

Memorandum

To: Chief, Migratory Bird Management
Region 7

From: Karen S Bollinger, Wildlife Biologist / Pilot
John I Hodges, retired - Wildlife Biologist / Pilot

Through: Eric J Taylor, Chief , Waterfowl Management Branch

Subject: Report to the Pacific Flyway Committee on the 1985-2010 Coastal Zone
Yukon-Kuskokwim Delta Goose Survey of geese, swans, and sandhill cranes.

INTRODUCTION AND METHODS

Aerial surveys of geese, tundra swans (*Cygnus columbianus*), and sandhill cranes (*Grus canadensis*) were conducted from 4-11 June 2010, in the coastal zone of the Yukon-Kuskokwim Delta (YKD) for the 26th consecutive year. Goose species surveyed include cackling Canada geese (*Branta hutchinsii minima*), greater white-fronted geese (*Anser albifrons frontalis*), emperor geese (*Chen canagica*), black brant (*Branta bernicla nigricans*), and Taverner's Canada geese (*Branta hutchinsii taverneri*). Please note that we are using the common names recognized by the Flyway and the scientific names recognized by the American Ornithological Union. To simplify terminology, these species will be referenced as cackling Canada geese, white-fronted geese, emperor geese, black brant, and Taverner's Canada geese, respectively, throughout the remainder of this document. A Cessna 206 on amphibious floats was flown using standard Department of Interior survey methodology, similar to previous years. The 106 transects flown comprised 2,534 km linear distance. Sample survey coverage measured 7.9% of the total 12,853 km² study area. Experienced aircrews completed the survey with Karen Bollinger serving as pilot/observer for the fifth straight year and John Hodges serving as right-seat observer for the second year in a row following four years as pilot/observer.

The survey-transect design (Fig. 1), initiated in 1998, was designed to obtain optimal distribution data. This is achieved by a four-year rotation design of unique sets of transect lines for each year. The years 1998-2001 comprised the first complete four-year rotation; 2002-2005, the second; 2006-2009, the third; and 2010 represents the first year of the fourth, four-year rotation. Standardized methodology for data collection involves a pilot and right-seat observer recording observations within a 200 m transect on each side of the plane, flying at an altitude of approximately 45 m and a speed of 150 km/hr. Observations were recorded directly into a laptop computer connected to the airplane global positioning system, so that each observation was matched with a latitude/longitude coordinate location.

Nesting phenology, estimated from egg float angles on searched nest plots, was three days earlier than the 1982-2010 average for cacklers, 2 days earlier for white-fronts and emperors, and 1 day

earlier for brant. In 2010, average hatch was 21 June for cacklers and white-fronts, and 20 June for emperors and black brant (Fischer et al. 2010).

Population Indices

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

All Geese and Sandhill Cranes

$$\text{indicated pairs} = 2 \times (\text{singles} + \text{pairs}^*)$$

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

Tundra Swans

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

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

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

$$*\text{pairs} = \text{no. of pairs (for all references)}$$

Stratification Design

Stratification of this survey is based on sampling effort, that is, the distances between transects which are 1, 2, 4, and 8 miles (Fig. 1). There are four primary strata with one small additional stratum in a high-density area. This additional stratum was created to better accommodate historical data for that area which had variable spacing between transects for several years (Fig. 1).

RESULTS

The 2010 aerial survey was conducted from 04 – 11 June. Timing of this year's aerial survey was comparable phenologically to previous years and coincided with early incubation (Fischer et al. 2010). The effect of different timing of the survey relative to nesting phenology is not completely understood, but it is generally 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 complicate that correlation because heavy predation increases the number of birds seen in flocks due to failed breeding attempts. In 2010, the proportion of nests that were active was higher than the long-term average for all geese (i.e., cacklers, white-fronts, emperor, and brant) for the area where nest plots were sampled (Fischer et al. 2010). In recent years the survey has been flown in fewer days and somewhat earlier in the nesting season than in the earlier, developmental years of the survey. Although there has been some variation in timing of the survey relative to nesting phenology during recent years, we do not think those variations have had a significant impact on results.

Cackling Canada Geese

The cackling Canada goose population has remained relatively stable (i.e., slightly increasing) and at population levels, although variable, near their peak since 1997. In 2010, indices for indicated total birds and pairs in 2010 were 82,192 and 50,232 birds, respectively; and annual growth rates measured 1.012 and 1.006, respectively for 1998-2010 (Tables 1, 2, and 6; Fig. 2). This contrasts sharply with the exponential growth rates (1.173 and 1.146, respectively, for total birds and pairs) exhibited from 1985 through 1997. The 2010 fall population estimate of 188,623 birds (the third highest) and 3-year running average of 180,859 birds (highest ever) also confirms the current high population level of cackling Canada geese (Appendix 1). This fall population estimate is based on the correlation between the indicated total spring index and fall count for the years 1985-1998 when fall counts were conducted.

Pacific White-fronted Geese

The Pacific white-fronted goose population in 2010 reversed the slight decline noted in 2009 and resulted in the second highest total index (174,556) and the highest pair index on record (74,791) (Tables 1, 2, and 6; Fig. 3 and 4). Although the log-linear growth rate for the total bird index for the last 15 years of the survey (1996-2010) of 1.059 is lower than that of 1.159 for the first 11 years of the survey (1985-1995) (Fig. 4); this goose population continues to exhibit a growth rate much greater than the other goose species on the Yukon-Kuskokwim Delta (Table 6). Annual growth rates over the 26-year history of the survey measured 1.101 and 1.106 for the total and pair indices, respectively (Fig. 3). The data does suggest, however, that the white-front population might be leveling off somewhat over the last 4 years (Fig. 3).

Pacific white-fronts nesting in Alaska are mainly concentrated on the Yukon Delta, both coastal and interior, with a very small percentage also found in Bristol Bay. Estimates for all Pacific white-fronts nesting in Alaska are determined from results of this survey combined with results from the survey of Bristol Bay and the interior Yukon Delta (Mallek and Groves 2010). These estimates are presented in Appendix 2. Only a small percentage of the Pacific white-fronts nesting in Alaska are found in Bristol Bay, as compared to those found in the Yukon Delta, both coastal and interior. In 2010, the coastal Yukon Delta (YKD) accounted for 77% of the birds; interior Yukon Delta, 20%; and Bristol Bay, only 3%. Population counts in 2010 for both the singles and pairs index and the total index were at new record highs for Alaska and the entire Yukon-Kuskokwim area. (Tables 1, 2, and 6; Appendix 2).

Both the 2010 fall population estimate (649,840) and 3-year running average (604,540) also totaled new record highs for Alaska Pacific white-fronts (Appendix 3). As for cacklers, this fall population estimate is based on the correlation between the spring total bird index and the fall count for the years 1985-1998 when reliable fall counts were available.

Emperor Geese

The emperor goose index for both indicated total birds (20,167) and indicated pairs (14,103) remained relatively unchanged from the previous year, but still below the record numbers of 2006 (26,562 and 17,460, respectively) (Tables 1, 2, and 6; Fig. 5). Population growth rates are slightly positive for both indices (1.018 and 1.027, respectively) for the 26 year history of the survey (Fig. 5).

Black Brant

This survey is not designed for colonial nesting species such as black brant. However, brant data collected does provide useful information on distribution, even though the annual population indices are highly variable (Tables 3 and 6, Fig. 6). Both the indicated total birds (23,897) and the pairs index (8,595) remained relatively unchanged from the previous year in 2009. The variation noted may reflect differences in survey timing related to black brant nesting phenology, and/or a difference in counting brant as pairs or flocks between observers. Black brant breeding numbers in major colonies are currently determined through aerial digital photography; but data for 2010 were not available for this report.

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. For these areas, arbitrary lines have been established to divide cackling Canada geese and Taverner's Canada geese observations for population index estimates. Our analyses suggest that the potential range overlap, and resulting misclassification of subspecies, do not substantially affect results. Results in 2010 for both the total number index (8,981) and the pair index (6,942) were higher than 2009 (7,610 and 4,245, respectively) (Tables 3 and 6; Fig. 7). Both indices are highly variable with slightly positive growth rates (1.012 and 1.004, respectively).

Tundra Swans

The index for tundra swan singles and pairs for 2010 (21,340) increased over that for 2009 (20,272). (Tables 4 and 6, Fig. 8). The index for total birds in 2010 (37,790) substantially increased from that recorded in 2009 (27,897). This dramatic increase is due to the fact that 5 groups of flocked swans (numbering 120, 150, 250, 270, and 450) fell within transect lines this year; and when expanded these resulted in an inflated total bird index. The nest index in 2010 (4,678) also increased from that in 2009 (3,808) and was 28% greater than the 25-year mean (Tables 4 and 6; Fig. 8). All three indices indicate slightly positive growth rates (1.010, 1.023, and 1.024 respectively (Fig. 8). As expected the total bird index is most variable as compared to the singles and pairs index and the nest index (Fig. 8).

Sandhill Cranes

In 2010, sandhill cranes indices for both total birds (18,926) and pairs (17,087) increased compared to 2009 (16,188 and 13,207, respectively) (Tables 5 and 6; Fig. 9). Total birds in 2010 were 14% above the 23-year mean and pairs 25% above the 23-year mean. Despite these increased numbers in 2010, both indices still indicate slightly declining trends in growth rates (0.993 and 0.997, respectively) (Tables 5 and 6, Fig. 9).

DISCUSSION

Over the 26-year history of the survey, all species except sandhill cranes have exhibited a positive annual growth rate. These growth rates have been most dramatic for cackling Canada geese and white-fronted geese, especially through the first 11-13 years of the survey. Numbers of cacklers and especially white-fronts have continued to increase through the present, although

at reduced rates. In 2010, numbers of both species of geese were at record high or near record high levels. Annual growth rates for emperor geese, black brant, and Taverner's Canada geese have been only slightly positive over the history of the survey. In 2010, numbers for emperor geese and black brant were little changed from 2009 and comparable to both the 25-year and 10-year means. Numbers of Taverner's Canada geese have been highly variable over the history of the survey; but in 2010, numbers were higher in comparison to 2009 and both the 25-year and 10-year means. Numbers of both tundra swans and sandhill cranes and numbers of swan nests were also at near record levels in 2010. It appears that numbers of geese have begun to level out in recent years, possibly due to populations reaching carrying capacity. Cackling Canada geese and white-fronted geese both achieved record high fall estimates and 3-year running averages in 2010, however.

Due to the annual variation in population levels, we stress that trends in population numbers represent more useful information as compared to annual numbers. Annual variation 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. Indices of both indicated pairs and total birds represent useful information and both should be used by managers in the decision making process.

ACKNOWLEDGMENTS

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Table 1. Indicated total^a population indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2010.

| 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 |

a--Indicated total = 2 x (singles + pairs) + birds in flocks

Table 2. Indicated pair^a indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2010.

| 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 |

a--Indicated pairs = 2 x (singles + pairs)

Table 3. Black brant and Taverner's Canada geese on the Yukon-Kuskokwim Delta, 1985-2010.

| Year | Black Brant | | Taverner's Canada Geese | |
|-------------|------------------------------|------------------------------|------------------------------|------------------------------|
| | Indicated Pairs ^a | Indicated Total ^b | Indicated Pairs ^a | Indicated Total ^b |
| 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 |

a--Indicated singles and pairs = 2 x (singles + pairs)

b--Indicated total = 2 x (singles + pairs) + birds in flocks

Table 4. Tundra swan population indices on the Yukon- Kuskokwim Delta, 1985-2010.

| Year | Singles and | | |
|-------------|--------------------|--------------------------|--------------------|
| | Pairs ^a | Total Birds ^b | Nests ^c |
| 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 |

a--Singles and Pairs = singles + (2 x pairs)

b--Total Birds = singles + (2 x pairs) + birds in flocks

c--Nests = number of active nest observations

Table 5. Sandhill Crane population indices on the YKD, 1987-2010.

| Year | Indicated | |
|-------------|--------------------|--------------------------|
| | Pairs ^a | Total Birds ^b |
| 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 |

a--Indicated Pairs = 2 x (singles + pairs)

b--Indicated Total Birds = 2 x (singles + pairs)
+ birds in flocks

Table 6. Comparison of 2010 indicated total birds and indicated pairs with 2009 numbers and with the 25-year and 10-year means for all species surveyed.

| | CCGO | WFGO | EMGO | BLBR | TCGO | TUSW | SACR ¹ | TUNE |
|---------------------------------|----------------|----------------|---------------|---------------|--------------|---------------|-------------------|--------------|
| Indicated Total Birds | | | | | | | | |
| 2009 | 67,434 | 144,678 | 20,684 | 23,033 | 7,610 | 27,897 | 16,188 | 3,808 |
| 2010 | 82,192 | 174,556 | 20,167 | 23,897 | 8,981 | 37,790 | 18,926 | 4,678 |
| 25-yr mean (1985-2009) | 54,725 | 79,356 | 19,736 | 23,636 | 7,779 | 26,365 | 16,578 | 3,649 |
| 10-yr mean (2000-2009) | 68,581 | 125,875 | 22,175 | 22,932 | 8,069 | 27,973 | 14,979 | 4,242 |
| % Change from 2009 | 21.9 | 20.7 | -2.5 | 3.8 | 18.0 | 35.5 | 16.9 | 22.8 |
| % Change - 25-yr mean | 50.2 | 120.0 | 2.2 | 1.1 | 15.5 | 43.3 | 14.2 | 28.2 |
| % Change - 10-yr mean | 19.8 | 38.7 | -9.1 | 4.2 | 11.3 | 35.1 | 26.4 | 10.3 |
| Rank - 26 yrs | 3rd of 26 | 2nd of 26 | 12th of 26 | 12th of 26 | 6th of 26 | 1st of 26 | 4th of 24 | 4th of 26 |
| Rank - 11 yrs | 2nd of 11 | 2nd of 11 | 8th of 11 | 4th of 11 | 4th of 11 | 1st of 11 | 1st of 11 | 3rd of 11 |
| Annual Growth Rate ² | 1.173 1.012 | 1.101 | 1.018 | 1.014 | 1.012 | 1.010 | 0.993 | 1.024 |
| Indicated Pairs | | | | | | | | |
| 2009 | 52,368 | 66,759 | 13,563 | 8,847 | 4,245 | 20,272 | 13,207 | 3,808 |
| 2010 | 50,232 | 74,791 | 14,103 | 8,595 | 6,942 | 21,340 | 17,087 | 4,678 |
| 25-yr mean (1985-2009) | 37,077 | 35,044 | 12,526 | 6,327 | 5,382 | 16,470 | 13,651 | 3,649 |
| 10-yr mean (2000-2009) | 47,379 | 58,917 | 14,829 | 8,235 | 5,362 | 18,971 | 12,920 | 4,242 |
| % Change from 2009 | -4.1 | 12.0 | 4.0 | -2.8 | 63.5 | 5.3 | 29.4 | 22.8 |
| % Change - 25-yr mean | 35.5 | 113.4 | 12.6 | 35.8 | 29.0 | 29.6 | 25.2 | 28.2 |
| % Change - 10-yr mean | 6.0 | 26.9 | -4.9 | 4.4 | 29.5 | 12.5 | 32.2 | 10.3 |
| Rank - 26 yrs | 5th of 26 | 1st of 26 | 10th of 26 | 7th of 26 | 4th of 26 | 3rd of 26 | 2nd of 24 | 4th of 26 |
| Rank - 11 yrs | 5th of 11 | 1st of 11 | 8th of 11 | 6th of 11 | 2nd of 11 | 3rd of 11 | 1st of 11 | 3rd of 26 |
| Annual Growth Rate ² | 1.146 1.006 | 1.106 | 1.027 | 1.056 | 1.004 | 1.023 | 0.997 | 1.024 |

¹ Sandhill Crane - 23-year mean and rank for 24-year interval

² Annual Growth Rates for CCGO for the intervals 1985-1997 and 1998-2010.

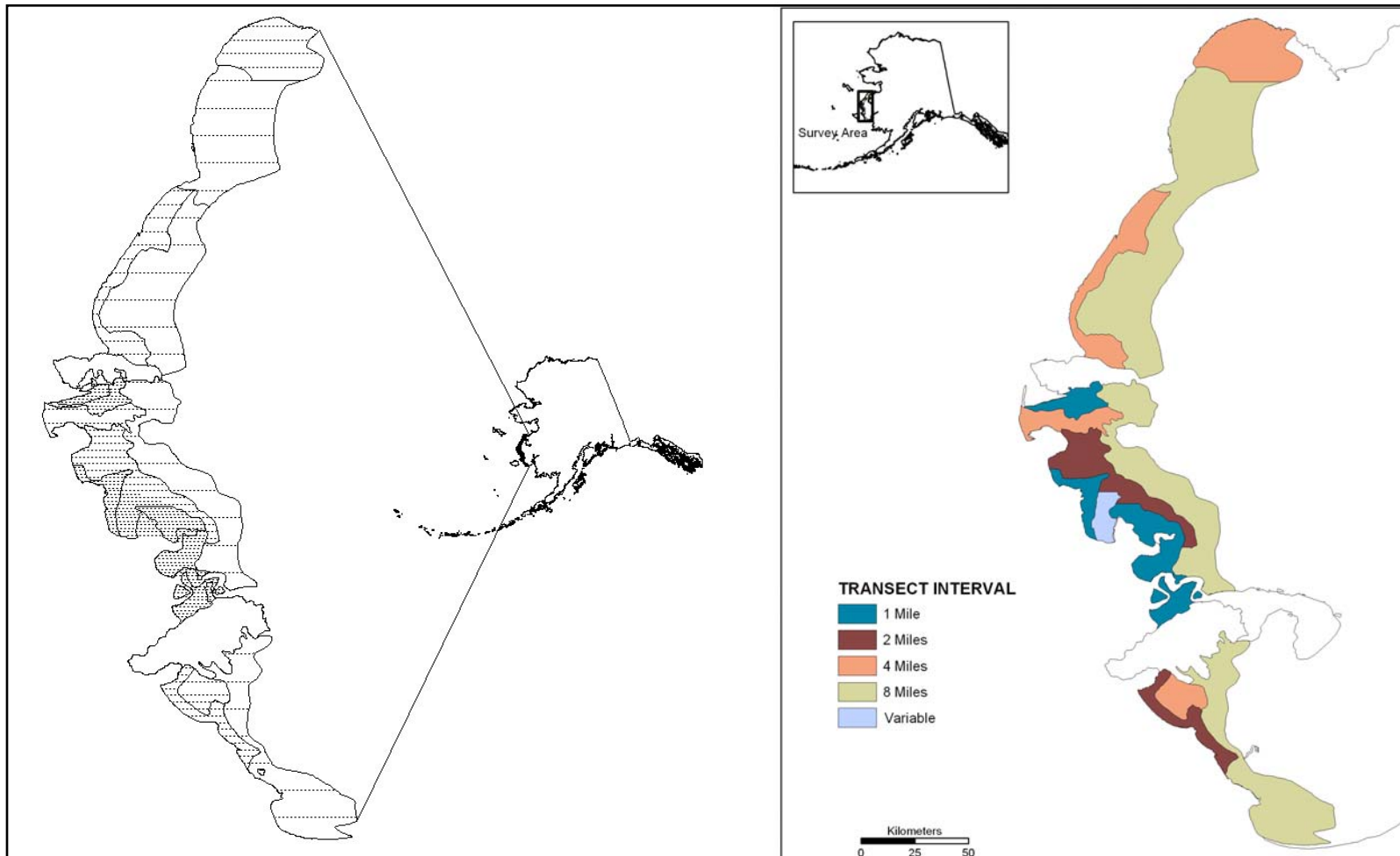


Figure 1. Flight lines (left side) and current 4-strata design (right side) for Yukon Delta aerial surveys.

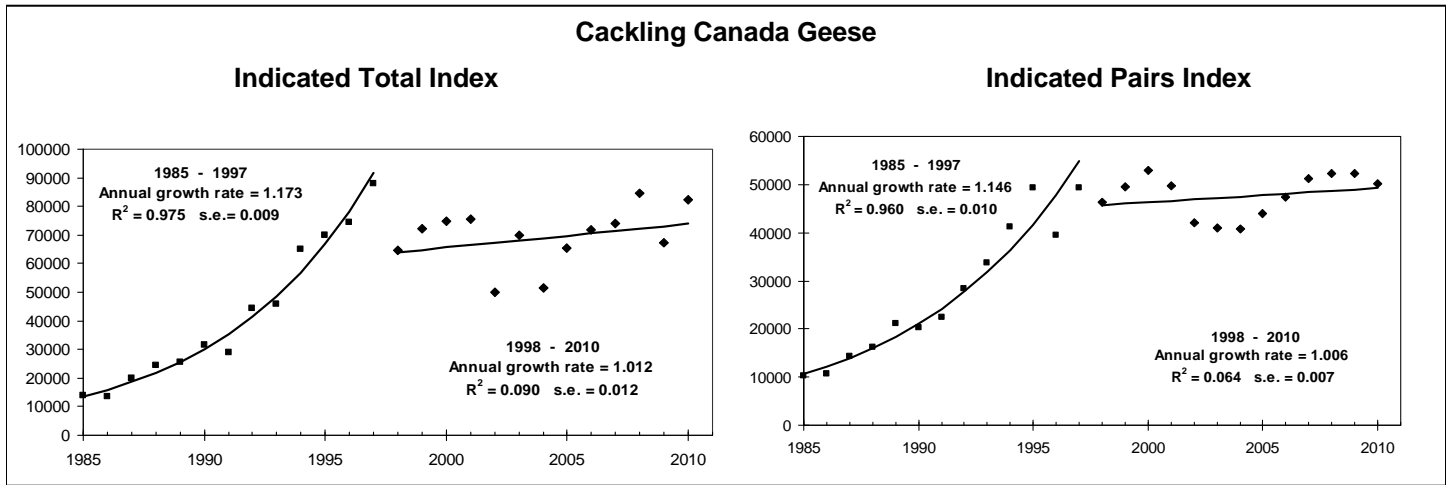


Fig. 2. Population index growth curves and average annual growth rates from log-linear regression for cackling Canada geese, for the first 13 years (1985-1997) and the last 13 years (1998-2010).

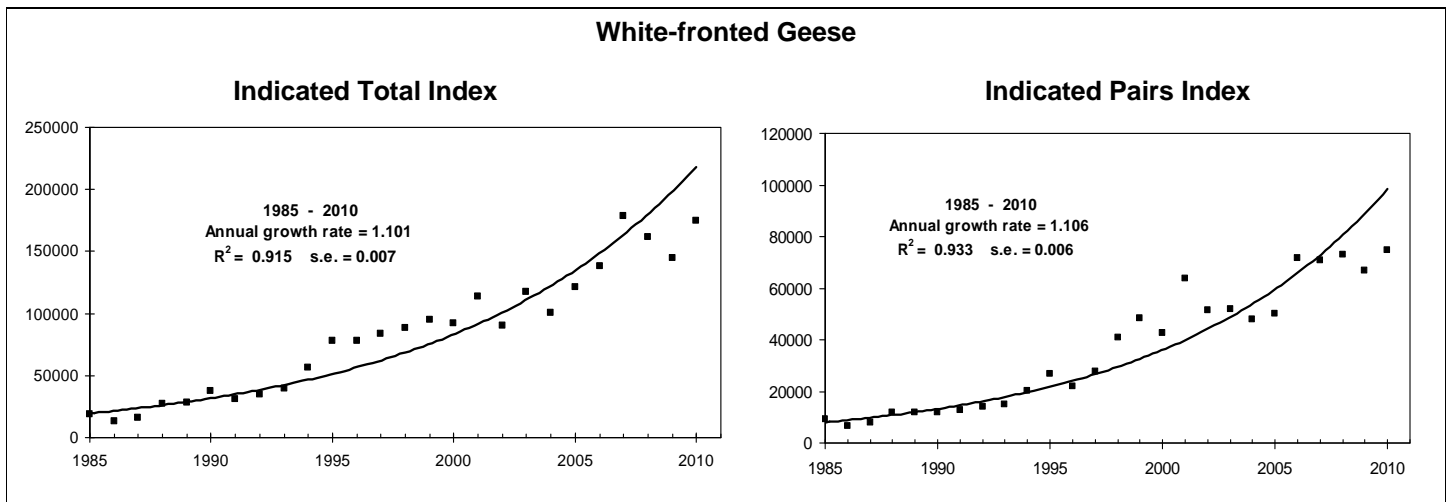


Fig. 3. Population index growth curves and average annual growth rates from log-linear regression for white-fronted geese, 1985-2010.

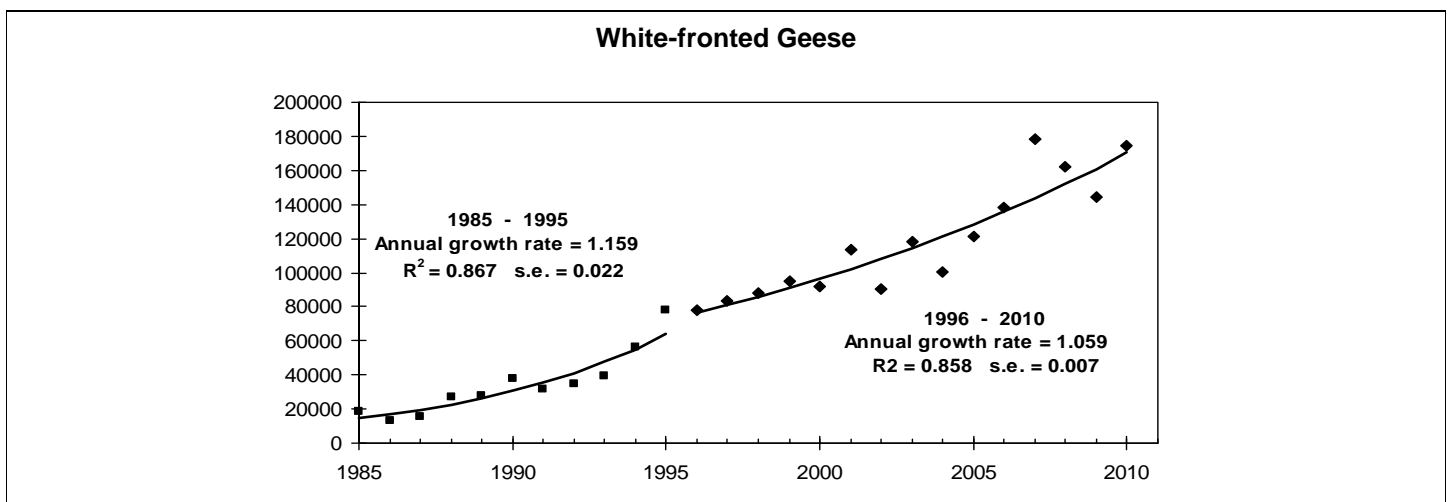


Fig. 4. Indicated total population index growth curves and average annual growth rates from log-linear regression for white-fronted geese based on the first 11 years (1985-1995) and the last 15 years (1996-2010).

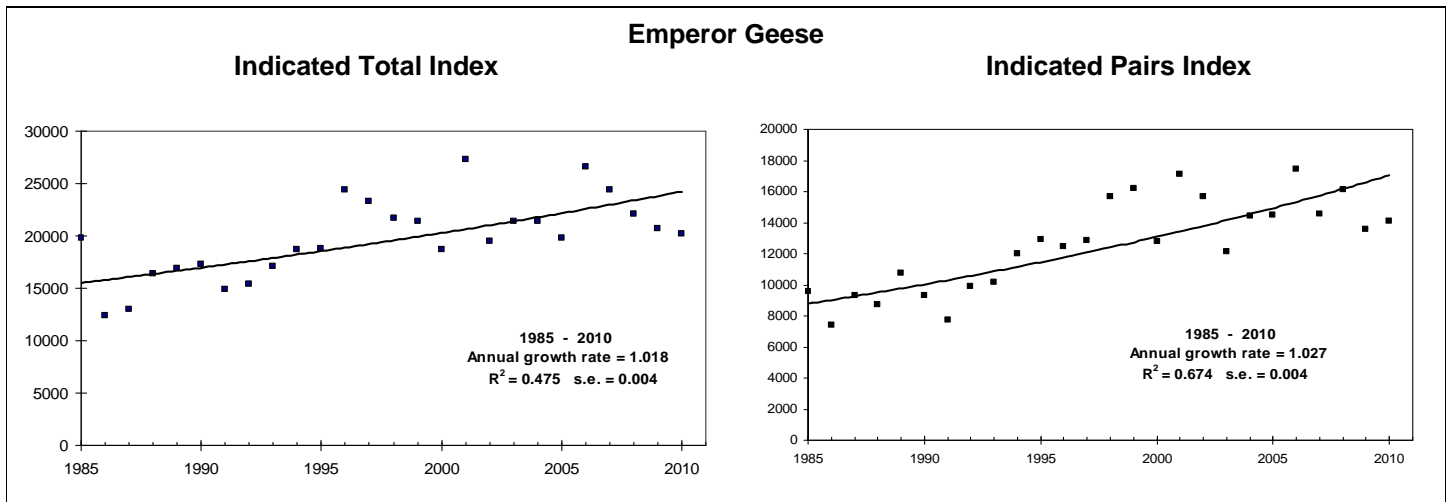


Fig. 5. Population index growth curves and average annual growth rates from log-linear regression for emperor geese, 1985-2010.

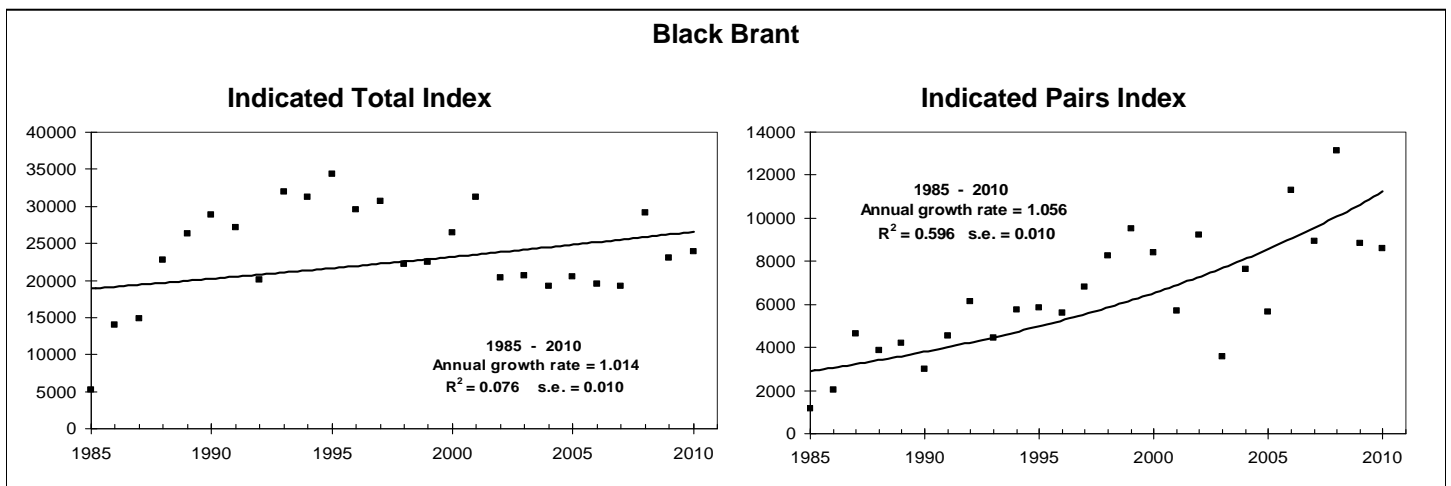


Fig. 6. Population index growth curves and average annual growth rates from log-linear regression for black brant, 1985-2010.

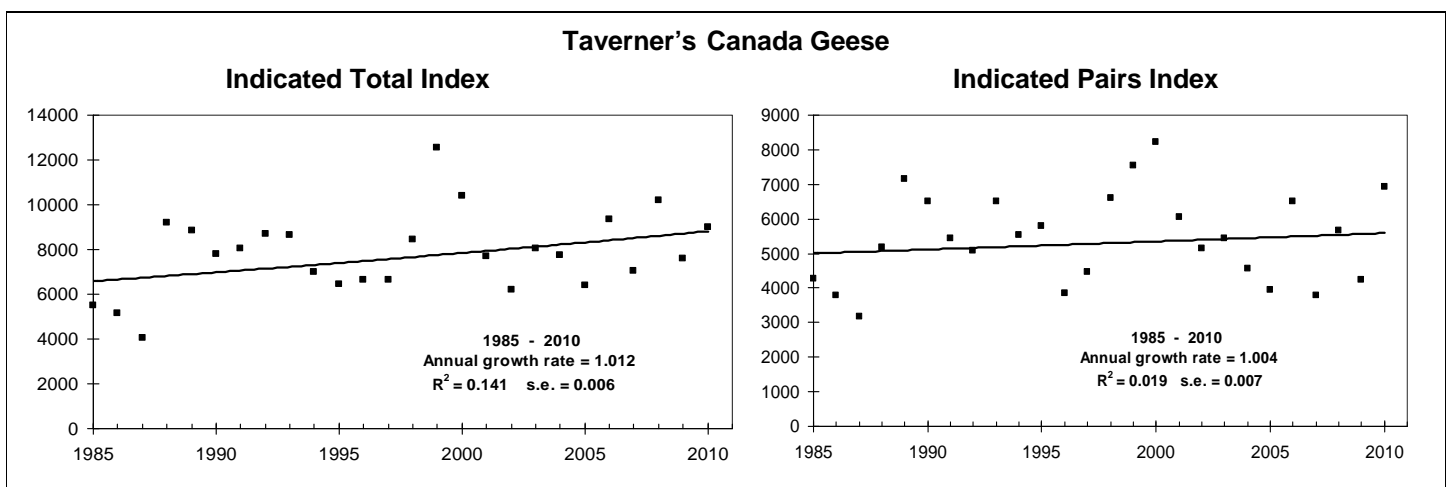


Fig. 7. Population index growth curves and average annual growth rates from log-linear regression for Taverner's Canada geese, 1985-2010.

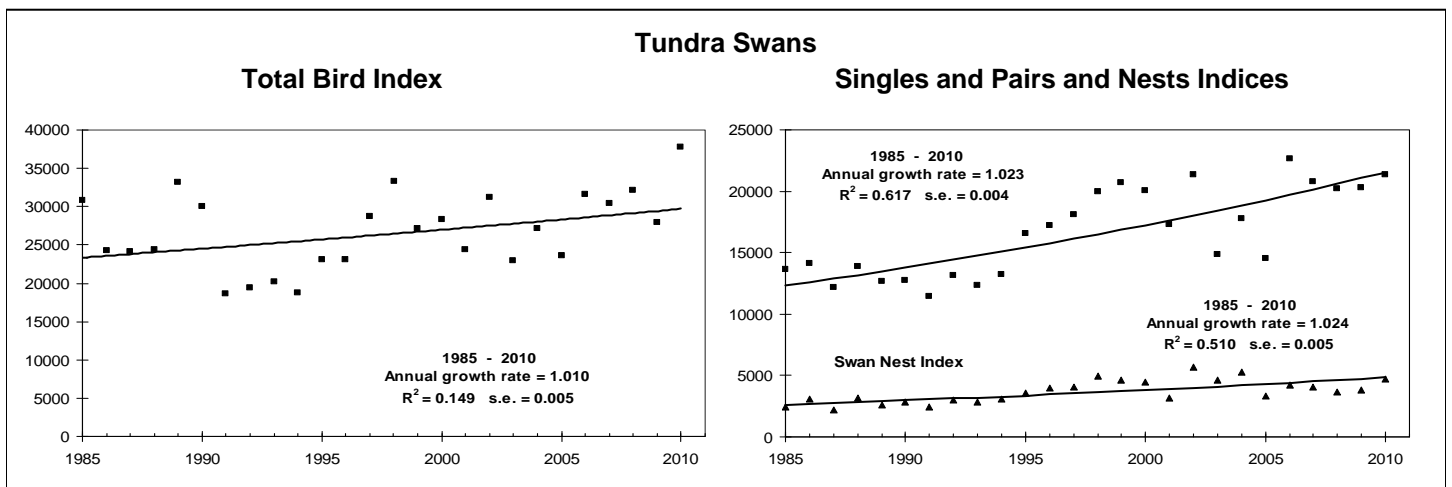


Fig. 8. Population index growth curves and average annual growth rates from log-linear regression for tundra swans, 1985-2010.

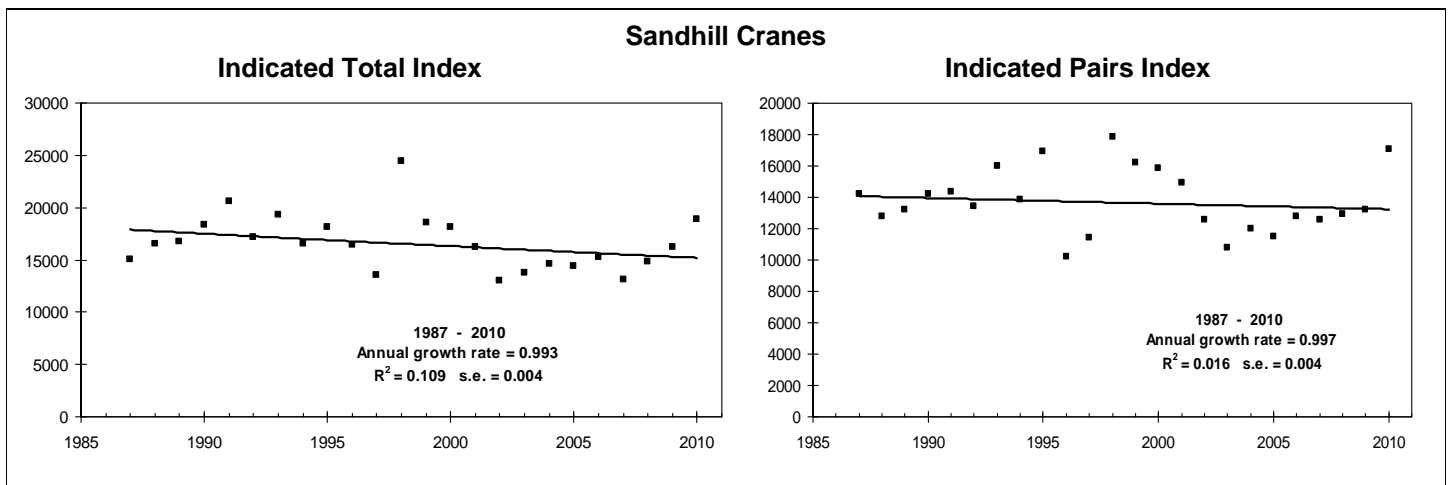
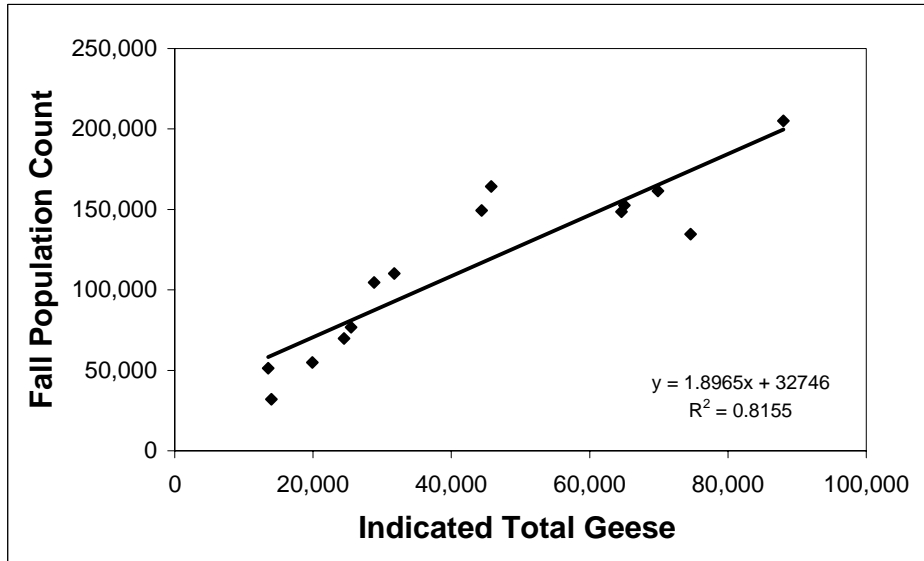


Fig. 9. Population index growth curves and average annual growth rates from log-linear regression for sandhill cranes, 1987-2010.

APPENDIX 1. Cackling Canada goose fall count, indicated total bird spring index, estimated fall population from the 1985-98 spring/fall correlation (see graph) and 3-year moving average of the estimated fall population.



| Year | Fall Count | Indicated Total Bird Index ^a | Fall Estimate ^b | 3-year Average |
|-------------|------------|---|----------------------------|----------------|
| 1985 | 32,100 | 13,963 | 59,227 | |
| 1986 | 51,400 | 13,502 | 58,353 | |
| 1987 | 54,800 | 19,921 | 70,526 | 62,702 |
| 1988 | 69,900 | 24,467 | 79,148 | 69,342 |
| 1989 | 76,800 | 25,475 | 81,059 | 76,911 |
| 1990 | 110,200 | 31,759 | 92,977 | 84,395 |
| 1991 | 104,600 | 28,843 | 87,447 | 87,161 |
| 1992 | 149,300 | 44,356 | 116,867 | 99,097 |
| 1993 | 164,300 | 45,749 | 119,509 | 107,941 |
| 1994 | 152,500 | 65,021 | 156,058 | 130,811 |
| 1995 | 161,400 | 69,888 | 165,289 | 146,952 |
| 1996 | 134,600 | 74,574 | 174,176 | 165,174 |
| 1997 | 205,100 | 88,018 | 199,672 | 179,712 |
| 1998 | 148,600 | 64,601 | 155,262 | 176,370 |
| 1999 | | 72,173 | 169,622 | 174,852 |
| 2000 | | 74,992 | 174,968 | 166,617 |
| 2001 | | 75,620 | 176,159 | 173,583 |
| 2002 | | 50,187 | 127,926 | 159,684 |
| 2003 | | 69,867 | 165,249 | 156,445 |
| 2004 | | 51,390 | 130,207 | 141,127 |
| 2005 | | 65,484 | 156,936 | 150,797 |
| 2006 | | 71,985 | 169,266 | 152,136 |
| 2007 | | 74,152 | 173,375 | 166,526 |
| 2008 | | 84,669 | 193,321 | 178,654 |
| 2009 | | 67,434 | 160,635 | 175,777 |
| 2010 | | 82,192 | 188,623 | 180,859 |

a--Indicated total based on new stratification

b--fall estimate based on indicated total bird index

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 Y-K Delta and Bristol Bay Lowlands (Bollinger and Hodges 2010; Mallek and Groves 2010).

| Year | Y-K Delta | | Y-K Interior | | Bristol Bay | | Y-K Total | | All PF W-fronts | |
|-------------|-----------------|----------------|-----------------|---------------|-----------------|--------------|-----------------|----------------|-----------------|----------------|
| | Singles + Pairs | Total Geese | Singles + Pairs | Total Geese | Singles + Pairs | Total Geese | Singles + Pairs | Total Geese | Singles + Pairs | Total 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 |

APPENDIX 3. Derivation of the annual fall population index for Pacific white-fronted geese from the relationship between June total indicated geese from the Y-K Delta and Bristol Bay to previous reliable fall surveys (1985-98).

| Year | Total Indicated Birds ¹ | Fall Survey | New Fall Index ² | 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 |

¹ TIB = 2 x (pairs + singles) + group birds Y-K Delta and Bristol Bay

² Fall Population Index = (TIB x 2.5498) + 71,339