

MBM

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Memorandum

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Subject: 2012 Yukon-Kuskokwim Delta Coastal Zone Survey of Geese, Swans,  
and Sandhill Cranes.

**INTRODUCTION AND METHODS**

This report summarizes information about the status of geese, tundra swans (*Cygnus columbianus*), and sandhill cranes (*Grus canadensis*) in the coastal zone of the Yukon-Kuskokwim Delta (YKD), Alaska. The Yukon-Kuskokwim Delta Coastal Zone Survey was flown 3-14 June 2012, representing the 28th consecutive year the U.S. Fish and Wildlife Service (USFWS) has conducted this project. Goose species surveyed include cackling Canada geese (*Branta hutchinsii minima*), Pacific greater white-fronted geese (*Anser albifrons frontalis*), emperor geese (*Chen canagica*), Pacific black brant (*Branta bernicla nigricans*), and Taverner's Canada geese (*Branta hutchinsii taverneri*). Species nomenclature follows common names recognized by the Pacific Flyway and scientific names recognized by the American Ornithological Union (Banks et al. 2003). Species are referenced as cackling Canada geese, white-fronted geese, emperor geese, black brant, and Taverner's Canada geese throughout the remainder of this document.

Survey procedures followed established USFWS and Canadian Wildlife Service (CWS) protocol for aerial waterfowl breeding population surveys (USFWS and CWS 1987). An amphibious Quest Kodiak (N700FW) was used to fly the survey in 2012. All previous surveys had been flown using an amphibious Cessna 206 as the survey platform. During the survey, the aircraft is flown along the centerline of pre-determined transect lines at a height of 30-45 m (100-150 feet) above ground level and at a ground speed of 145-170 km/hr (90-105 miles/hr; 78-90 knots). The aircraft Global Positioning System (GPS) is used to navigate the aircraft to transect "start" and "end" waypoints and maintain the aircraft along the transect centerline. In previous surveys, a biologist-pilot and right-seat observer each recorded observations of geese, swans, and cranes within 200 m of the flight path on their respective side of the aircraft. In 2012, only the right-seat observer recorded observations. Bart Stone, Office of Aviation Services, served solely as pilot and did not record any observations. The author served as front right-seat observer for the

survey counting all geese, swans, and cranes. Bob Platte, USFWS, served as rear right-seat observer, counting all other waterbirds including ducks, loons, gulls, terns, and jaegers. Each observation is recorded vocally using a microphone to a sound file (.wav format), linked with simultaneous GPS coordinates, and saved to a laptop computer. After the flight, a transcription program is used to replay the sound files and combine the transcribed observation data with the geographic coordinates to produce a text data file. The transcribed text file is then used for data analyses.

## Population Indices

Monitoring populations is an essential tool for waterfowl management; however, most surveys of waterfowl rely on aerial indices rather than estimates of the actual population size because it is not possible for aerial survey observers to detect all birds. The proportion of birds detected may change with observer experience, survey timing, weather conditions, aircraft platform, spring phenology, habitat conditions, species (intra- and extra-) density, age structure, or nest success. Such changes may vary annually, show a pattern, or shift progressively over time.

Population indices used in this report are calculated for the following species or groups of species as follows:

### All Geese and Sandhill Cranes

$$\textit{indicated breeding birds} = 2 \times (\textit{singles} + \textit{pairs}^a)$$

$$\textit{indicated total birds} = 2 \times (\textit{singles} + \textit{pairs}) + \textit{birds in flocks}$$

### Tundra Swans

$$\textit{total birds} = \textit{singles} + (2 \times \textit{pairs}) + \textit{birds in flocks}$$

$$\textit{singles and pairs} = \textit{singles} + (2 \times \textit{pairs})$$

$$\textit{nests} = \textit{number of active nests observed}$$

$$^a \textit{pairs} = \textit{number of pairs and not number of birds in pairs}$$

*This definition applies to all species in this report.*

These population indices are based on the assumption that a single goose or crane observed represents a pair, with the unseen mate being on a nest. And even though cranes are larger than geese, we assume the visibility of cranes to be similar to that of geese because of the crane's cryptic coloration. We assume that all swans are observed and a complete count is attained; thus, the number of single swans is not doubled.

In 2012, population indices for geese, swans, and sandhill cranes from this survey were derived based on observations made on only the right side of the aircraft rather than both sides of the aircraft as in previous years. However, the right-seat observer has conducted this survey for over 5 years; therefore, the results reported here are believed comparable relative to previous surveys.

## **Stratification Design and Survey Design**

The survey area extends from the coast to approximately 50 km (31 mi) inland from Kuskokwim Bay in the south to Norton Sound in the north (Fig. 1). Originally, the entire coastal zone was divided into 16 strata based on generally homogeneous physiographic regions determined from unclassified LANDSAT images (Butler 1988). In 2004, the stratification design was simplified and reduced to four primary strata and one small stratum. The small stratum was created to better accommodate historical data for a high-density area which had had variable spacing between transects for several years. Indices for both indicated breeding birds and indicated total birds were recalculated for the entire history of the survey to reflect the new 4+1 stratification design.

The survey design was standardized in 1998 after slight changes were made over the years in the number and placement of transects. Beginning that year, the survey used a stratified sampling design with four sampling intensities related to goose densities with 1.6 km (1 mi) intervals between transects in higher goose density areas and 3.2 km (2 mi), 6.4 km (4 mi) and 12.9 km (8 mi) intervals in successively less dense areas (Fig. 1). Transects were systematically placed in an east-west orientation from a randomly selected starting point. To obtain optimal distribution data and more complete coverage, four sets of unique transect lines were drawn. During the four-year survey rotation of these unique sets, nearly complete coverage of each interval zone is achieved. In the 1.6 km interval zone, each transect was moved 0.4 km between each unique set. Similarly, transects within the 3.2 km interval zone were moved 0.8 km between each unique set; transects within the 6.4 km interval zone, 1.2 km; and transects within the 12.9 km interval zone, 2.4 km between each unique set. The years 1998-2001 comprised the first complete four-year rotation; 2002-2005, the second; and 2006-2009, the third complete four-year rotation. The year 2012 represents the third year of the fourth, four-year rotation. These same transects were flown in the years 2000, 2004, and 2008. The 106 transects flown in 2011 totaled 2,369 km (1,472 mi) linear distance. Sample survey coverage measured 7.4% of the total 12,852 km<sup>2</sup> (4,962 mi<sup>2</sup>) study area.

## **RESULTS**

The aerial crew arrived in Bethel on 02 June 2012 and the survey was initiated on 03 June 2012. Survey dates were 03, 04, 05, 06, 10, 11, 13, and 14 June. Low visibility and fog prevented flying surveys on the intervening days. During the 28-year history of the survey, the maximum range of dates has been from 29 May to 24 June. Since 1993, however, the interval for flying the survey has been much more concise, with dates extending from 29 May to 15 June. The goal for timing the survey is to coincide with the laying and early incubation of nesting geese. We considered that consistent survey timing relative to nesting would reduce variation in visibility rates linked to normal shifts in nesting behaviors such as constancy of nest attendance, and the flocking and departure of failed breeders. We set an objective for beginning the survey each year at nine days after average clutch initiation for cackling geese. However, clutch initiation data, collected by ground crews (Fischer et al. 2011), are not available until after the aerial survey is completed. Therefore, to determine appropriate dates to start the survey, we use weather variables on the Yukon-Kuskokwim Delta to predict nest initiation. In 2012, the

average cackling goose nest initiation date was predicted to be 27 May (R. Stehn, pers. comm); thus, the ideal start date for the aerial survey was 05 June. In comparison to recent years, 2012 spring phenology on the Yukon-Kuskokwim Delta was late due to cold spring temperatures and a large snow pack. We elected to begin the survey on 03 June based on reports from biologists working on the YKD. We believe survey timing in 2012 was accurate based on our observations of goose distribution and pairings and the availability of nesting habitat at the start of the survey. On 03 June 2012, the tundra was mostly clear of snow, except in gullies and other areas where snow had drifted. Ponds and marshes ranged from 100% ice-free to 100% ice-covered; and most sloughs and rivers were ice-clogged. During the survey, some of the habitat appeared to be flooded, which was assumed to be due to the snow melt being held in place by the clogged sloughs and rivers. By 14 June 2012, some greening up of the tundra had occurred and only ~15% of the lakes in the northern areas had ice.

Nesting phenology for cackling Canada geese has advanced at an average of -0.295 days per year since 1982 (Fischer et al. 2011). In 1982, the average cackler clutch initiation date occurred on 05 June and in 2011, on 25 May, a difference of almost two weeks. Our aerial survey start dates have also generally advanced to reflect the earlier nesting phenology. The variation in survey timing relative to nesting phenology is not completely understood; however, it is assumed that the relative number of failed breeders increases as the nesting season progresses. Therefore, surveys timed later relative to nesting phenology could result in greater numbers of flocked birds and fewer pairs observed than if the survey had been flown earlier in the nesting season. Differences in nesting success could also complicate this relationship because predation increases the number of birds seen in flocks due to failed breeding attempts. Nest initiation, nest hatch, and the proportion of active nests in 2012 based on ground-based nest searches (Fischer and Stehn 2012, in prep) can help verify the timing of the aerial survey relative to nesting phenology. Exact timing of the aerial survey is not considered critical to data integrity, however, given other limitations (e.g., weather delays, mechanical delays).

### **Cackling Canada Geese**

In 2012, the indicated total birds for cackling geese was estimated to be  $60,395 \pm 2,663$  [SE]; and indicated breeding birds,  $51,729 \pm 2,349$  on the Yukon-Kuskokwim Delta breeding grounds. These indices represent an increase of 12% and 22% from the 2011 indices of  $53,799 \pm 2,137$  and  $42,361 \pm 1,796$ , respectively (Tables 1, 2, 6). Different growth rates were calculated for the time period when cackler numbers were rapidly increasing (1985-1997) versus the time period when the population appears to have stabilized (1998-2012). From 1985-1997, indicated total birds and indicated breeding birds growth rates were  $1.173 \pm 0.009$  and  $1.146 \pm 0.010$ , respectively. However, for the last 14 years (1998-2012), indicated total birds and indicated breeding birds annual growth rates were  $0.999 \pm 0.0099$  and  $1.004 \pm 0.006$ , respectively, suggesting a stable population (Fig. 2).

In March 2011, the Pacific Flyway Council adopted a new method for estimating the fall population index of cackling geese, after assessment of alternative methods by the U.S. Fish and Wildlife Service, Migratory Bird Management Office (Alaska) (Stehn 2011). The original method, used to predict the fall population from 1998-2010, relied on a simple linear relationship

between indicated total birds on the Yukon-Kuskokwim Delta breeding grounds (i.e., this aerial survey) regressed on the 1985-1998 fall coordinated count data (Pacific Flyway Council 1999, Bollinger 2011). The new adopted method uses ratio estimation to establish the relationship between the indicated total birds index from the Yukon-Kuskokwim Delta breeding ground survey (i.e., this aerial survey) and the 1989-2003 mark-resight data to estimate a fall population size. An index ratio of 3.35 is applied to the indicated total birds index from the Yukon-Kuskokwim Delta Coastal Zone Survey to derive a fall population index. The 2011 cackler population index was 180,227 birds, and the 3-year (2009-2011) average was 227,158 (Bollinger 2011, Appendix 1). The 2012 cackler population index is 202,323 birds and the 3-year (2010-2012) average is 219,298 birds (Appendix 1).

### **Pacific White-fronted Geese**

In 2012, the Pacific white-fronted goose indicated total birds index was  $181,519 \pm 15,461$  and indicated breeding birds index,  $97,654 \pm 8,422$ . The indicated total birds index and the indicated breeding birds index were 8% and 22% higher, respectively, than those of 2011 ( $168,925 \pm 16,068$  and  $84,551 \pm 8,127$ ) (Tables 1, 2, 6). The 2012 population indices are the highest on record (Tables 1, 2, 6). The average annual growth rates for indicated total birds and indicated breeding birds from 1985-2012 measured  $1.096 \pm 0.006$  and  $1.102 \pm 0.005$ , respectively (Fig. 3). These remain the highest growth rates of the five goose species on the Yukon-Kuskokwim Delta; however, in recent years the rate of increase appears to be decreasing. The average annual growth rate for indicated total birds for the first 22 years of the survey (1985-2006) measured  $1.105 \pm 0.008$  as compared to  $1.013 \pm 0.023$  for the last 6 years of the survey (2007-2012) (Fig. 4).

Timm and Dau (1979) speculated that over 95% of the Pacific white-front population occurs on the Yukon-Kuskokwim Delta. Today, indices for all Pacific white-fronts occurring in Alaska are determined from results of the Yukon-Kuskokwim Delta Coastal Zone Survey (i.e., this survey) and the surveys of the interior Yukon-Kuskokwim Delta and Bristol Bay (i.e. Alaska-Yukon Waterfowl Breeding Population and Habitat Survey (WBPHS)) (Appendix 2; Mallek and Groves 2012, in prep). Earlier analysis of these June aerial breeding birds surveys estimated that the YKD accounts for an average of nearly 97% of the Pacific white-fronts population (Eldridge and Dau 2002; Conant and Groves 2002). In 2012, the coastal Yukon-Kuskokwim Delta, the interior Yukon-Kuskokwim Delta, and Bristol Bay accounted for 78%, 20%, and 2%, of the total Pacific white-fronted goose population, respectively (Appendix 2). In 2012, the indicated total birds index (232,513) and the indicated breeding birds index (122,079) were the highest since the survey was initiated (Appendix 2).

The fall population estimate for Pacific white-fronted geese is based on the correlation between indicated total birds from breeding pair surveys (i.e., Yukon-Kuskokwim Delta Coastal Zone Survey and Alaska-Yukon WBPHS) and counts from the fall survey (1985-1998). Both the 2012 fall estimate (664,201 birds) and the 3-year average (639,437 birds) set new record highs above the previous 2010 record highs of 649,840 and 604,540, respectively (Appendix 3).

## **Emperor Geese**

The 2012 emperor goose indices for indicated total birds ( $20,388 \pm 1,554$ ) and indicated breeding birds ( $17,207 \pm 1,307$ ) were 3.9% lower and 16.8% higher than the respective 2011 indices ( $21,223 \pm 1,284$  and  $14,730 \pm 828$ ) (Tables 1, 2, 6). From 1985-2012, the average annual population growth rate for indicated total birds was  $1.015 \pm 0.003$  and for indicated breeding birds,  $1.025 \pm 0.003$  (Fig. 5).

## **Black Brant**

This Yukon Delta Coastal Breeding Waterfowl Survey was not specifically designed to assess the population of colonial nesting species, such as Pacific black brant. However, we believe that these survey data are still useful in assessing the general population trend and distribution. Currently, the black brant population is primarily monitored by the U.S. Fish and Wildlife Service and the Pacific Flyway via mid-winter surveys that occur in Alaska, British Columbia, Washington, Oregon, California, and Mexico (see Collins et al. 2011). An aerial digital photographic survey (Wilson 2011) of five historic black brant nesting colonies on the Yukon-Kuskokwim Delta has shown a decrease in the number of nests in these colonies over the long-term (1992-2011). However, the potential increase in indicated breeding pairs as shown in the Yukon Delta Coastal Breeding Waterfowl Survey may reflect a recent shift in the distribution of breeding pairs from traditional nesting colonies to a more dispersed pattern over the Yukon-Kuskokwim Delta (R. Stehn, USFWS, unpubl. data).

The 2012 indicated total birds index ( $21,912 \pm 3249$ ) was 36% higher than the 2011 index ( $16,156 \pm 2,014$ ) and the 2012 indicated breeding birds index ( $17,541 \pm 2695$ ) was 42% higher than the 2011 index ( $12,375 \pm 1,664$ ) (Tables 3, 6). Average annual growth rates for indicated total birds and indicated breeding birds were  $1.008 \pm 0.009$  and  $1.059 \pm 0.008$ , respectively (Fig. 6).

## **Taverner's Canada Geese**

This subspecies is found primarily interior to the coastal zone surveyed, but some overlap occurs on the eastern, northern, and southern portions of the survey area. Lines have been established to categorize Canada goose observations as either cacklers or Taverner's for population indices. In 2012, the indicated total birds index ( $8,980 \pm 3,684$ ) and the indicated breeding birds index ( $6,680 \pm 2,979$ ) were 51% and 47% higher, respectively, than in 2011 ( $5,952 \pm 1,732$  and  $4,543 \pm 1,381$ ) (Tables 3, 6; Fig. 7). Average annual growth rates measured  $1.009 \pm 0.005$  and  $1.004 \pm 0.006$  for indicated total birds and indicated breeding birds, respectively.

## **Tundra Swans**

Total birds in 2012 ( $39,291 \pm 5,715$ ) were 18% higher as compared to 2011 ( $33,451 \pm 4,399$ ); and the index for tundra swan singles and pairs for 2012 ( $26,201 \pm 2,240$ ) was 16% higher than the 2011 index ( $22,543 \pm 1,640$ ) (Tables 4, 6, Fig. 8). Average annual growth rates measured  $1.012 \pm 0.004$  and  $1.024 \pm 0.003$ , respectively for total birds and for singles and pairs. The nest index in 2012 (4,275) was 28% below the 2011 record high (5,974), 11% greater than the long-term average (25-years: 1987-2011), and 6% below the 10-year mean (2002-2011) (Tables 4, 6). Counts of singles and pairs, total birds, and nests all showed positive growth rates ( $1.012 \pm 0.004$ ,  $1.024 \pm 0.003$ , and  $1.024 \pm 0.004$ , respectively) (Fig. 8).

## **Sandhill Cranes**

In 2012, the indices for indicated total birds ( $18,990 \pm 2,033$ ) and for indicated breeding birds ( $16,916 \pm 1,440$ ) were 44% and 38% higher than the respective 2011 indices ( $13,138 \pm 1,178$  and  $12,264 \pm 1,067$ ) (Tables 5, 6; Fig. 9). In 2012, total birds and pairs were 15% and 23% above the long-term average (1986-2011). Average annual growth rates for both indicated total birds and indicated breeding birds were  $0.994 \pm 0.004$  and  $0.999 \pm 0.004$ , respectively (Fig. 9).

## **DISCUSSION**

Annual variation in population indices may be attributed to factors other than real population changes, such as variation among years in visibility, survey timing, habitat conditions, nest success, and changes in observers. Due to the annual variation in population levels, we stress that trends in population numbers represent more useful information than just considering the results of each individual year separately.

## **ACKNOWLEDGMENTS**

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## LITERATURE CITED

- Banks, R.C., C. Cicero, J.L. Dunn, A.W. Kratter, P.C. Rasmussen, J.V. Remsen Jr, J.D. Rising, and D.F. Stotz. 2003. Forty-fifth supplement to the American Ornithologists' Union check-list of North American birds. *The Auk*: 121:985-995.
- Bollinger, K.S. 2011. 2011 Yukon-Kuskokwim Delta coastal zone survey of geese, swans, and sandhill cranes: Memorandum. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1412 Airport Way, Fairbanks, Alaska. 22pp.
- Butler, W.I. 1988. Relative abundance and distribution of geese, swans and sandhill cranes on the coastal zone of the Yukon-Kuskokwim Delta. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management. 1011 E. Tudor Rd, Anchorage, Alaska.
- Collins, D.P., C.A. Palmer, and R.E. Trost. 2011. 2011 Pacific Flyway Data Book. Unpubl. Report. U.S. Fish and Wildlife Service, Division Migratory Bird Management, Portland, Oregon. 106pp.
- Conant, B. and D. Groves. 2002. Alaska-Yukon Waterfowl Breeding Population Survey. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, Juneau, Alaska.
- Eldridge, W.E. and C.P. Dau. 2002. Preliminary report to the Pacific Flyway Committee on the combined Pacific white-fronted goose surveys to estimate a breeding population index for Alaska, 1985-2002. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska.
- Fischer, J.B., R.A. Stehn and G. Walters. 2011. Nest population size and potential production of geese and spectacled eiders on the Yukon-Kuskokwim Delta, Alaska, 1985-2011. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska. 43pp.
- Fischer, J.B. and R.A. Stehn. 2012. Nest population sizes and potential production of geese and eiders on the Yukon-Kuskokwim Delta, Alaska, 1985 – 2012. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska. In prep.
- Mallek, E. and D.J. Groves. 2012. Alaska-Yukon waterfowl breeding population survey. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1412 Airport Way, Fairbanks, Alaska. In prep.
- Pacific Flyway Council. 1999. Pacific Flyway management plan for the cackling Canada goose. Unpubl. Report. Cackling Canada Goose Subcommittee, Pacific Flyway Study Comm., USFWS, Portland, Oregon. 36 pp.+ appendices.



- Stehn, R., 2011. Monitoring the population of cackling geese. Interim report for the Pacific Flyway Study Committee. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska.
- Timm, D.E., and C. Dau. 1979. Productivity, mortality, distribution, and population status of Pacific Flyway white-fronted geese. Pages 280-298 in R.L. Jarvis and J.C. Bartonek, eds. Management and biology of Pacific Flyway geese. Oregon State Univ. Bookstores, Inc. Corvallis, Oregon.
- U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys. Unpubl. manual as revised, U.S. Fish and Wildlife Service, Laurel, Maryland.
- Wilson, H.M. 2011. Aerial photographic survey of brant colonies on the Yukon-Kuskokwim Delta, Alaska, 2011. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska. 11pp.

Table 1. Indicated total<sup>a</sup> population indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2012.

| Year        | Cackling Canada Geese |              | White-fronted Geese |               | Emperor Geese |              |
|-------------|-----------------------|--------------|---------------------|---------------|---------------|--------------|
|             | Index                 | SE           | Index               | SE            | Index         | SE           |
| 1985        | 13,963                | 1,605        | 18,914              | 1,482         | 19,805        | 1,960        |
| 1986        | 13,502                | 1,013        | 13,400              | 1,014         | 12,430        | 1,008        |
| 1987        | 19,921                | 1,390        | 15,717              | 1,413         | 13,035        | 1,121        |
| 1988        | 24,467                | 1,507        | 27,191              | 2,642         | 16,392        | 1,402        |
| 1989        | 25,475                | 1,567        | 28,004              | 2,430         | 16,855        | 1,220        |
| 1990        | 31,759                | 2,166        | 37,836              | 4,067         | 17,347        | 1,401        |
| 1991        | 28,843                | 1,688        | 31,286              | 2,294         | 14,888        | 1,284        |
| 1992        | 44,356                | 2,632        | 34,671              | 2,908         | 15,416        | 994          |
| 1993        | 45,749                | 2,534        | 39,748              | 3,020         | 17,147        | 1,230        |
| 1994        | 65,021                | 3,181        | 56,513              | 3,730         | 18,733        | 1,059        |
| 1995        | 69,888                | 3,756        | 77,710              | 5,483         | 18,764        | 1,072        |
| 1996        | 74,574                | 4,008        | 78,032              | 5,339         | 24,413        | 2,476        |
| 1997        | 88,018                | 4,359        | 83,215              | 5,738         | 23,287        | 1,451        |
| 1998        | 64,601                | 3,701        | 87,881              | 7,874         | 21,741        | 1,541        |
| 1999        | 72,173                | 3,509        | 95,040              | 8,876         | 21,406        | 1,591        |
| 2000        | 74,992                | 3,352        | 91,911              | 6,591         | 18,667        | 949          |
| 2001        | 75,620                | 3,734        | 113,603             | 9,358         | 27,297        | 1,473        |
| 2002        | 50,187                | 2,487        | 90,407              | 7,537         | 19,504        | 1,326        |
| 2003        | 69,867                | 3,482        | 117,951             | 12,034        | 21,378        | 1,746        |
| 2004        | 51,390                | 2,691        | 100,622             | 9,611         | 21,396        | 1,097        |
| 2005        | 65,484                | 3,091        | 121,017             | 12,000        | 19,798        | 1,190        |
| 2006        | 71,985                | 3,291        | 138,067             | 10,648        | 26,562        | 1,697        |
| 2007        | 74,152                | 3,138        | 178,515             | 15,035        | 24,362        | 1,508        |
| 2008        | 84,699                | 3,517        | 161,979             | 14,831        | 22,100        | 1,038        |
| 2009        | 67,434                | 2,909        | 144,678             | 14,065        | 20,684        | 1,092        |
| 2010        | 82,192                | 4,755        | 174,556             | 21,450        | 20,167        | 1,199        |
| 2011        | 53,799                | 2,137        | 168,925             | 16,068        | 21,223        | 1,284        |
| <b>2012</b> | <b>60,395</b>         | <b>2,663</b> | <b>181,519</b>      | <b>15,461</b> | <b>20,388</b> | <b>1,554</b> |

<sup>a</sup> Indicated total = 2 x (singles + pairs) + birds in flocks

Table 2. Indicated pair<sup>a</sup> indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2012.

| Year        | Cackling Canada Geese |              | White-fronted Geese |              | Emperor Geese |              |
|-------------|-----------------------|--------------|---------------------|--------------|---------------|--------------|
|             | Index                 | SE           | Index               | SE           | Index         | SE           |
| 1985        | 10,313                | 1,378        | 9,382               | 776          | 9,542         | 852          |
| 1986        | 10,770                | 854          | 6,713               | 513          | 7,413         | 611          |
| 1987        | 14,367                | 967          | 7,819               | 653          | 9,312         | 746          |
| 1988        | 16,290                | 1,009        | 11,953              | 890          | 8,695         | 829          |
| 1989        | 21,168                | 1,330        | 11,982              | 968          | 10,737        | 791          |
| 1990        | 20,330                | 1,341        | 11,705              | 938          | 9,282         | 787          |
| 1991        | 22,405                | 1,290        | 12,584              | 902          | 7,758         | 590          |
| 1992        | 28,443                | 1,697        | 14,077              | 1,086        | 9,879         | 686          |
| 1993        | 33,781                | 1,828        | 15,010              | 1,213        | 10,183        | 787          |
| 1994        | 41,200                | 2,135        | 20,155              | 1,432        | 12,007        | 712          |
| 1995        | 49,354                | 2,872        | 26,985              | 1,911        | 12,892        | 806          |
| 1996        | 39,543                | 2,371        | 21,887              | 1,626        | 12,433        | 604          |
| 1997        | 49,254                | 2,570        | 27,611              | 1,521        | 12,820        | 741          |
| 1998        | 46,372                | 2,896        | 40,872              | 3,888        | 15,686        | 1,136        |
| 1999        | 49,556                | 2,401        | 48,207              | 3,791        | 16,208        | 1,285        |
| 2000        | 52,855                | 2,428        | 42,558              | 2,693        | 12,798        | 680          |
| 2001        | 49,665                | 2,451        | 63,555              | 5,228        | 17,112        | 926          |
| 2002        | 41,982                | 2,033        | 51,381              | 4,491        | 15,646        | 1,215        |
| 2003        | 40,993                | 2,058        | 51,670              | 4,797        | 12,141        | 869          |
| 2004        | 40,848                | 2,219        | 47,928              | 4,973        | 14,410        | 848          |
| 2005        | 44,018                | 2,220        | 50,141              | 4,067        | 14,490        | 817          |
| 2006        | 47,500                | 2,293        | 71,484              | 6,104        | 17,460        | 936          |
| 2007        | 51,194                | 2,345        | 70,670              | 7,824        | 14,562        | 1,004        |
| 2008        | 52,368                | 2,444        | 73,022              | 5,980        | 16,110        | 724          |
| 2009        | 52,368                | 2,328        | 66,759              | 6,004        | 13,563        | 646          |
| 2010        | 50,232                | 2,200        | 74,791              | 9,359        | 14,103        | 781          |
| 2011        | 42,361                | 1,796        | 84,551              | 8,127        | 14,730        | 828          |
| <b>2012</b> | <b>51,729</b>         | <b>2,349</b> | <b>97,654</b>       | <b>8,422</b> | <b>17,207</b> | <b>1,307</b> |

<sup>a</sup> Indicated pairs = 2 x (singles + pairs)

Table 3. Indicated pair and total population indices for black brant and Taverner's Canada geese on the Yukon-Kuskokwim Delta, 1985-2012.

| Year        | Black Brant                  |                              | Taverner's Canada Geese      |                              |
|-------------|------------------------------|------------------------------|------------------------------|------------------------------|
|             | Indicated Pairs <sup>a</sup> | Indicated Total <sup>b</sup> | Indicated Pairs <sup>a</sup> | Indicated Total <sup>b</sup> |
| 1985        | 1,180                        | 5,164                        | 4,285                        | 5,517                        |
| 1986        | 2,030                        | 14,007                       | 3,782                        | 5,150                        |
| 1987        | 4,652                        | 14,893                       | 3,187                        | 4,059                        |
| 1988        | 3,840                        | 22,713                       | 5,191                        | 9,217                        |
| 1989        | 4,220                        | 26,231                       | 7,142                        | 8,865                        |
| 1990        | 2,989                        | 28,820                       | 6,498                        | 7,819                        |
| 1991        | 4,528                        | 27,151                       | 5,454                        | 8,063                        |
| 1992        | 6,144                        | 20,026                       | 5,089                        | 8,698                        |
| 1993        | 4,446                        | 32,004                       | 6,519                        | 8,643                        |
| 1994        | 5,764                        | 31,278                       | 5,536                        | 7,017                        |
| 1995        | 5,858                        | 34,401                       | 5,780                        | 6,475                        |
| 1996        | 5,620                        | 29,503                       | 3,856                        | 6,644                        |
| 1997        | 6,818                        | 30,738                       | 4,466                        | 6,630                        |
| 1998        | 8,252                        | 22,127                       | 6,607                        | 8,446                        |
| 1999        | 9,492                        | 22,520                       | 7,532                        | 12,532                       |
| 2000        | 8,402                        | 26,381                       | 8,232                        | 10,384                       |
| 2001        | 5,686                        | 31,242                       | 6,063                        | 7,701                        |
| 2002        | 9,208                        | 20,396                       | 5,145                        | 6,204                        |
| 2003        | 3,588                        | 20,621                       | 5,426                        | 8,043                        |
| 2004        | 7,641                        | 19,238                       | 4,580                        | 7,755                        |
| 2005        | 5,634                        | 20,560                       | 3,942                        | 6,385                        |
| 2006        | 11,279                       | 19,495                       | 6,523                        | 9,355                        |
| 2007        | 8,937                        | 19,191                       | 3,800                        | 7,042                        |
| 2008        | 13,132                       | 29,166                       | 5,663                        | 10,209                       |
| 2009        | 8,847                        | 23,033                       | 4,245                        | 7,610                        |
| 2010        | 8,595                        | 23,897                       | 6,942                        | 8,981                        |
| 2011        | 12,375                       | 16,156                       | 4,543                        | 5,952                        |
| <b>2012</b> | <b>17,541</b>                | <b>21,912</b>                | <b>6,680</b>                 | <b>8,980</b>                 |

<sup>a</sup> Indicated singles and pairs = 2 x (singles + pairs)

<sup>b</sup> Indicated total = 2 x (singles + pairs) + birds in flocks

Table 4. Tundra swan population indices on the Yukon-Kuskokwim Delta, 1985-2012.

| Year        | Singles and        |                          |                    |
|-------------|--------------------|--------------------------|--------------------|
|             | Pairs <sup>a</sup> | Total Birds <sup>b</sup> | Nests <sup>c</sup> |
| 1985        | 13,664             | 30,874                   | 2,471              |
| 1986        | 14,093             | 24,299                   | 3,093              |
| 1987        | 12,149             | 24,180                   | 2,177              |
| 1988        | 13,872             | 24,459                   | 3,159              |
| 1989        | 12,695             | 33,115                   | 2,613              |
| 1990        | 12,759             | 30,006                   | 2,802              |
| 1991        | 11,465             | 18,663                   | 2,442              |
| 1992        | 13,174             | 19,411                   | 3,009              |
| 1993        | 12,348             | 20,180                   | 2,818              |
| 1994        | 13,204             | 18,787                   | 3,086              |
| 1995        | 16,594             | 23,052                   | 3,560              |
| 1996        | 17,238             | 23,121                   | 3,975              |
| 1997        | 18,106             | 28,683                   | 4,034              |
| 1998        | 19,947             | 33,355                   | 4,964              |
| 1999        | 20,727             | 27,211                   | 4,601              |
| 2000        | 20,048             | 28,306                   | 4,494              |
| 2001        | 17,251             | 24,395                   | 3,147              |
| 2002        | 21,356             | 31,193                   | 5,713              |
| 2003        | 14,823             | 23,015                   | 4,646              |
| 2004        | 17,760             | 27,099                   | 5,301              |
| 2005        | 14,548             | 23,645                   | 3,360              |
| 2006        | 22,663             | 31,545                   | 4,224              |
| 2007        | 20,760             | 30,454                   | 4,074              |
| 2008        | 20,233             | 32,184                   | 3,649              |
| 2009        | 20,272             | 27,897                   | 3,808              |
| 2010        | 21,340             | 37,790                   | 4,678              |
| 2011        | 22,543             | 33,451                   | 5,974              |
| <b>2012</b> | <b>26,201</b>      | <b>39,291</b>            | <b>4,275</b>       |

<sup>a</sup> Singles and Pairs = singles + (2 x pairs)

<sup>b</sup> Total Birds = singles + (2 x pairs) + birds in flocks

<sup>c</sup> Nests = number of active nest observations

Table 5. Sandhill Crane population indices on the Yukon-Kuskokwim Delta, 1987-2012.

| Year        | Indicated          |                          |
|-------------|--------------------|--------------------------|
|             | Pairs <sup>a</sup> | Total Birds <sup>b</sup> |
| 1985        |                    |                          |
| 1986        |                    |                          |
| 1987        | 14,246             | 15,079                   |
| 1988        | 12,777             | 16,549                   |
| 1989        | 13,247             | 16,719                   |
| 1990        | 14,228             | 18,310                   |
| 1991        | 14,358             | 20,601                   |
| 1992        | 13,394             | 17,185                   |
| 1993        | 16,012             | 19,312                   |
| 1994        | 13,832             | 16,548                   |
| 1995        | 16,906             | 18,182                   |
| 1996        | 10,220             | 16,430                   |
| 1997        | 11,446             | 13,530                   |
| 1998        | 17,859             | 24,458                   |
| 1999        | 16,236             | 18,612                   |
| 2000        | 15,886             | 18,144                   |
| 2001        | 14,923             | 16,211                   |
| 2002        | 12,605             | 13,076                   |
| 2003        | 10,779             | 13,778                   |
| 2004        | 12,014             | 14,608                   |
| 2005        | 11,468             | 14,464                   |
| 2006        | 12,778             | 15,298                   |
| 2007        | 12,599             | 13,138                   |
| 2008        | 12,944             | 14,882                   |
| 2009        | 13,207             | 16,188                   |
| 2010        | 17,087             | 18,926                   |
| 2011        | 12,264             | 13,138                   |
| <b>2012</b> | <b>16,916</b>      | <b>18,990</b>            |

<sup>a</sup> Indicated Pairs = 2 x (singles + pairs)

<sup>b</sup> Indicated Total Birds = 2 x (singles + pairs) + birds in flocks

Table 6. Comparison of 2012 indicated total birds, indicated pairs, and tundra swan nests with 2011 numbers and with the 27-year, 25-year, and 10-year means for all species surveyed.

|                                 | CCGO           | WFGO           | EMGO          | BLBR          | TCGO         | TUSW          | SACR <sup>a</sup> | TUNE         |
|---------------------------------|----------------|----------------|---------------|---------------|--------------|---------------|-------------------|--------------|
| <b>Indicated Total Birds</b>    |                |                |               |               |              |               |                   |              |
| 2010                            | 82,192         | 174,556        | 20,167        | 23,897        | 8,981        | 37,790        | 18,926            | 4,678        |
| 2011                            | 53,799         | 168,925        | 21,223        | 16,156        | 5,952        | 33,451        | 13,138            | 5,974        |
| <b>2012</b>                     | <b>60,935</b>  | <b>181,519</b> | <b>20,388</b> | <b>21,912</b> | <b>8,980</b> | <b>39,291</b> | <b>18,990</b>     | <b>4,275</b> |
| 27-yr mean:1985-2011            | 55,707         | 86,200         | 19,807        | 23,368        | 7,755        | 27,051        | ----              | 3,773        |
| 25-yr mean:1987-2011            | 59,065         | 91,803         | 20,102        | 24,471        | 7,949        | 27,008        | 16,534            | 3,852        |
| 10-yr mean:2002-2011            | 67,116         | 139,672        | 21,717        | 21,174        | 7,754        | 29,827        | 14,749            | 4,543        |
| % Change from 2011              | 12.3           | 7.5            | -3.9          | 35.6          | 50.9         | 17.5          | 44.5              | -28.4        |
| % Change: 25-yr mean            | 2.3            | 97.7           | 1.4           | -10.5         | 13.0         | 45.5          | 14.9              | 11.0         |
| % Change: 10-yr mean            | -10.0          | 30.0           | -6.1          | 3.5           | 15.8         | 31.7          | 28.8              | -5.9         |
| Rank - 28 yrs                   | 16th of 28     | 1st of 287     | 13th of 28    | 17th of 28    | 7th of 28    | 1st of 28     | 4th of 26         | 9th of 28    |
| Rank - 11 yrs                   | 8th of 11      | 1st of 11      | 8th of 11     | 4th of 11     | 4th of 11    | 1st of 11     | 1st of 11         | 6th of 11    |
| Annual Growth Rate <sup>b</sup> | 1.173<br>0.999 | 1.096          | 1.015         | 1.008         | 1.009        | 1.012         | 0.994             | 1.024        |
| <b>Indicated Pairs</b>          |                |                |               |               |              |               |                   |              |
| 2010                            | 50,232         | 74,791         | 14,103        | 8,595         | 6,942        | 21,340        | 17,087            | 4,678        |
| 2011                            | 42,361         | 84,551         | 14,730        | 12,375        | 4,543        | 22,543        | 12,264            | 5,974        |
| <b>2012</b>                     | <b>51,729</b>  | <b>97,654</b>  | <b>17,207</b> | <b>17,541</b> | <b>6,680</b> | <b>26,201</b> | <b>16,916</b>     | <b>4,275</b> |
| 27-yr mean:1985-2011            | 37,760         | 38,350         | 12,665        | 6,635         | 5,408        | 16,875        | ----              | 3,773        |
| 25-yr mean:1987-2011            | 39,938         | 40,774         | 13,001        | 7,038         | 5,518        | 17,115        | 13,733            | 3,852        |
| 10-yr mean:2002-2011            | 46,386         | 64,240         | 14,722        | 8,924         | 5,081        | 19,630        | 12,775            | 4,543        |
| % Change from 2011              | 22.1           | 15.5           | 16.8          | 41.7          | 47.0         | 16.2          | 37.9              | -28.4        |
| % Change: 25-yr mean            | 29.5           | 139.5          | 32.4          | 149.2         | 21.0         | 53.1          | 23.2              | 11.0         |
| % Change: 10-yr mean            | 11.5           | 52.0           | 16.9          | 96.6          | 31.5         | 33.5          | 32.4              | -5.9         |
| Rank - 28 yrs                   | 4th of 28      | 1st of 28      | 2nd of 28     | 1st of 28     | 5th of 28    | 1st of 28     | 3rd of 26         | 9th of 28    |
| Rank - 11 yrs                   | 3rd of 11      | 1st of 11      | 2nd of 11     | 1st of 11     | 2nd of 11    | 1st of 11     | 2nd of 11         | 6th of 11    |
| Annual Growth Rate <sup>b</sup> | 1.146<br>1.004 | 1.102          | 1.025         | 1.059         | 1.004        | 1.024         | 0.999             | 1.024        |

<sup>a</sup> Sandhill Crane - rank for 26-year interval.

<sup>b</sup> Annual Growth Rates for CCGO for the intervals 1985-1997 and 1998-2012.

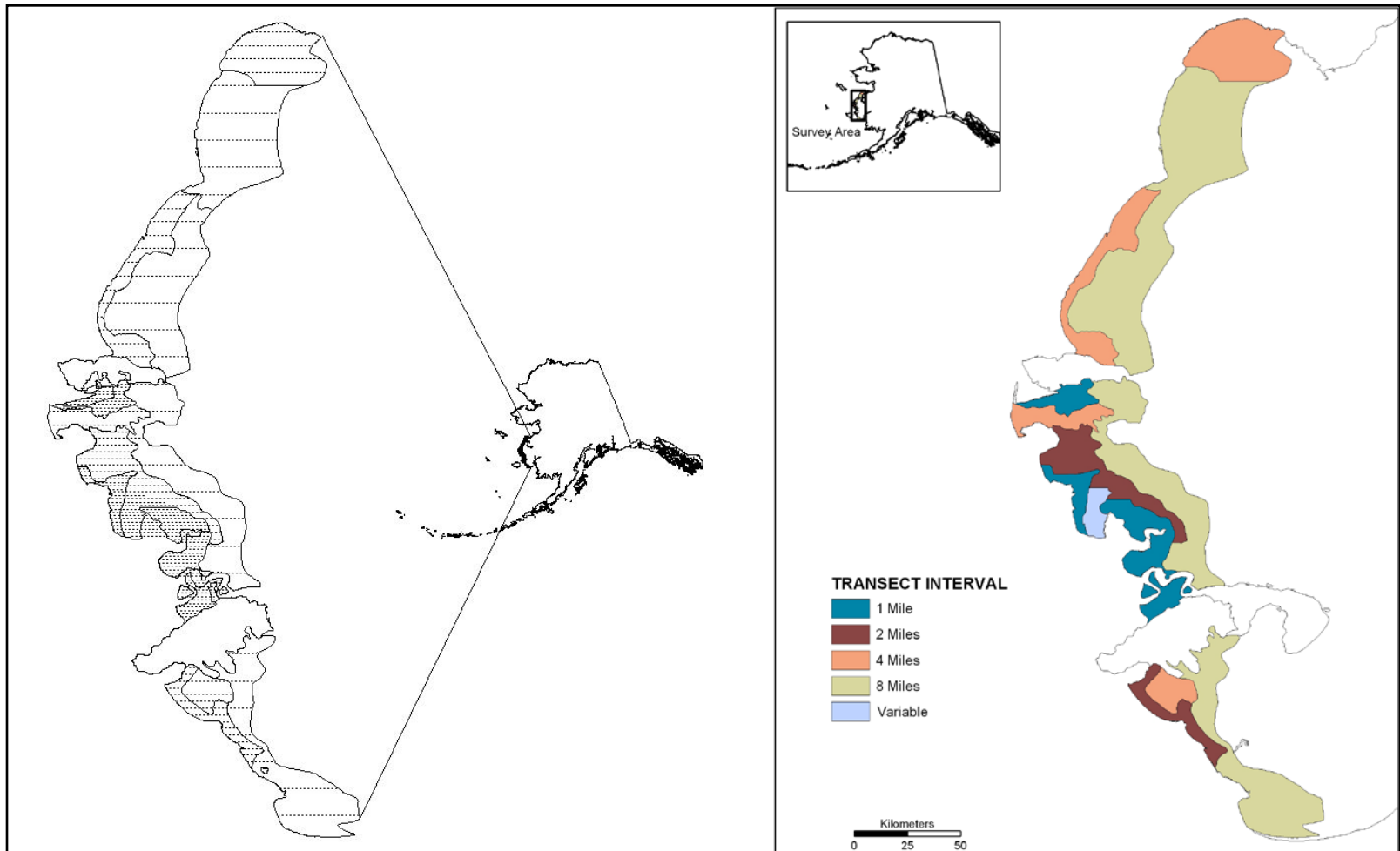
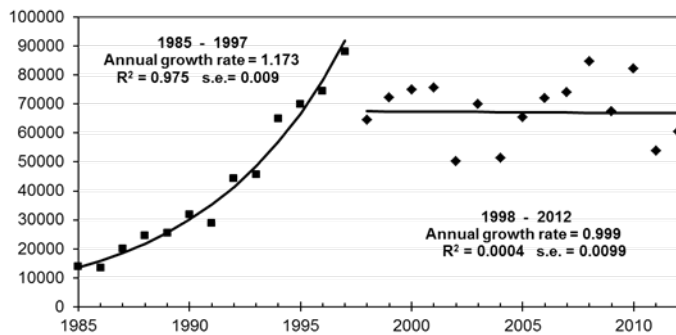


Figure 1. Flight lines (left side) and current 4-strata design (right side) for Yukon Delta aerial surveys.

## Cackling Canada Geese

### Indicated Total Index



### Indicated Pairs Index

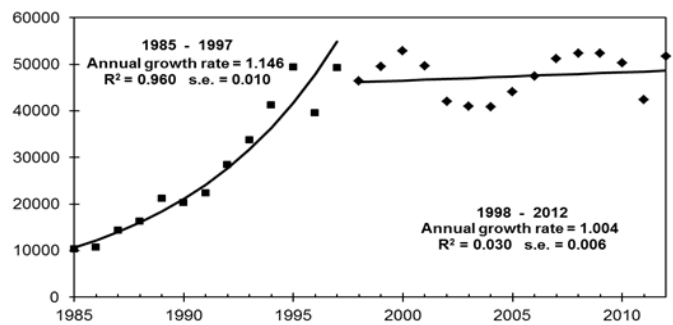
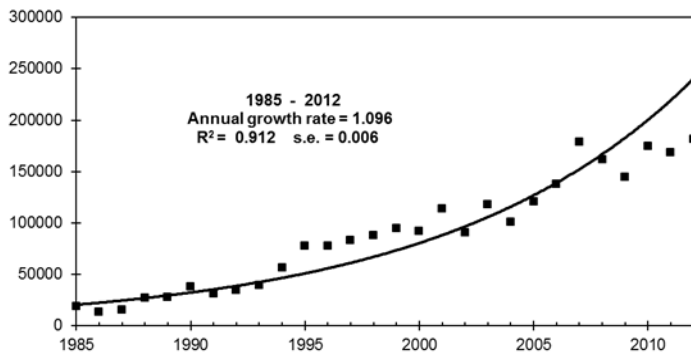


Fig. 2. Population index growth curves and average annual growth rates from log-linear regression for cackling Canada geese, for the first 13 years (1985-1997) and the last 14 years (1998-2012).

## White-fronted Geese

### Indicated Total Index



### Indicated Pairs Index

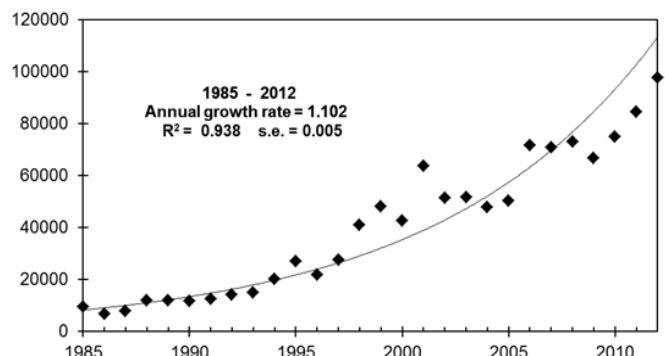


Fig. 3. Population index growth curves and average annual growth rates from log-linear regression for white-fronted geese, 1985-2012.

## White-fronted Geese

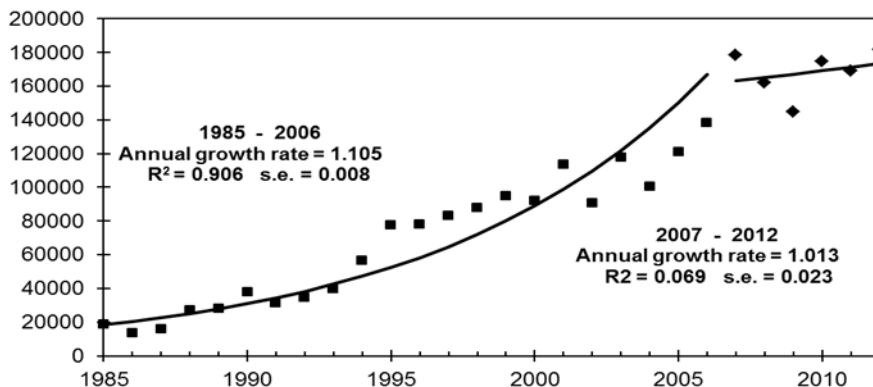
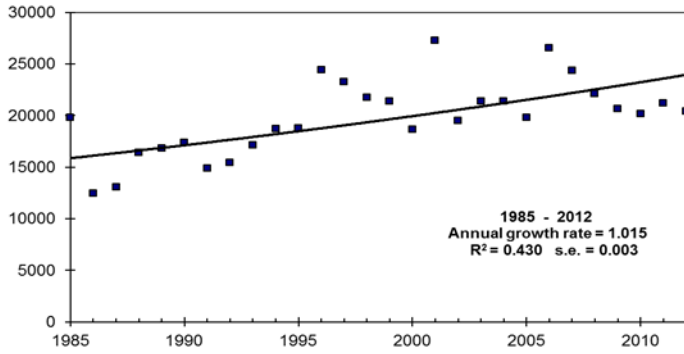


Fig. 4. Indicated total population index growth curves and average annual growth rates from log-linear regression for white-fronted geese based on the first 22<sup>16</sup> years (1985-2006) and the last 6 years (2007-2012).



### Emperor Geese

#### Indicated Total Index



#### Indicated Pairs Index

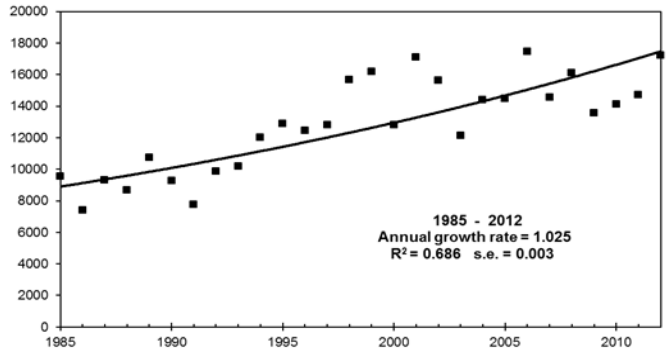
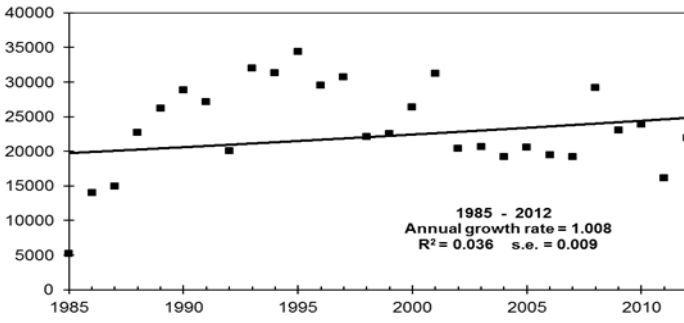


Fig. 5. Population index growth curves and average annual growth rates from log-linear regression for emperor geese, 1985-2012.

### Black Brant

#### Indicated Total Index



#### Indicated Pairs Index

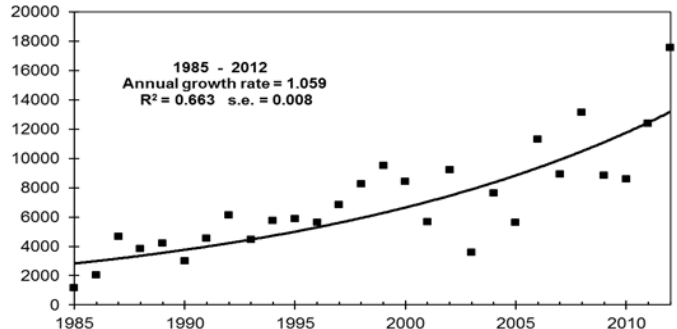
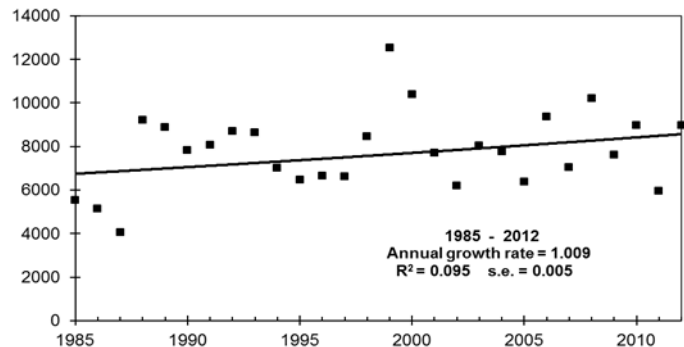


Fig. 6. Population index growth curves and average annual growth rates from log-linear regression for black brant, 1985-2012

### Taverner's Canada Geese

#### Indicated Total Index



#### Indicated Pairs Index

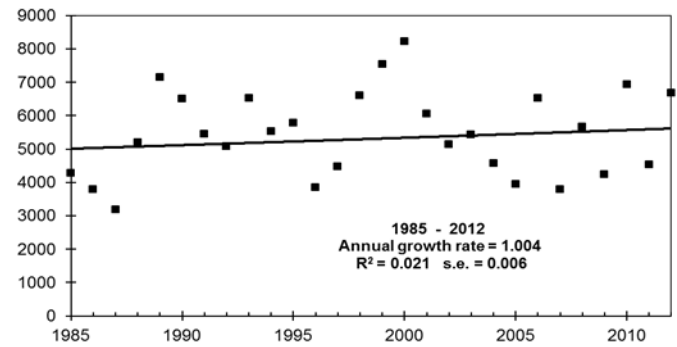


Fig. 7. Population index growth curves and average annual growth rates from log-linear regression for Taverner's Canada geese, 1985-2012.

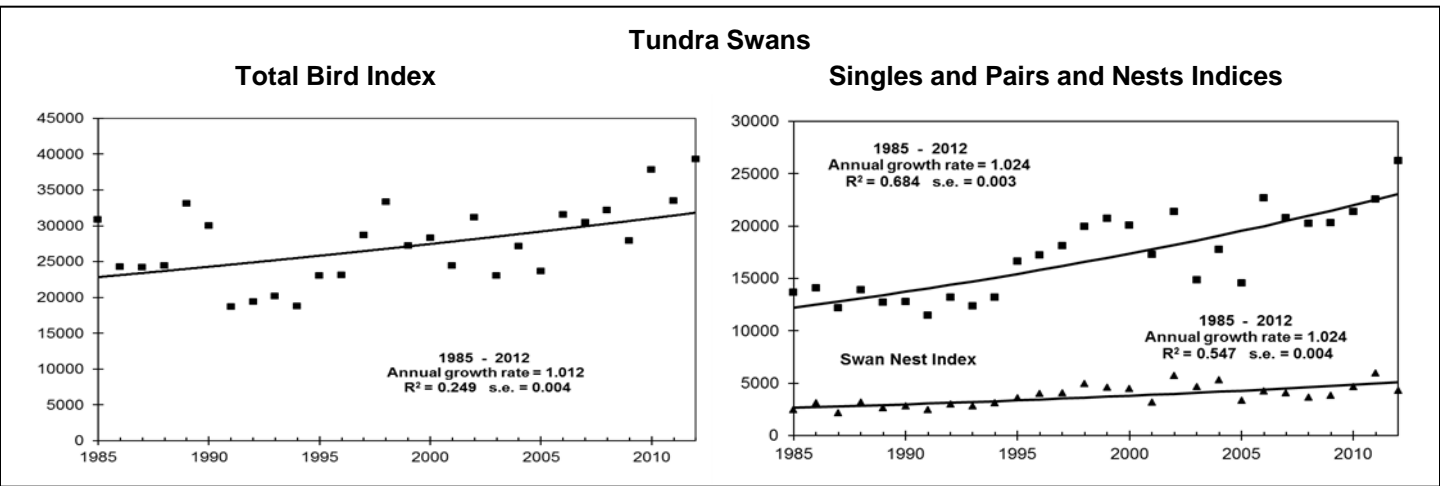


Fig. 8. Population index growth curves and average annual growth rates from log-linear regression for tundra swans, 1985-2012.

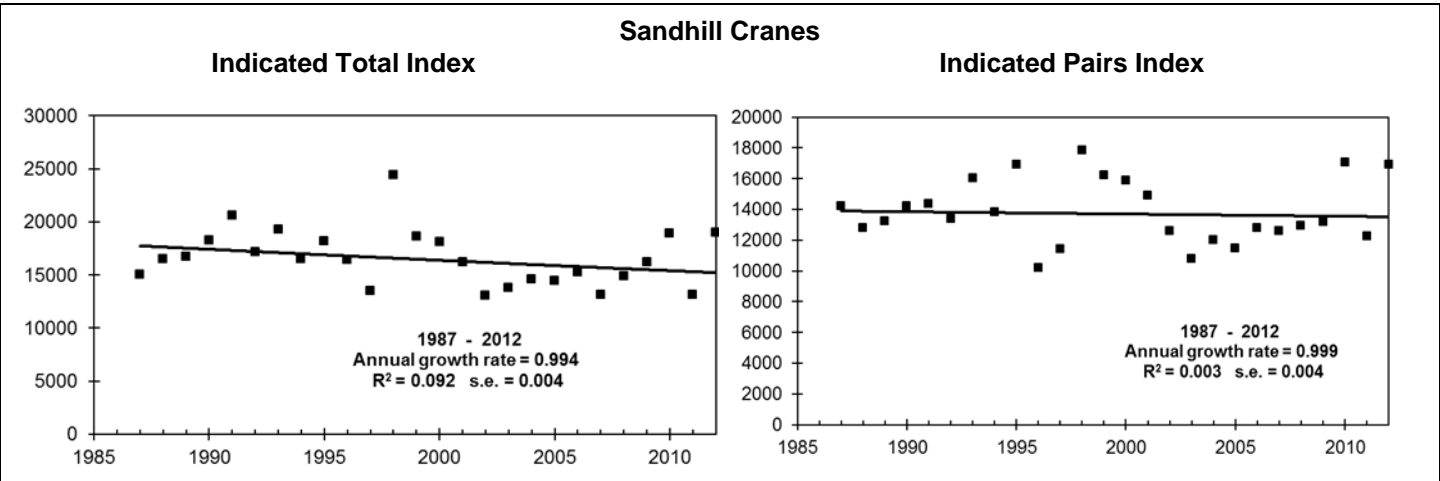


Fig. 9. Population index growth curves and average annual growth rates from log-linear regression for sandhill cranes, 1987-2012.

Appendix 1. Cackling Canada goose fall population estimate based on total indicated bird index from the Yukon-Kuskokwim Delta breeding ground survey and the 1989-2003 mark-resight estimate. This fall index calculation method was adopted in 2011. The 3-year average is also presented.

| Year        | Total Indicated Birds <sup>a</sup> | Mark Resight Estimate | Fall Population Index <sup>b</sup> Adopted 2011 | 3 - year Average |
|-------------|------------------------------------|-----------------------|-------------------------------------------------|------------------|
| 1985        | 13,963                             |                       | 46,776                                          |                  |
| 1986        | 13,502                             |                       | 45,232                                          |                  |
| 1987        | 19,921                             |                       | 66,735                                          | 52,914           |
| 1988        | 24,467                             |                       | 81,964                                          | 64,644           |
| 1989        | 25,475                             | 92,062                | 85,341                                          | 78,014           |
| 1990        | 31,759                             | 94,237                | 106,393                                         | 91,233           |
| 1991        | 28,843                             | 148,628               | 96,624                                          | 96,119           |
| 1992        | 44,356                             | 149,542               | 148,593                                         | 117,203          |
| 1993        | 45,749                             | 184,844               | 153,259                                         | 132,825          |
| 1994        | 65,021                             | 198,558               | 217,820                                         | 173,224          |
| 1995        | 69,888                             | 202,969               | 234,125                                         | 201,735          |
| 1996        | 74,574                             | 193,531               | 249,823                                         | 233,923          |
| 1997        | 88,018                             | 256,715               | 294,860                                         | 259,603          |
| 1998        | 64,601                             | 215,644               | 216,413                                         | 253,699          |
| 1999        | 72,173                             | 306,065               | 241,780                                         | 251,018          |
| 2000        | 74,992                             | 273,108               | 251,223                                         | 236,472          |
| 2001        | 75,620                             | 206,249               | 253,327                                         | 248,777          |
| 2002        | 50,187                             | 177,794               | 168,126                                         | 224,226          |
| 2003        | 69,867                             | 251,594               | 234,054                                         | 218,503          |
| 2004        | 51,390                             |                       | 172,157                                         | 191,446          |
| 2005        | 65,484                             |                       | 219,371                                         | 208,527          |
| 2006        | 71,985                             |                       | 241,150                                         | 210,893          |
| 2007        | 74,152                             |                       | 248,409                                         | 236,310          |
| 2008        | 84,669                             |                       | 283,641                                         | 257,733          |
| 2009        | 67,434                             |                       | 225,904                                         | 252,651          |
| 2010        | 82,192                             |                       | 275,343                                         | 261,629          |
| 2011        | 53,799                             |                       | 180,227                                         | 227,158          |
| <b>2012</b> | <b>60,395</b>                      |                       | <b>202,323</b>                                  | <b>219,298</b>   |

<sup>a</sup> Total Indicated Birds = 2 x (pairs + singles) + group birds Yukon-Kuskokwim Delta.

<sup>b</sup> Fall Population Index = (Total Indicated Birds x 3.35)

Appendix 2. Indices of Pacific white-fronted geese as indicated breeding birds (2 x singles + paired) and indicated total geese from June aerial surveys of the Yukon-Kuskokwim Delta and Bristol Bay Lowlands (Bollinger 2012; Mallek and Groves 2012,in prep).

| Year        | Yukon-Kuskokwim Delta |                | Yukon-Kuskokwim Interior |                | Bristol Bay        |                | Yukon-Kuskokwim Total |                | All Pacific Flyway WFGO's |                |
|-------------|-----------------------|----------------|--------------------------|----------------|--------------------|----------------|-----------------------|----------------|---------------------------|----------------|
|             | Singles<br>+ Pairs    | Total<br>Geese | Singles<br>+ Pairs       | Total<br>Geese | Singles<br>+ Pairs | Total<br>Geese | Singles<br>+ Pairs    | Total<br>Geese | Singles<br>+ Pairs        | Total<br>Geese |
| 1985        | 9,382                 | 18,914         | 5,698                    | 12,082         | 1,219              | 5,050          | 15,080                | 30,996         | 16,299                    | 36,046         |
| 1986        | 6,713                 | 13,400         | 5,894                    | 10,019         | 1,915              | 4,266          | 12,607                | 23,419         | 14,522                    | 27,685         |
| 1987        | 7,819                 | 15,717         | 4,715                    | 7,564          | 1,045              | 3,657          | 12,534                | 23,281         | 13,579                    | 26,938         |
| 1988        | 11,953                | 27,191         | 9,037                    | 14,145         | 522                | 3,918          | 20,990                | 41,336         | 21,512                    | 45,254         |
| 1989        | 11,982                | 28,004         | 5,108                    | 16,307         | 1,045              | 5,398          | 17,090                | 44,311         | 18,135                    | 49,709         |
| 1990        | 11,705                | 37,836         | 8,841                    | 18,468         | 871                | 2,003          | 20,546                | 56,304         | 21,417                    | 58,307         |
| 1991        | 12,584                | 31,286         | 6,287                    | 13,262         | 1,741              | 4,527          | 18,871                | 44,548         | 20,612                    | 49,075         |
| 1992        | 14,077                | 34,671         | 6,287                    | 16,110         | 522                | 7,052          | 20,364                | 50,781         | 20,886                    | 57,833         |
| 1993        | 15,010                | 39,748         | 8,055                    | 22,790         | 697                | 1,306          | 23,065                | 62,538         | 23,762                    | 63,844         |
| 1994        | 20,155                | 56,513         | 6,680                    | 12,966         | 871                | 4,092          | 26,835                | 69,479         | 27,706                    | 73,571         |
| 1995        | 26,985                | 77,710         | 7,859                    | 10,215         | 1,393              | 2,612          | 34,844                | 87,925         | 36,237                    | 90,537         |
| 1996        | 21,887                | 78,032         | 15,914                   | 36,543         | 697                | 4,353          | 37,801                | 114,575        | 38,498                    | 118,928        |
| 1997        | 27,611                | 83,215         | 15,521                   | 30,452         | 871                | 3,657          | 43,132                | 113,667        | 44,003                    | 117,324        |
| 1998        | 40,872                | 87,881         | 16,307                   | 34,381         | 1,567              | 1,915          | 57,179                | 122,262        | 58,746                    | 124,177        |
| 1999        | 48,207                | 95,040         | 10,806                   | 27,800         | 1,393              | 3,483          | 59,013                | 122,840        | 60,406                    | 126,323        |
| 2000        | 42,558                | 91,911         | 8,841                    | 16,798         | 871                | 1,654          | 51,399                | 108,709        | 52,270                    | 110,363        |
| 2001        | 63,555                | 113,603        | 10,806                   | 24,460         | 348                | 6,095          | 74,361                | 138,063        | 74,709                    | 144,158        |
| 2002        | 51,381                | 90,407         | 14,146                   | 17,387         | 1,219              | 5,311          | 65,527                | 107,794        | 66,746                    | 113,105        |
| 2003        | 51,670                | 117,951        | 11,002                   | 17,387         | 522                | 2,177          | 62,672                | 135,338        | 63,194                    | 137,515        |
| 2004        | 47,928                | 100,622        | 9,234                    | 16,601         | 1,045              | 1,828          | 57,162                | 117,223        | 58,207                    | 119,051        |
| 2005        | 50,141                | 121,017        | 10,216                   | 18,566         | 174                | 6,530          | 60,357                | 139,583        | 60,531                    | 146,113        |
| 2006        | 71,484                | 138,067        | 13,360                   | 28,979         | 3,309              | 4,702          | 84,844                | 167,046        | 88,153                    | 171,748        |
| 2007        | 70,670                | 178,515        | 16,503                   | 28,488         | 697                | 2,177          | 87,173                | 207,003        | 87,870                    | 209,180        |
| 2008        | 73,022                | 161,979        | 20,040                   | 54,913         | 522                | 1,045          | 93,062                | 216,892        | 93,584                    | 217,937        |
| 2009        | 66,759                | 144,678        | 17,486                   | 32,712         | 1,045              | 5,137          | 84,245                | 177,390        | 85,290                    | 182,527        |
| 2010        | 74,791                | 174,556        | 23,773                   | 44,402         | 2,786              | 7,923          | 98,564                | 218,958        | 101,350                   | 226,881        |
| 2011        | 84,551                | 168,925        | 19,254                   | 33,989         | 1,219              | 6,095          | 103,805               | 202,914        | 105,024                   | 209,009        |
| <b>2012</b> | <b>97,654</b>         | <b>181,519</b> | <b>23,380</b>            | <b>47,250</b>  | <b>1,045</b>       | <b>3,744</b>   | <b>121,034</b>        | <b>228,769</b> | <b>122,079</b>            | <b>232,513</b> |

Appendix 3. Fall population index for Pacific white-fronted based on relationship of total indicated geese from June surveys on the Yukon-Kuskokwim Delta and Bristol Bay Lowlands with the 1985-1998 fall survey counts. The 3-year average is also presented.

| Year        | Total Indicated Birds <sup>a</sup> | Fall Survey | Fall Population Index <sup>b</sup> | 3-year Average |
|-------------|------------------------------------|-------------|------------------------------------|----------------|
| 1985        | 36,046                             | 93,800      | 163,249                            |                |
| 1986        | 27,685                             | 107,100     | 141,930                            |                |
| 1987        | 26,938                             | 130,600     | 140,026                            | 148,402        |
| 1988        | 45,254                             | 161,500     | 186,728                            | 156,228        |
| 1989        | 49,709                             | 218,800     | 198,087                            | 174,947        |
| 1990        | 58,307                             | 240,800     | 220,010                            | 201,608        |
| 1991        | 49,075                             | 236,500     | 196,470                            | 204,856        |
| 1992        | 57,833                             | 230,900     | 218,802                            | 211,761        |
| 1993        | 63,844                             | 295,100     | 234,128                            | 216,467        |
| 1994        | 73,571                             | 324,800     | 258,930                            | 237,287        |
| 1995        | 90,537                             | 277,500     | 302,190                            | 265,083        |
| 1996        | 118,928                            | 344,100     | 374,582                            | 311,901        |
| 1997        | 117,324                            | 319,000     | 370,492                            | 349,088        |
| 1998        | 124,177                            | 413,100     | 387,966                            | 377,680        |
| 1999        | 126,323                            |             | 393,437                            | 383,965        |
| 2000        | 110,363                            |             | 352,743                            | 378,048        |
| 2001        | 144,158                            |             | 438,913                            | 395,031        |
| 2002        | 113,105                            |             | 359,734                            | 383,797        |
| 2003        | 137,515                            |             | 421,975                            | 406,874        |
| 2004        | 119,051                            |             | 374,895                            | 385,535        |
| 2005        | 146,113                            |             | 443,898                            | 413,589        |
| 2006        | 171,748                            |             | 509,262                            | 442,685        |
| 2007        | 209,180                            |             | 604,706                            | 519,289        |
| 2008        | 217,937                            |             | 627,035                            | 580,334        |
| 2009        | 182,527                            |             | 536,746                            | 589,496        |
| 2010        | 226,881                            |             | 649,840                            | 604,540        |
| 2011        | 209,009                            |             | 604,270                            | 596,952        |
| <b>2012</b> | <b>232,513</b>                     |             | <b>664,201</b>                     | <b>639,437</b> |

<sup>a</sup> Total Indicated Birds = 2 x (pairs + singles) + group birds - Pacific Flyway - Yukon-Kuskokwim Delta and Bristol Bay.

<sup>b</sup> Fall Population Index = (TIB x 2.5498) + 71,339