77	166
5	Fish Creek Delta	70.40043	-151.45161	90	60	150	118	94	212
5	Fish Creek Delta	70.40254	-151.47029	55	30	85	98	25	123
5	Fish Creek Delta	70.3987	-151.46284	10	0	10	na	na	
5	Fish Creek Delta	70.40147	-151.46415	2	0	2	na	na	
5	Fish Creek Delta	70.40245	-151.47044	20	0	20	na	na	
5	Fish Creek West	70.43407	-151.73966	20	0	20	na	na	
5	Atigaru Pt.	70.53153	-151.75504	24	9	33	na	na	

Appendix C. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults	No. Young	Total
5	Atigaru Pt.	70.53197	-151.74427	80	0	80	114	0	114
5	Atigaru Pt.	70.54437	-151.73445	45	0	45	na	na	
5	Atigaru Pt.	70.54834	-151.73061	60	0	60	na	na	
5	Atigaru Pt.	70.54982	-151.75954	250	0	250	na	na	
5	Atigaru Pt.	70.54876	-151.75115	40	0	40	na	na	
5	Atigaru Pt.	70.53901	-151.75750	45	0	45	na	na	
5	Atigaru Pt.	70.54759	-151.76368	190	0	190	na	na	
5	Atigaru Pt.	70.54986	-151.77017	11	0	11	na	na	
5	Smith River	70.87893	-153.24531	100	0	100	na	na	
5	Smith River	70.91591	-153.18224	150	0	150	na	na	
5	Smith River	70.91543	-153.17805	120	0	120	na	na	
5	Smith River	70.90758	-153.17696	100	0	100	na	na	
5	Smith River	70.89403	-153.18181	160	0	160	na	na	
5	Smith River	70.89133	-153.19563	130	0	130	na	na	
5	Smith River	70.89023	-153.20508	50	0	50	na	na	
5	Smith River	70.90594	-153.14511	10	0	10	na	na	
5	Kokruagorok	70.89601	-153.09645	80	0	80	na	na	
5	Kokruagorok	70.89628	-153.08719	30	0	30	na	na	
5	Kokruagorok	70.89997	-153.03956	30	0	30	na	na	
5	Kokruagorok	70.89348	-153.03758	20	0	20	na	na	
5	Kokruagorok	70.89028	-153.03474	150	0	150	na	na	
5	Kokruagorok	70.88712	-152.99286	75	0	75	na	na	
5	Pogik Bay	70.85903	-152.94016	25	0	25	na	na	
5	Pogik Bay	70.85217	-152.93722	350	0	350	na	na	
5	Pogik Bay	70.85115	-152.92619	100	0	100	na	na	
5	Pogik Bay	70.85393	-152.91185	75	0	75	na	na	
5	Pogik Bay	70.85582	-152.90002	110	0	110	na	na	
5	Pogik Bay	70.86073	-152.89727	30	0	30	na	na	
5	Pogik Bay	70.86308	-152.89917	15	0	15	na	na	
5	Cape Halket	70.82920	-152.26590	130	0	130	na	na	
5	Cape Halket	70.78392	-152.30771	45	0	45	na	na	
5	Cape Halket	70.78044	-152.31792	70	0	70	na	na	
5	Cape Halket	70.76958	-152.32438	35	0	35	na	na	
5	Abraham BM	70.74154	-152.35856	20	0	20	na	na	
5	Abraham BM	70.74809	-152.40350	7	0	7	na	na	
5	Abraham BM	70.74579	-152.39969	65	0	65	na	na	
5	Abraham BM	70.73986	-152.46774	12	0	12	na	na	
5	Abraham BM	70.74236	-152.46288	40	0	40	na	na	
5	Abraham BM	70.73097	-152.52649	115	0	115	na	na	
5	Abraham BM	70.72045	-152.51453	20	0	20	na	na	
5	Abraham BM	70.72066	-152.50469	210	0	210	na	na	
5	Garry Creek	70.66989	-152.48068	120	0	120	na	na	
5	Garry Creek	70.67208	-152.48731	10	0	10	na	na	

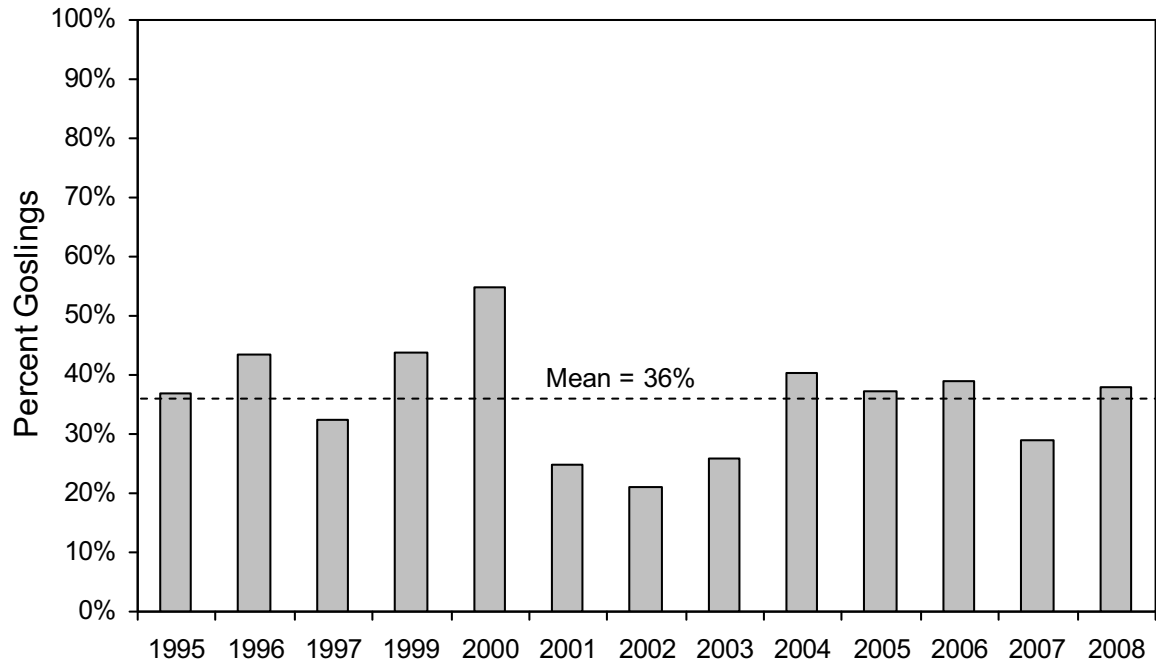


## Appendix C. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults	No. Young	Total
5	Garry Creek	70.66671	-152.48589	50	0	50	na	na	
5	Garry Creek	70.65986	-152.46672	30	0	30	na	na	
5	Garry Creek	70.65668	-152.46446	20	0	20	na	na	
5	Garry Creek	70.65757	-152.46484	10	0	10	na	na	
5	Garry Creek	70.65103	-152.48071	200	0	200	na	na	
5	Garry Creek	70.64334	-152.46889	20	0	20	na	na	
5	Garry Creek	70.62697	-152.47021	55	0	55	na	na	
5	Garry Creek	70.68332	-152.49684	180	0	180	na	na	
5	Garry Creek	70.66436	-152.51099	15	0	15	na	na	
5	Garry Creek	70.61930	-152.50181	25	15	40	na	na	
5	Garry Creek	70.62993	-152.51093	20	0	20	na	na	
5	Garry Creek	70.63274	-152.51636	240	0	240	na	na	
5	Garry Creek	70.64026	-152.52931	600	0	600	na	na	
5	Garry Creek	70.63950	-152.53584	240	0	240	na	na	
5	Kogru River	70.55055	-152.61785	150	0	150	na	na	
5	Saktuina Pt.	70.60654	-152.30913	100	0	100	na	na	
5	Saktuina Pt.	70.60725	-152.41750	90	0	90	na	na	
5	Garry Creek	70.62095	-152.52813	25	35	60	40	39	79
5	Garry Creek	70.62130	-152.52587	125	0	125	na	na	

Appendix D. Distribution and composition of Brant groups based on visual estimates during brood-rearing surveys, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Section Year	Total Groups	Brood Groups	Adults Without Broods	Adults With Broods	Total Adults	Goslings	Total Birds in Brood Groups	Total Birds
Dease Inlet								
1995	15	11	170	373	543	278	651	821
1996	17	12	786	236	1,022	227	463	1,249
1997	24	6	1,288	110	1,398	100	210	1,498
1999	21	14	172	302	474	366	668	840
2000	17	13	646	340	986	266	606	1,252
2001	16	9	1,165	739	1,904	148	887	2,052
2002	24	7	856	312	1,168	58	370	1,226
2003	38	13	4,427	606	5,033	238	844	5,271
2004	54	19	3,112	420	3,532	438	858	3,970
2005	16	4	1,338	243	1,581	86	329	1,667
2006	18	18	0	703	703	441	1,144	1,144
2007	22	10	414	299	713	205	504	918
2008	25	15	536	364	900	212	576	1,112
Mean	24	12	1,147	388	1,535	236	624	1,771
SD	11	4	1,267	186	1,322	124	260	1,336
Smith Bay								
1995	8	5	340	210	550	65	275	615
1996	5	4	225	80	305	38	118	343
1997	5	3	530	120	650	39	159	689
1999	30	13	1,680	286	1,966	203	489	2,169
2000	2	1	130	120	250	200	320	450
2001	22	7	3,219	201	3,420	243	444	3,663
2002	14	6	1,218	267	1,485	115	382	1,600
2003	20	7	2,581	371	2,952	131	502	3,083
2004	22	11	1,940	310	2,250	145	455	2,395
2005	41	12	2,018	412	2,430	323	735	2,753
2006	54	29	3,412	1,307	4,719	814	2,121	5,533
2007	49	11	3,210	275	3,485	192	467	3,677
2008	23	3	2,034	92	2,126	47	139	2,173
Mean	23	9	1,734	312	2,045	197	508	2,242
SD	17	7	1,178	317	1,381	205	515	1,533
Harrison Bay								
1995	16	9	670	969	1,639	566	1,535	2,205
1996	16	10	119	512	631	368	880	999
1997	43	21	1,048	655	1,703	284	939	1,987
1999	45	19	1,753	790	2,543	501	1,291	3,044
2000	6	5	14	210	224	342	552	566
2001	38	4	5,718	368	6,086	44	412	6,130
2002	46	8	3,946	410	4,356	89	499	4,445
2003	60	9	11,062	318	11,380	81	399	11,461
2004	91	19	7,484	879	8,363	508	1,387	8,871
2005	49	20	2,391	1,547	3,938	896	2,443	4,834
2006	53	25	2,758	1,082	3,840	720	1,802	4,560
2007	68	15	4,723	1,182	5,905	319	1,501	6,224
2008	99	29	6,376	1,707	8,083	1,061	2,768	9,144
Mean	48	15	3,697	818	4,515	445	1,262	4,959
SD	27	8	3,290	471	3,335	311	759	3,336



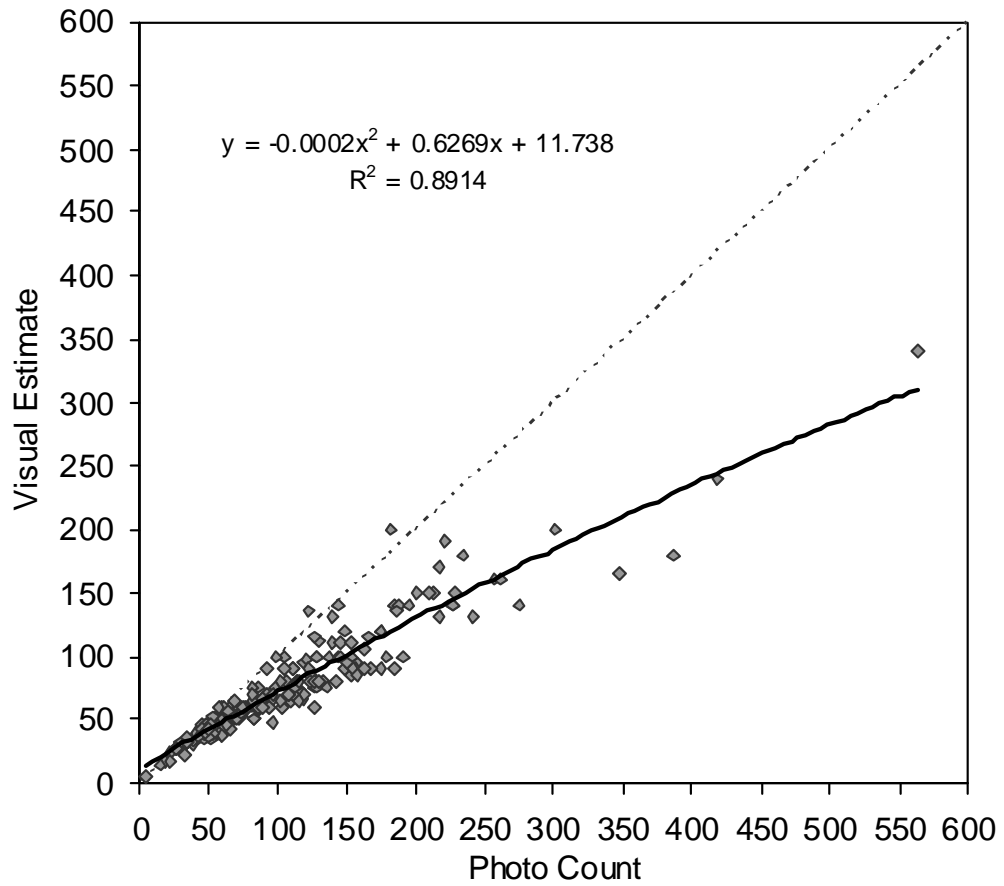
Appendix E. Percent goslings in Brant brood-rearing groups, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Appendix F. Number of Brant by visual estimates and from photos of each of 34 brood-rearing groups, Barrow to Fish Creek, Alaska, 2008. (Data are sorted by total group size from photos.)

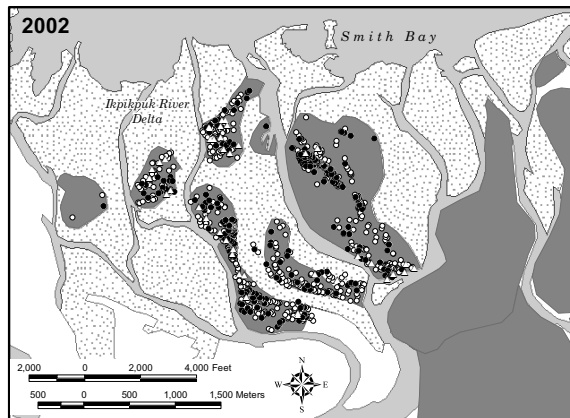
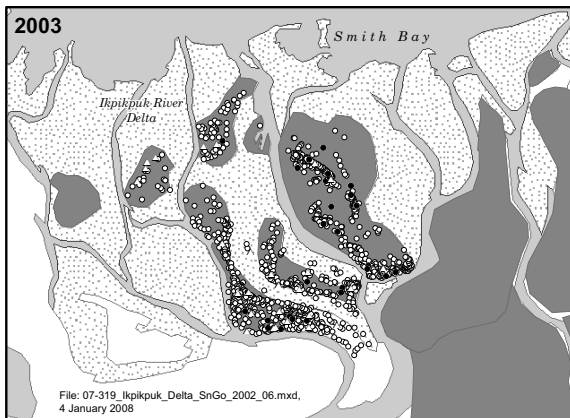
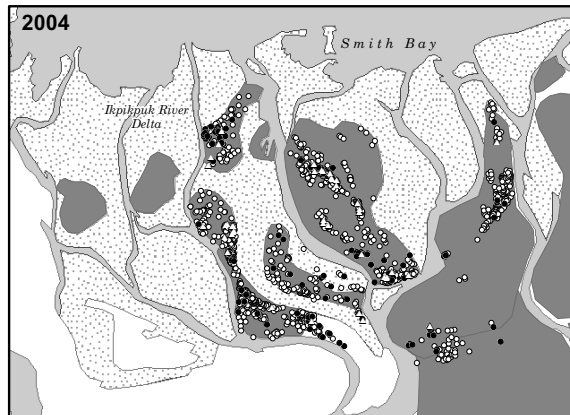
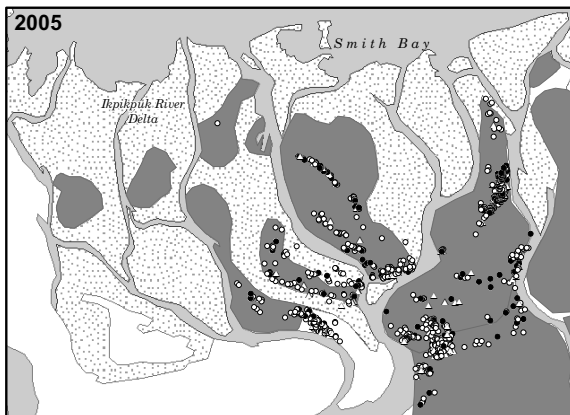
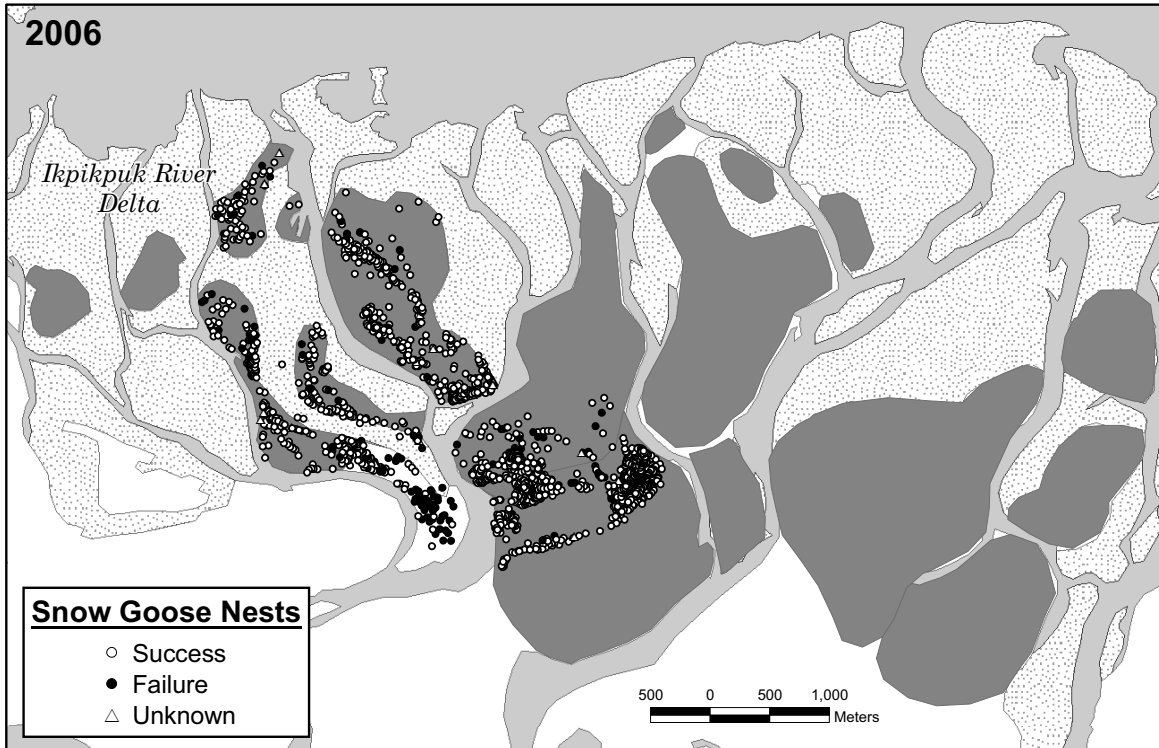
Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
33	22	21	-1	-4.5	5	5	0	0	27	26	-1	-3.7
34	18	23	5	27.8	12	15	3	25	30	38	8	26.7
25	40	42	2	5	8	9	1	12.5	48	51	3	6.3
27	30	33	3	10	13	21	8	61.5	43	54	11	25.6
4	30	29	-1	-3.3	25	27	2	8	55	56	1	1.8
13	40	35	-5	-12.5	20	25	5	25	60	60	0	0
26	26	28	2	7.7	20	33	13	65	46	61	15	32.6
22	50	55	5	10	10	11	1	10	60	66	6	10
17	30	41	11	36.7	30	28	-2	-6.7	60	69	9	15
24	30	31	1	3.3	30	40	10	33.3	60	71	11	18.3
30	30	37	7	23.3	30	35	5	16.7	60	72	12	20
23	25	40	15	60	35	39	4	11.4	60	79	19	31.7
31	20	32	12	60	30	51	21	70	50	83	33	66
12	50	54	4	8	40	37	-3	-7.5	90	91	1	1.1
28	50	59	9	18	20	33	13	65	70	92	22	31.4
5	55	69	14	25.5	20	43	23	115	75	112	37	49.3
29	50	87	37	74	22	29	7	31.8	72	116	44	61.1
1	45	52	7	15.6	50	65	15	30	95	117	22	23.2
16	48	56	8	16.7	50	64	14	28	98	120	22	22.4
21	55	98	43	78.2	30	25	-5	-16.7	85	123	38	44.7
7	70	68	-2	-2.9	42	62	20	47.6	112	130	18	16.1
2	70	85	15	21.4	40	55	15	37.5	110	140	30	27.3
9	80	87	7	8.8	60	57	-3	-5	140	144	4	2.9
10	60	81	21	35	40	63	23	57.5	100	144	44	44
3	60	66	6	10	50	79	29	58	110	145	35	31.8
32	60	107	47	78.3	35	50	15	42.9	95	157	62	65.3
19	70	89	19	27.1	45	77	32	71.1	115	166	51	44.3
6	140	116	-24	-17.1	60	65	5	8.3	200	181	-19	-9.5
11	90	88	-2	-2.2	50	97	47	94	140	185	45	32.1
14	90	123	33	36.7	50	65	15	30	140	188	48	34.3

Appendix F. Continued.

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
20	90	118	28	31.1	60	94	34	56.7	150	212	62	41.3
15	130	144	14	10.8	60	77	17	28.3	190	221	31	16.3
8	120	202	82	68.3	40	55	15	37.5	160	257	97	60.6
18	120	125	5	4.2	80	175	95	118.8	200	300	100	50
Mean	58.6	71.2	12.6	22.6	35.6	50.2	14.5	37.1	94.3	121.4	27.1	27.7
Sum	1994	2421	427	21.4	1212	1706	494	40.8	3206	4127	921	28.7



Appendix G. Comparison of visual estimates of the size of Snow Goose and Brant brood-rearing groups made during aerial surveys with counts made from photographs of each group, Barrow to Fish Creek, Alaska, 2008.



Appendix H. Locations and fates of Snow Goose nests on the Ikpikuk River delta, 2002–2006.

Appendix I. Locations and numbers of Snow Geese (visual estimates and photo counts) during brood-rearing surveys, Barrow to Fish Creek, Alaska, 2008.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
3	Tangent Point	71.09957	-155.14905	30	1	31			
3	Admiralty Bay	70.86486	-156.03081	1	0	1			
3	Admiralty Bay	70.75485	-155.94804	6	8	14	6	9	15
3	Kurgorak Bay	70.98586	-155.21641	1	0	1			
4	Avatanak Bight	70.86824	-153.46673	6	9	15			
4	Avatanak Bight	70.88024	-153.42242	50	65	115	60	66	126
4	Avatanak Bight	70.88536	-153.40184	30	15	45	34	11	45
4	Avatanak Bight	70.88643	-153.40038	4	0	4			
4	Point McLeod	70.88749	-153.76875	26	25	51	27	33	60
4	Point McLeod	70.88213	-153.78316	22	0	22			
4	Boat Creek	70.85941	-153.86727	8	20	28			
4	Boat Creek	70.85881	-153.86135	16	22	38			
4	Boat Creek	70.85710	-153.83904	2	3	5			
4	Boat Creek	70.85087	-153.83692	10	13	23			
4	Imakruak Lake	70.81476	-153.99132	12	16	28			
4	Imakruak Lake	70.81069	-153.93699	26	6	32	27	6	33
4	Imakruak Lake	70.80765	-153.96110	40	20	60	65 (1)	13	78
4	Imakruak Lake	70.80335	-153.96674	50	90	140	90 (1)	104	194
4	Imakruak Lake	70.80969	-153.96261	16	20	36			
4	Imakruak Lake	70.79951	-153.96683	6	0	6			
4	Naluakruk Lake	70.86592	-153.58045	18	0	18			
4	Naluakruk Lake	70.86007	-153.59520	50	0	50			
4	Naluakruk Lake	70.86102	-153.62764	20	0	20			
4	Naluakruk Lake	70.85102	-153.68082	30	0	30	(2)		
4	Naluakruk Lake	70.85085	-153.68530	26	0	26	(2)		
4	Boat Creek	70.83403	-153.87299	2	3	5			
4	Imakruak Lake	70.81797	-153.99973	14	21	35			
4	Mayoriak River	70.79873	-154.05290	30	45	75	33 (2)	53	86
4	Mayoriak River	70.79138	-154.05182	35	0	35	51 (1)	0	51
4	Mayoriak River	70.77790	-154.05938	14	30	44	21	42	63
4	Mayoriak River	70.77559	-154.06507	5	12	17	5 (1)	12	17
4	Mayoriak River	70.78240	-154.06987	10	20	30	10	22	32
4	Mayoriak River	70.78659	-154.08883	16	20	36	18	20	38
4	Ikpikpuk River	70.78504	-154.27792	22	30	52	22	32	54
4	Ikpikpuk River	70.79418	-154.30042	36	40	76	52	76	128
4	Ikpikpuk River	70.81026	-154.33493	30	12	42	44	13	57
4	Ikpikpuk River	70.82018	-154.38518	14	20	34	17 (1)	25	42
4	Ikpikpuk River	70.81552	-154.40127	12	20	32	16 (1)	17	33
4	Ikpikpuk River	70.81589	-154.41229	26	0	26			
4	Ikpikpuk River	70.81814	-154.39825	8	15	23	8	14	22
4	Ikpikpuk River	70.81613	-154.52954	4	8	12			
4	Ikpikpuk River	70.81633	-154.53719	2	0	2			



Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
4	Ikpikpuk River	70.81090	-154.58337	2	3	5			
4	Ikpikpuk River	70.80990	-154.58786	22	30	52	29	23	52
4	Ikpikpuk River	70.81025	-154.57428	22	0	22			
4	Ikpikpuk River	70.80498	-154.52426	40	60	100	63 (1)	74	137
4	Ikpikpuk River	70.80276	-154.50273	26	35	61	35	46	81
4	Ikpikpuk River	70.80182	-154.46627	70	70	140	120 (1)	154	274
4	Ikpikpuk River	70.80393	-154.40873	12	26	38	14 (2)	26	40
4	Ikpikpuk River	70.80978	-154.41493	6	6	12			
4	Ikpikpuk River	70.80811	-154.39547	18	25	43	24 (2)	37	61
4	Ikpikpuk River	70.81332	-154.40288	6	12	18			
4	Ikpikpuk River	70.80084	-154.38794	24	40	64	43	66	109
4	Ikpikpuk River	70.79513	-154.35109	40	40	80	66 (1)	66	132
4	Ikpikpuk River	70.79352	-154.34426	3	5	8			
4	Ikpikpuk River	70.79513	-154.35109	12	0	12			
4	Ikpikpuk River	70.79821	-154.32814	12	30	42	19 (1)	35	54
4	Ikpikpuk River	70.79886	-154.33129	30	30	60	42 (1)	29	71
4	Ikpikpuk River	70.79898	-154.33588	12	16	28	12	15	27
4	Ikpikpuk River	70.79487	-154.33213	10	12	22	13	19	32
4	Ikpikpuk River	70.78882	-154.33303	5	0	5			
4	Ikpikpuk River	70.78863	-154.33080	18	23	41	27	28	55
4	Ikpikpuk River	70.78923	-154.35969	70	80	150	97 (2)	131	228
4	Ikpikpuk River	70.78987	-154.36206	70	70	140	133 (2)	94	227
4	Ikpikpuk River	70.80052	-154.36987	70	70	140	147 (10)	80	227
4	Ikpikpuk River	70.80226	-154.37078	30	12	42	57 (3)	9	66
4	Ikpikpuk River	70.79543	-154.39373	26	30	56	38 (1)	34	72
4	Ikpikpuk River	70.79521	-154.38963	25	0	25			
4	Ikpikpuk River	70.79459	-154.38353	30	40	70	52 (3)	58	110
4	Ikpikpuk River	70.79076	-154.38168	36	45	81	63	60	123
4	Ikpikpuk River	70.80256	-154.43371	45	0	45			
4	Ikpikpuk River	70.80162	-154.47162	70	90	160	121 (1)	141	262
4	Ikpikpuk River	70.79016	-154.46322	50	60	110	72 (1)	81	153
4	Ikpikpuk River	70.80211	-154.43721	26	40	66	34 (3)	54	88
4	Ikpikpuk River	70.80035	-154.43658	8	10	18			
4	Ikpikpuk River	70.79003	-154.38394	36	45	81	66	60	126
4	Ikpikpuk River	70.78463	-154.38616	70	60	130	97 (1)	42	139
4	Ikpikpuk River	70.78865	-154.57420	90	0	90			
4	Ikpikpuk River	70.79311	-154.57227	80	100	180	185 (2)	202	387
4	Ikpikpuk River	70.79200	-154.57542	30	30	60	29	32	61
4	Ikpikpuk River	70.79125	-154.57607	50	50	100	77 (6)	101	178
4	Ikpikpuk River	70.79014	-154.58338	16	16	32	16	13	29
4	Ikpikpuk River	70.77186	-154.40535	80	90	170	103 (3)	113	216
4	Ikpikpuk River	70.77252	-154.40746	6	11	17			
4	Ikpikpuk River	70.77811	-154.41614	30	55	85	61	91	152

## Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
4	Ikpikpuk River	70.78074	-154.46544	70	0	70			
4	Ikpikpuk River	70.77823	-154.53656	30	20	50	43	25	68
4	Ikpikpuk River	70.77272	-154.48226	18	25	43	24 (1)	35	59
4	Ikpikpuk River	70.77260	-154.48442	40	50	90	89 (5)	85	174
4	Ikpikpuk River	70.77057	-154.44463	16	20	36	17 (1)	27	44
4	Ikpikpuk River	70.76777	-154.40579	80	100	180	106 (2)	128	234
4	Ikpikpuk River	70.76950	-154.42374	18	0	18	22 (1)	0	22
4	Ikpikpuk River	70.75756	-154.41795	20	20	40	23	23	46
4	Ikpikpuk River	70.75607	-154.42925	4	9	13			
4	Ikpikpuk River	70.75659	-154.41853	40	50	90	77 (1)	77	154
4	Ikpikpuk River	70.75325	-154.45128	75	90	165	155 (1)	192	347
4	Ikpikpuk River	70.75034	-154.45954	4	7	11			
4	Piasuk River	70.76652	-154.74075	70	0	70			
4	Piasuk River	70.76341	-154.77944	10	13	23			
4	Piasuk River	70.76732	-154.85271	4	8	12			
4	Piasuk River	70.77599	-154.78360	10	12	22			
4	Piasuk River	70.77870	-154.73360	22	20	42			
4	Piasuk River	70.78647	-154.69564	30	3	33	34	4	38
4	Piasuk River	70.77943	-154.69660	8	7	15			
4	Piasuk River	70.77886	-154.67033	10	16	26	10	16	26
4	Piasuk River	70.77732	-154.67305	26	40	66	58 (2)	59	117
4	Piasuk River	70.77530	-154.66420	30	45	75	42	40	82
4	Ikpikpuk River	70.78816	-154.62805	16	24	40	16	25	41
4	Ikpikpuk River	70.77948	-154.59350	36	45	81	59 (1)	47	106
4	Ikpikpuk River	70.76706	-154.57757	24	35	59	34	51	85
4	Ikpikpuk River	70.76800	-154.58205	4	3	7			
4	Ikpikpuk River	70.77167	-154.57958	15	0	15			
4	Piasuk River	70.78324	-154.66196	20	35	55	25	38	63
4	Piasuk River	70.79597	-154.67134	60	40	100	67 (2)	32	99
4	Piasuk River	70.79431	-154.67732	16	0	16			
4	Piasuk River	70.79078	-154.70884	65	0	65	69 (1)	0	69
4	Piasuk River	70.79040	-154.74481	22	22	44	24	24	48
4	Piasuk River	70.78828	-154.74193	16	3	19			
4	Piasuk River	70.78474	-154.73698	20	0	20			
4	Piasuk River	70.78286	-154.73334	36	30	66	58 (2)	38	96
4	Piasuk River	70.79086	-154.75893	35	0	35	46	0	46
4	Piasuk River	70.78970	-154.84331	10	0	10			
4	Piasuk River	70.79714	-154.91787	50	0	50			
4	Piasuk River	70.79699	-154.90755	24	30	54	32	40	72
4	Piasuk River	70.80106	-154.90117	10	22	32			
4	Piasuk River	70.79595	-154.87851	20	0	20			
4	Piasuk River	70.80439	-154.75008	60	30	90	81	29	110
4	Piasuk River	70.80501	-154.70500	4	6	10			

## Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
4	Piasuk River	70.80427	-154.71066	36	30	66	49 (2)	40	89
4	Piasuk River	70.79974	-154.69537	4	10	14			
4	Piasuk River	70.79974	-154.69537	25	0	25			
4	Piasuk River	70.80445	-154.64086	30	30	60	43	42	85
4	Piasuk River	70.80460	-154.64377	70	0	70			
4	Ikpikpuk River	70.79537	-154.60345	30	10	40	37 (2)	11	48
4	Ikpikpuk River	70.79622	-154.60835	20	30	50	28	43	71
4	Piasuk River	70.81628	-154.67652	30	0	30			
4	Piasuk River	70.82090	-154.68501	30	30	60	61 (2)	42	103
4	Piasuk River	70.81685	-154.69238	30	6	36			
4	Piasuk River	70.81475	-154.77384	25	0	25			
4	Piasuk River	70.81185	-154.78121	60	60	120	109 (4)	66	175
4	Piasuk River	70.81346	-154.77375	10	12	22			
4	Piasuk River	70.81179	-154.78440	10	10	20			
4	Piasuk River	70.81772	-154.78428	20	26	46	23	25	48
4	Piasuk River	70.81483	-154.82101	10	8	18			
4	Piasuk River	70.81465	-154.84505	60	70	130	153 (2)	63	216
4	Piasuk River	70.80660	-154.87204	20	20	40	32	25	57
4	Piasuk River	70.81417	-154.88730	36	40	76	53	56	109
4	Piasuk River	70.81818	-154.97103	30	35	65	39 (2)	42	81
4	Piasuk River	70.81491	-154.97656	30	30	60	39 (3)	54	93
4	Piasuk River	70.82681	-154.91388	30	0	30			
4	Piasuk River	70.82407	-154.77674	75	75	150	121 (2)	79	200
4	Piasuk River	70.83668	-154.68268	12	0	12			
4	Piasuk River	70.83562	-154.68730	40	50	90	57	91	148
4	Piasuk River	70.83534	-154.68895	40	60	100	73 (2)	79	152
4	Piasuk River	70.83636	-154.69416	6	12	18			
4	Piasuk River	70.82782	-154.69084	300	0	300			
4	Piasuk River	70.82703	-154.69369	18	1	19			
4	Piasuk River	70.82703	-154.69369	50	20	70	64 (1)	17	81
4	Piasuk River	70.82703	-154.69369	30	20	50	46	24	70
4	Piasuk River	70.82771	-154.67197	30	50	80	50	64	114
4	Piasuk River	70.82454	-154.64278	50	15	65	85 (3)	17	102
4	Piasuk River	70.82428	-154.64627	50	0	50	83 (1)	0	83
4	Piasuk River	70.83238	-154.63515	36	55	91	66 (2)	87	153
4	Piasuk River	70.82610	-154.60752	12	20	32	15	19	34
4	Piasuk River	70.83466	-154.63146	30	40	70	48 (6)	71	119
4	Piasuk River	70.84515	-154.71817	16	22	38	30 (3)	29	59
4	Piasuk River	70.83529	-154.74040	22	28	50			
4	Piasuk River	70.84300	-154.76932	4	7	11			
4	Piasuk River	70.85826	-154.81340	18	0	18			
4	Piasuk River	70.86161	-154.81870	30	30	60	75 (2)	52	127
4	Piasuk River	70.86209	-154.82105	40	40	80	57 (2)	45	102

## Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
4	Piasuk River	70.86328	-154.82414	30	30	60	35	21	56
4	Piasuk River	70.86791	-154.82902	50	40	90	103 (1)	53	156
4	Piasuk River	70.87142	-154.83227	32	15	47	80 (4)	16	96
4	Piasuk River	70.86578	-154.83241	30	0	30			
4	Piasuk River	70.85611	-154.81937	15	0	15			
4	Piasuk River	70.86101	-154.77761	65	0	65	115 (2)	0	115
4	Piasuk River	70.86036	-154.76124	40	30	70	83 (5)	25	108
4	Piasuk River	70.85479	-154.76229	50	50	100	76 (2)	52	128
4	Piasuk River	70.85660	-154.71915	18	21	39			
4	Piasuk River	70.85115	-154.65933	180	160	340	371 (9)	192	563
4	Piasuk River	70.85675	-154.67668	40	50	90	66 (3)	101	167
4	Piasuk River	70.85013	-154.67472	35	20	55	56 (2)	17	73
4	Piasuk River	70.86217	-154.64955	200	0	200			
4	Piasuk River	70.85921	-154.76056	40	30	70	81 (5)	26	107
4	Piasuk River	70.86832	-154.80491	30	30	60	37	38	75
4	Piasuk River	70.88057	-154.83077	70	80	150	142 (3)	67	209
4	Piasuk River	70.87819	-154.79205	30	15	45	56	7	63
4	Piasuk River	70.87873	-154.80031	65	10	75	134 (11)	1	135
4	Piasuk River	70.87298	-154.80372	22	24	46	25	23	48
4	N. Piasuk River	70.88806	-154.80519	50	0	50			
4	N. Piasuk River	70.88833	-154.81659	20	20	40	28 (2)	24	52
4	N. Piasuk River	70.90314	-154.77800	60	60	120	101 (4)	47	148
4	N. Piasuk River	70.89806	-154.80518	40	35	75	67 (2)	30	97
4	N. Piasuk River	70.89567	-154.81214	36	40	76	51 (2)	61	112
4	N. Piasuk River	70.89242	-154.83022	20	22	42	25	20	45
4	N. Piasuk River	70.88710	-154.87052	40	40	80	58 (4)	72	130
4	N. Piasuk River	70.88590	-154.87407	12	1	13			
4	N. Piasuk River	70.89558	-154.87498	30	30	60	46	43	89
4	N. Piasuk River	70.90649	-154.78329	8	10	18			
4	N. Piasuk River	70.91522	-154.71200	25	0	25			
4	SE Sinclair Lake	70.90490	-154.66644	40	50	90	87 (5)	97	184
4	SE Sinclair Lake	70.90246	-154.66459	30	6	36	42 (1)	7	49
4	SE Sinclair Lake	70.90335	-154.66174	6	2	8			
4	SE Sinclair Lake	70.90531	-154.64937	30	50	80	57 (5)	58	115
4	SE Sinclair Lake	70.90729	-154.63358	60	75	135	57 (2)	65	122
4	SE Sinclair Lake	70.90885	-154.65712	50	55	105	74 (4)	88	162
4	SE Sinclair Lake	70.91394	-154.72582	50	0	50	59 (1)	0	59
4	SE Sinclair Lake	70.91314	-154.65457	60	75	135	86	100	186
4	SE Sinclair Lake	70.92448	-154.62027	12	12	24			
4	SE Sinclair Lake	70.92251	-154.63757	28	0	28			
4	SE Sinclair Lake	70.92257	-154.64235	6	15	21			
4	SE Sinclair Lake	70.92745	-154.65562	40	60	100	61 (1)	84	145
4	SE Sinclair Lake	70.92201	-154.69201	12	18	30			

Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
4	SE Sinclair Lake	70.92223	-154.69787	6	12	18			
4	SE Sinclair Lake	70.93217	-154.70342	34	20	54	55	10	65
4	SE Sinclair Lake	70.93225	-154.68002	50	20	70	82 (7)	14	96
4	SE Sinclair Lake	70.93386	-154.68094	26	30	56	25 (1)	39	64
4	SE Sinclair Lake	70.94316	-154.63819	50	80	130	104 (5)	137	241
4	SE Sinclair Lake	70.94391	-154.72363	40	50	90	105 (4)	49	154
4	SE Sinclair Lake	70.94198	-154.72860	20	40	60	31	43	74
4	SE Sinclair Lake	70.95298	-154.70427	110	130	240	253 (7)	165	418
4	SE Sinclair Lake	70.95493	-154.70361	40	55	95	61	89	150
4	SE Sinclair Lake	70.94718	-154.66104	40	60	100	51 (1)	77	128
4	SE Sinclair Lake	70.94751	-154.64036	16	16	32	18	16	34
4	SE Sinclair Lake	70.94950	-154.64647	20	20	40	27 (1)	19	46
4	SE Sinclair Lake	70.94939	-154.64400	40	45	85	74 (1)	83	157
4	SE Sinclair Lake	70.94977	-154.64859	40	50	90	58	53	111
4	SE Sinclair Lake	70.95174	-154.60976	4	7	11	(2)		
4	Sinclair Lake	70.99722	-154.70886	25	0	25			
4	Sinclair Lake	71.04401	-154.73278	40	50	90	44 (2)	61	105
4	Sinclair Lake	71.04382	-154.73085	12	20	32	13	21	34
4	Sinclair Lake	71.04705	-154.74301	100	0	100			
4	Sinclair Lake	71.06122	-154.86732	20	25	45	23	28	51
4	Sinclair Lake	71.05194	-154.86346	40	40	80	60 (2)	82	142
4	Sinclair Lake	71.05257	-154.87409	50	50	100	115	76	191
4	Sinclair Lake	71.02234	-154.85592	10	0	10			
4	Sinclair Lake	71.01619	-154.85494	75	0	75			
4	Sinclair Lake	70.98187	-154.82814	12	11	23			
4	Sinclair Lake	71.01324	-154.88858	90	0	90			
4	Sinclair Lake	71.00233	-154.96548	6	0	6			
4	Sinclair Lake	70.98562	-154.95373	22	20	42	29 (3)	20	49
4	McKay Inlet	71.01435	-154.99266	50	0	50			
4	McKay Inlet	71.05419	-155.03733	14	22	36	16	26	42
4	McKay Inlet	71.04257	-155.08171	4	3	7			
4	McKay Inlet	71.03989	-155.07867	20	10	30			
4	McKay Inlet	71.04159	-155.07193	90	0	90			
4	McKay Inlet	71.04023	-155.08232	16	19	35			
4	McKay Inlet	71.03140	-155.09647	40	50	90	69 (3)	94	163
4	Sinclair Lake	70.95983	-154.72971	40	50	90	47 (1)	75	122
4	Sinclair Lake	70.96484	-154.72770	14	22	36	13	21	34
5	Fish Creek Delta	70.38614	-151.25098	4	7	11			
5	Fish Creek Delta	70.41887	-151.39634	50	70	120	73 (2)	101	174
5	Fish Creek Delta	70.43312	-151.53109	12	19	31			
5	Fish Creek Delta	70.38238	-151.37228	6	0	6			
5	Fish Creek Delta	70.38977	-151.37069	12	0	12			
5	Atigaru Pt.	70.55799	-151.93738	12	14	26			

Appendix I. Continued.

Section	Location	Latitude	Longitude	Visual Estimate			Photo Count		
				No. Adults	No. Young	Total	No. Adults <sup>a</sup>	No. Young	Total
5	Garry Creek	70.66512	-152.48503	14	30	44			
5	Garry Creek	70.65668	-152.46446	30	0	30			
5	Garry Creek	70.65757	-152.46484	20	0	20			
5	Garry Creek	70.65466	-152.47257	18	24	42			
5	Garry Creek	70.65006	-152.46050	30	0	30			
5	Garry Creek	70.64454	-152.46489	35	0	35			
5	Garry Creek	70.62697	-152.47021	15	0	15			
5	Garry Creek	70.67309	-152.49616	16	22	38	29	14	43
5	Garry Creek	70.63595	-152.52887	75	0	75	126 (2)	0	126
5	Garry Creek	70.68307	-152.54102	17	0	17			
5	Garry Creek	70.65367	-152.55915	525	0	525			
5	Garry Creek	70.64358	-152.57414	140	0	140			
5	Garry Creek	70.64647	-152.55252	60	5	65	81 (3)	5	86
5	Garry Creek	70.66729	-152.57718	75	0	75			
5	Kogru River	70.53638	-152.56694	43	0	43	(1)		
5	Kogru River	70.54499	-152.59304	8	15	23	(1)		
5	Kogru River	70.54547	-152.61305	12	16	28			
5	Kogru River	70.55055	-152.61785	8	0	8			
5	Kogru River	70.56847	-152.12977	5	0	5			
5	Saktuina Pt.	70.58434	-152.08563	12	0	12			
5	Saktuina Pt.	70.59683	-152.38586	12	0	12	(1)		
5	N. Garry Creek	70.71776	-152.76798	55	0	55			
Total Snow Geese				9,427	6,508	15,935			

<sup>a</sup> Blue phase adult Snow Geese listed in parentheses

Appendix J. Distribution and composition of Snow Geese groups based on visual estimates during brood-rearing surveys, Barrow to Fish Creek, Alaska, 1995–1997 and 1999–2008.

Section	Total Groups	Brood Groups	Adults Without Broods	Adults With Broods	Total Adults	Goslings	Total Birds in Brood Groups	Total Birds
Year								
<b>Dease Inlet</b>								
1995	3	3	0	23	23	39	62	62
1996	1	1	0	3	3	6	9	9
1997	2	2	0	5	5	8	13	13
1999	1	1	0	2	2	3	5	5
2000	1	0	1	0	1	0	0	1
2001	1	1	0	4	4	7	11	11
2002	2	1	22	12	34	9	21	43
2003	4	4	0	46	46	45	91	91
2004	4	3	3	57	60	66	123	126
2005	5	2	27	16	43	16	32	59
2006	2	2	0	66	66	95	161	161
2007	5	4	19	48	67	69	117	136
2008	4	2	2	36	38	9	45	47
Mean	3	2	6	24	30	29	53	59
SD	2	1	10	23	25	31	53	54
<b>Smith Bay</b>								
1995	6	6	0	154	154	164	318	318
1996	3	1	57	10	67	6	16	73
1997	8	6	21	87	108	127	214	235
1999	21	16	88	467	555	560	1,027	1,115
2000	22	19	102	513	615	753	1,266	1,368
2001	17	10	379	234	613	145	379	758
2002	23	20	71	897	968	783	1,680	1,751
2003	33	32	20	1,308	1,328	1,625	2,933	2,953
2004	46	43	156	1,497	1,653	1,808	3,305	3,461
2005	54	34	2,418	1,827	4,245	1,353	3,180	5,598
2006	113	111	13	4,888	4,901	5,877	10,765	10,778
2007	88	73	1,091	2,489	3,580	2,507	4,996	6,087
2008	247	194	2,296	5,772	8,068	6,277	12,049	14,345
Mean	52	43	516	1,549	2,066	1,691	3,241	3,757
SD	67	55	868	1,845	2,433	2,089	3,925	4,420
<b>Harrison Bay</b>								
1995	4	4	0	21	21	29	50	50
1996	3	2	50	50	100	73	123	173
1997	12	2	363	6	369	3	9	372
1999	9	6	190	46	236	61	107	297
2000	19	10	382	110	492	157	267	649
2001	13	8	43	114	157	89	203	246
2002	12	6	17	104	121	71	175	192
2003	11	8	18	157	175	146	303	321
2004	19	4	732	828	1,560	131	959	1,691
2005	15	7	550	73	623	152	225	775
2006	37	30	198	573	771	700	1,273	1,471
2007	25	5	985	98	1,083	69	167	1,152
2008	28	10	1,115	206	1,321	222	428	1,543
Mean	16	8	357	184	541	146	330	687
SD	10	7	382	241	504	177	371	583

Appendix K. Number of Snow Geese by visual estimates and from photos of each of 149 brood-rearing groups, Barrow to Fish Creek, Alaska, 2008. (Data are sorted by total group size from photos.)

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
147	6	6	0	0	8	9	1	12.5	14	15	1	7.1
12	5	5	0	0	12	12	0	0.0	17	17	0	0.0
20	8	8	0	0	15	14	-1	-6.7	23	22	-1	-4.3
61	10	10	0	0	16	16	0	0.0	26	26	0	0.0
31	12	12	0	0	16	15	-1	-6.3	28	27	-1	-3.6
49	16	16	0	0	16	13	-3	-18.8	32	29	-3	-9.4
13	10	10	0	0	20	22	2	10.0	30	32	2	6.7
32	10	13	3	30	12	19	7	58.3	22	32	10	45.5
7	26	27	1	3.8	6	6	0	0.0	32	33	1	3.1
19	12	16	4	33.3	20	17	-3	-15.0	32	33	1	3.1
93	12	15	3	25	20	19	-1	-5.0	32	34	2	6.3
135	16	18	2	12.5	16	16	0	0.0	32	34	2	6.3
140	12	13	1	8.3	20	21	1	5.0	32	34	2	6.3
149	14	13	-1	-7.1	22	21	-1	-4.5	36	34	-2	-5.6
14	16	18	2	12.5	20	20	0	0.0	36	38	2	5.6
60	30	34	4	13.3	3	4	1	33.3	33	38	5	15.2
25	12	14	2	16.7	26	26	0	0.0	38	40	2	5.3
64	16	16	0	0	24	25	1	4.2	40	41	1	2.5
18	14	17	3	21.4	20	25	5	25.0	34	42	8	23.5
145	14	16	2	14.3	22	26	4	18.2	36	42	6	16.7
4	16	29	13	81.3	22	14	-8	-36.4	38	43	5	13.2
55	16	17	1	6.3	20	27	7	35.0	36	44	8	22.2
3	30	34	4	13.3	15	11	-4	-26.7	45	45	0	0.0
116	20	25	5	25	22	20	-2	-9.1	42	45	3	7.1
57	20	23	3	15	20	23	3	15.0	40	46	6	15.0
136	20	27	7	35	20	19	-1	-5.0	40	46	6	15.0
69	22	24	2	9.1	22	24	2	9.1	44	48	4	9.1
75	30	37	7	23.3	10	11	1	10.0	40	48	8	20.0
79	20	23	3	15	26	25	-1	-3.8	46	48	2	4.3
111	22	25	3	13.6	24	23	-1	-4.2	46	48	2	4.3



Appendix K. Continued.

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
120	30	42	12	40	6	7	1	16.7	36	49	13	36.1
144	22	29	7	31.8	20	20	0	0.0	42	49	7	16.7
141	20	23	3	15	25	28	3	12.0	45	51	6	13.3
21	22	29	7	31.8	30	23	-7	-23.3	52	52	0	0.0
112	20	28	8	40	20	24	4	20.0	40	52	12	30.0
15	22	22	0	0	30	32	2	6.7	52	54	2	3.8
29	12	19	7	58.3	30	35	5	16.7	42	54	12	28.6
33	18	27	9	50	23	28	5	21.7	41	55	14	34.1
98	30	35	5	16.7	30	21	-9	-30.0	60	56	-4	-6.7
17	30	44	14	46.7	12	13	1	8.3	42	57	15	35.7
81	20	32	12	60	20	25	5	25.0	40	57	17	42.5
53	18	24	6	33.3	25	35	10	40.0	43	59	16	37.2
95	16	30	14	87.5	22	29	7	31.8	38	59	21	55.3
6	26	27	1	3.8	25	33	8	32.0	51	60	9	17.6
26	18	24	6	33.3	25	37	12	48.0	43	61	18	41.9
47	30	29	-1	-3.3	30	32	2	6.7	60	61	1	1.7
11	14	21	7	50	30	42	12	40.0	44	63	19	43.2
67	20	25	5	25	35	38	3	8.6	55	63	8	14.5
109	30	56	26	86.7	15	7	-8	-53.3	45	63	18	40.0
128	26	25	-1	-3.8	30	39	9	30.0	56	64	8	14.3
126	34	55	21	61.8	20	10	-10	-50.0	54	65	11	20.4
37	30	57	27	90	12	9	-3	-25.0	42	66	24	57.1
52	30	43	13	43.3	20	25	5	25.0	50	68	18	36.0
89	30	46	16	53.3	20	24	4	20.0	50	70	20	40.0
30	30	42	12	40	30	29	-1	-3.3	60	71	11	18.3
76	20	28	8	40	30	43	13	43.3	50	71	21	42.0
38	26	38	12	46.2	30	34	4	13.3	56	72	16	28.6
71	24	32	8	33.3	30	40	10	33.3	54	72	18	33.3
105	35	56	21	60	20	17	-3	-15.0	55	73	18	32.7
131	20	31	11	55	40	43	3	7.5	60	74	14	23.3
107	30	37	7	23.3	30	38	8	26.7	60	75	15	25.0

Appendix K. Continued.

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
8	40	65	25	62.5	20	13	-7	-35.0	60	78	18	30.0
23	26	35	9	34.6	35	46	11	31.4	61	81	20	32.8
83	30	39	9	30	35	42	7	20.0	65	81	16	24.6
88	50	64	14	28	20	17	-3	-15.0	70	81	11	15.7
63	30	42	12	40	45	40	-5	-11.1	75	82	7	9.3
66	24	34	10	41.7	35	51	16	45.7	59	85	26	44.1
74	30	43	13	43.3	30	42	12	40.0	60	85	25	41.7
5	60	81	21	35	5	5	0	0.0	65	86	21	32.3
10	30	33	3	10	45	53	8	17.8	75	86	11	14.7
43	26	34	8	30.8	40	54	14	35.0	66	88	22	33.3
73	36	49	13	36.1	30	40	10	33.3	66	89	23	34.8
118	30	46	16	53.3	30	43	13	43.3	60	89	29	48.3
84	30	39	9	30	30	54	24	80.0	60	93	33	55.0
70	36	58	22	61.1	30	38	8	26.7	66	96	30	45.5
100	32	80	48	150	15	16	1	6.7	47	96	49	104.3
127	50	82	32	64	20	14	-6	-30.0	70	96	26	37.1
114	40	67	27	67.5	35	30	-5	-14.3	75	97	22	29.3
68	60	67	7	11.7	40	32	-8	-20.0	100	99	-1	-1.0
91	50	85	35	70	15	17	2	13.3	65	102	37	56.9
97	40	57	17	42.5	40	45	5	12.5	80	102	22	27.5
77	30	61	31	103.3	30	42	12	40.0	60	103	43	71.7
139	40	44	4	10	50	61	11	22.0	90	105	15	16.7
65	36	59	23	63.9	45	47	2	4.4	81	106	25	30.9
106	40	81	41	102.5	30	26	-4	-13.3	70	107	37	52.9
101	40	83	43	107.5	30	25	-5	-16.7	70	108	38	54.3
27	24	43	19	79.2	40	66	26	65.0	64	109	45	70.3
82	36	53	17	47.2	40	56	16	40.0	76	109	33	43.4
39	30	52	22	73.3	40	58	18	45.0	70	110	40	57.1
72	60	81	21	35	30	29	-1	-3.3	90	110	20	22.2
138	40	58	18	45	50	53	3	6.0	90	111	21	23.3
115	36	51	15	41.7	40	61	21	52.5	76	112	36	47.4

Appendix K. Continued.

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
90	30	50	20	66.7	50	64	14	28.0	80	114	34	42.5
121	30	57	27	90	50	58	8	16.0	80	115	35	43.8
62	26	58	32	123.1	40	59	19	47.5	66	117	51	77.3
94	30	48	18	60	40	71	31	77.5	70	119	49	70.0
122	60	57	-3	-5	75	65	-10	-13.3	135	122	-13	-9.6
148	40	47	7	17.5	50	75	25	50.0	90	122	32	35.6
40	36	63	27	75	45	60	15	33.3	81	123	42	51.9
2	50	60	10	20	65	66	1	1.5	115	126	11	9.6
44	36	66	30	83.3	45	60	15	33.3	81	126	45	55.6
96	30	75	45	150	30	52	22	73.3	60	127	67	111.7
16	36	52	16	44.4	40	76	36	90.0	76	128	52	68.4
102	50	76	26	52	50	52	2	4.0	100	128	28	28.0
134	40	51	11	27.5	60	77	17	28.3	100	128	28	28.0
117	40	58	18	45	40	72	32	80.0	80	130	50	62.5
28	40	66	26	65	40	66	26	65.0	80	132	52	65.0
110	65	134	69	106.2	10	1	-9	-90.0	75	135	60	80.0
22	40	63	23	57.5	60	74	14	23.3	100	137	37	37.0
45	70	97	27	38.6	60	42	-18	-30.0	130	139	9	6.9
142	40	60	20	50	40	82	42	105.0	80	142	62	77.5
125	40	61	21	52.5	60	84	24	40.0	100	145	45	45.0
86	40	57	17	42.5	50	91	41	82.0	90	148	58	64.4
113	60	101	41	68.3	60	47	-13	-21.7	120	148	28	23.3
133	40	61	21	52.5	55	89	34	61.8	95	150	55	57.9
51	30	61	31	103.3	55	91	36	65.5	85	152	67	78.8
87	40	73	33	82.5	60	79	19	31.7	100	152	52	52.0
42	50	72	22	44	60	81	21	35.0	110	153	43	39.1
92	36	66	30	83.3	55	87	32	58.2	91	153	62	68.1
58	40	77	37	92.5	50	77	27	54.0	90	154	64	71.1
130	40	105	65	162.5	50	49	-1	-2.0	90	154	64	71.1
99	50	103	53	106	40	53	13	32.5	90	156	66	73.3
137	40	74	34	85	45	83	38	84.4	85	157	72	84.7

Appendix K. Continued.

Photo/Group	Adults				Young				Total			
	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change	Visual	Photo	Difference	% Change
123	50	74	24	48	55	88	33	60	105	162	57	54.3
146	40	69	29	72.5	50	94	44	88	90	163	73	81.1
104	40	66	26	65	50	101	51	102	90	167	77	85.6
1	50	73	23	46	70	101	31	44.3	120	174	54	45
54	40	89	49	122.5	50	85	35	70	90	174	84	93.3
78	60	109	49	81.7	60	66	6	10	120	175	55	45.8
48	50	77	27	54	50	101	51	102	100	178	78	78
119	40	87	47	117.5	50	97	47	94	90	184	94	104.4
124	60	86	26	43.3	75	100	25	33.3	135	186	51	37.8
143	50	115	65	130	50	76	26	52	100	191	91	91
9	50	90	40	80	90	104	14	15.6	140	194	54	38.6
85	75	121	46	61.3	75	79	4	5.3	150	200	50	33.3
108	70	142	72	102.9	80	67	-13	-16.3	150	209	59	39.3
50	80	103	23	28.8	90	113	23	25.6	170	216	46	27.1
80	60	153	93	155	70	63	-7	-10	130	216	86	66.2
35	70	133	63	90	70	94	24	34.3	140	227	87	62.1
36	70	147	77	110	70	80	10	14.3	140	227	87	62.1
34	70	97	27	38.6	80	131	51	63.8	150	228	78	52
56	80	106	26	32.5	100	128	28	28	180	234	54	30
129	50	104	54	108	80	137	57	71.3	130	241	111	85.4
41	70	121	51	72.9	90	141	51	56.7	160	262	102	63.8
24	70	120	50	71.4	70	154	84	120	140	274	134	95.7
59	75	155	80	106.7	90	192	102	113.3	165	347	182	110.3
46	80	185	105	131.3	100	202	102	102	180	387	207	115
132	110	253	143	130	130	165	35	26.9	240	418	178	74.2
103	180	371	191	106.1	160	192	32	20	340	563	223	65.6
Mean	36	59	22	51.5	39	51	12	23	76	110	34	38.3
Sum	5437	8778	3341	61.4	5855	7653	1798	23.5	11292	16431	5139	45.5

Appendix L. Band histories of Snow Geese recaptured at the Ikpikpuk, Piasuk, Colville, and Sagavanirktok banding sites, 2000–2008. Histories are excluded for birds banded and recaptured at the same banding site.

Band Number	Banding Site				Recapture Site			
	Location	Lat-Long <sup>a</sup>	Date	Age <sup>b</sup> Sex <sup>c</sup> Color	Location	Lat-Long <sup>a</sup>	Date <sup>c</sup>	
1367-96306	Howe Island, AK	701-1474	7/29/1993	L M White	Piasuk River Delta, AK	704-1543	8/5/2000	
4007-59960	Banks Island, NT	722-1252	7/14/1996	L F White	Ikpikpuk River Delta, AK	704-1542	8/4/2001	
4007-90572	Atkinson Point, NU	674-1025	7/13/1998	L M White	Ikpikpuk River Delta, AK	704-1542	8/4/2001	
4007-59960	Banks Island, NT	722-1252	7/14/1996	L F White	Ikpikpuk River Delta, AK	704-1542	7/31/2002	
1277-05671	Banks Island, NT	722-1250	7/19/1994	ASY M White	Ikpikpuk River Delta, AK	704-1543	8/1/2002	
1557-09503	MacKenzie Delta, NT	692-1351	8/2/1999	L F White	Ikpikpuk River Delta, AK	704-1542	8/2/2002	
1557-09583	MacKenzie Delta, NT	692-1351	8/2/1999	L F White	Ikpikpuk River Delta, AK	704-1543	8/2/2002	
1557-64441	Banks Island, NT	725-1240	7/18/2001	AHY M White	Ikpikpuk River Delta, AK	704-1542	8/2/2003	
1587-48941	Banks Island, NT	722-1251	7/16/2002	AHY M White	Ikpikpuk River Delta, AK	704-1542	8/2/2003	
1557-09583	MacKenzie Delta, NT	692-1351	8/2/1999	L F White	Ikpikpuk River Delta, AK	704-1543	8/3/2003	
4007-47492	Wrangel Island, Russia	713-1793	8/4/2002	AHY U White	Ikpikpuk River Delta, AK	704-1542	8/3/2003	
4007-47318	Wrangel Island, Russia	713-1793	8/3/2002	HY M White	Ikpikpuk River Delta, AK	704-1543	8/2/2005	
1587-12548	Wapusk National Park, MB	583-0932	7/23/2001	L M White	Ikpikpuk River Delta, AK	704-1543	8/3/2005	
1707-34532	Banks Island, NT	725-1234	7/13/2004	AHY M White	Ikpikpuk River Delta, AK	704-1543	8/3/2005	
1707-35147	Banks Island, NT	722-1231	7/15/2004	AHY F White	Ikpikpuk River Delta, AK	704-1543	8/3/2005	
1557-12367	Banks Island, NT	724-1231	7/16/2000	AHY M White	Piasuk River Delta, AK	705-1544	8/4/2005	
1587-48943	Banks Island, NT	722-1251	7/16/2002	AHY F White	Piasuk River Delta, AK	705-1544	8/4/2005	
1367-96343	Howe Island, AK	701-1474	7/30/1993	L M White	Piasuk River Delta, AK	705-1544	8/5/2005	
1707-36303	Banks Island, NT	725-1241	7/15/2005	AHY M White	Ikpikpuk River Delta, AK	704-1543	8/2/2006	
1557-07792	Banks Island, NT	722-1252	7/18/1998	AHY M White	Ikpikpuk River Delta, AK	704-1543	8/3/2006	
1587-47339	MacKenzie Delta, NT	692-1351	7/31/2001	L F White	Ikpikpuk River Delta, AK	704-1543	8/3/2006	
1707-34127	Banks Island, NT	725-1241	7/12/2004	SY M White	Ikpikpuk River Delta, AK	704-1543	8/3/2006	
1707-34821	Banks Island, NT	722-1231	7/14/2004	SY F White	Ikpikpuk River Delta, AK	704-1543	8/3/2006	
4007-48092	Wrangel Island, Russia	713-1793	8/4/2002	HY M White	Ikpikpuk River Delta, AK	704-1543	8/3/2006	
1557-10015	Banks Island, NT	725-1245	7/10/2000	SY M White	Ikpikpuk River Delta, AK	704-1543	8/4/2006	
1707-34119	Banks Island, NT	725-1241	7/12/2004	SY F White	Ikpikpuk River Delta, AK	704-1543	8/4/2006	
4007-49657	Wrangel Island, Russia	713-1793	8/6/2004	HY M White	Ikpikpuk River Delta, AK	704-1543	8/4/2006	
4007-49901	Wrangel Island, Russia	713-1793	8/6/2004	AHY M White	Ikpikpuk River Delta, AK	704-1542	8/3/2007	
1727-55532	Wrangel Island, Russia	713-1793	7/23/2005	L F White	Ikpikpuk River Delta, AK	704-1542	8/4/2007	
1847-11195	Siksikik Island, NT	723-1244	7/15/2006	AHY M White	Ikpikpuk River Delta, AK	704-1542	8/4/2007	
1707-71015	Piasuk River Delta, AK	705-1544	8/4/2005	L M White	Colville River Delta, AK	702-1501	8/1/2008	

Appendix L. Continued.

Band Number	Banding Site				Recapture Site			
	Location	Lat-Long <sup>a</sup>	Date	Age <sup>b</sup> Sex <sup>c</sup> Color	Location	Lat-Long <sup>a</sup>	Date <sup>c</sup>	
1587-47339	Richard Island, NT	692-1351	7/31/2001	L F White	Ikpikpuk River Delta, AK	704-1543	8/2/2008	
1727-55532	Wrangel Island, Russia	713-1793	7/23/2005	L F White	Ikpikpuk River Delta, AK	704-1543	8/2/2008	
1847-12407	Banks Island, NT	725-1241	7/15/2007	AHY F White	Ikpikpuk River Delta, AK	704-1543	8/2/2008	
1847-50672	Johnson Point, NU	675-1004	8/2/2007	AHY M White	Ikpikpuk River Delta, AK	704-1543	8/2/2008	
1707-71975	Ikpikpuk River Delta, AK	704-1543	8/4/2006	L M White	Sagavanirktok River Delta, AK	701-1486	8/4/2008	
1587-47889	Banks Island, NT	722-1251	7/12/2002	AHY F White	Sagavanirktok River Delta, AK	701-1475	8/5/2008	
1847-07721	Wrangel Island, Russia	713-1793	7/28/2007	AHY F White	Sagavanirktok River Delta, AK	701-1483	8/6/2008	

<sup>a</sup> Location is within the 10 minute block of latitude, for example, 705 = 70°50' N latitude, while 1544 = 154°40' W longitude

<sup>b</sup> Age: Refers to age at time of banding. L = local, not flight-capable gosling; HY = flight-capable hatch-year bird; AHY = after-hatch year; ASY = after second year

<sup>c</sup> Sex: Refers to sex at time of banding. F = female, M = male

<sup>d</sup> Bird recaptured on multiple occasions within study area

<sup>e</sup> Data are current through 6 December 2008