

MBM

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Memorandum

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Through: Eric J. Taylor, Waterfowl Management Branch Chief, USFWS-MBM, Region 7

Subject: 2011 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 2011 aerial survey, flown from 3-11 June, represents the 27th consecutive year the U.S. Fish and Wildlife Service has conducted this survey. 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 follow an established USFWS and Canadian Wildlife Service (CWS) protocol for aerial waterfowl breeding population surveys (USFWS and CWS 1987). A Cessna 206 on amphibious floats, (N234JB in 2011) has been the survey platform used for all years of the survey. During the survey, the aircraft is flown along the centerline of pre-determined transect lines at a height of 30-45 m (100-150 ft) above ground level and at a ground speed of 145-170 km/hr (90-105 miles/hr, 78-90 kts). 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. The pilot and right-seat observer each record observations of geese, swans, and cranes within 200 m of the flight path on their side of the aircraft using microphones. Each observation is recorded vocally to a sound file (.wav format), linked with simultaneous GPS coordinates, and saved to separate computers for each observer. After the flight, a transcription program is used to replay the sound files to 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.

The aerial survey crew changed in 2011. Karen Bollinger continued serving as pilot/observer for the sixth straight year, but there was a change in the right-seat observer. William Eldridge had served as right-seat observer for 22 years (1987-2008), followed by John Hodges in 2009 and 2010. John had also flown this survey as pilot/observer four years (2001, 2003-2005). For the first time, Robert Platte flew as front right-seat observer in 2011 counting geese, swans, and cranes. Robert had flown on this survey for the past 20 years (1991-2010) as rear, right-seat observer where he counted all other waterbirds (e.g., ducks, loons, gulls, terns) instead of geese, swans, and cranes.

Population Indices

Monitoring populations is an essential tool for waterfowl management; however, in nearly all cases, 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, habitat, density of the same or other species, 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

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

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

Tundra Swans

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

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

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

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

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. Although cranes are larger than geese, we assume the visibility of cranes is similar to that of geese because of comparable plumage color. However, for swans, we assume that all birds are observed and we obtain a complete count. It is for this reason that the number of single swans is not doubled.

Stratification Design and Survey Design

The survey area extends from the coast to approximately 50 km inland and 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 only four primary strata and one additional small stratum. This additional small stratum was created to better accommodate historical data for a high-density area that had variable spacing between transects for several years. Indices for indicated total birds and indicated breeding birds were recalculated for the entire history of the survey to reflect the new stratification design.

The survey design, which had changed slightly over the years in the number and placement of transects, was standardized in 1998. 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. Also, in order to obtain optimal distribution data and more complete coverage, four sets of unique transect lines were drawn. These four sets of transect lines achieve near complete coverage of each interval zone during the four-year survey rotation of each unique set of transect lines. In the 1.6 km interval zone, each transect was moved 0.4 km annually within each unique set. Similarly, transects within the 3.2 km interval zone were moved 0.8 km within each unique set; transects within the 6.4 km interval zone were moved 1.2 km within each unique set; and transects within the 12.9 km interval zone were moved 2.4 km within each unique set. The years, 1998-2001 comprised the first complete four-year rotation; 2002-2005, the second; and 2006-2009, the third. The year 2011 represents the second year of the fourth, four-year rotation. These same transects were flown in the years 1999, 2003, and 2007. The 101 transects flown in 2011 totaled 2,489 km in length and covered 7.75% of the 12,832 km² study area.

RESULTS

The aerial crew arrived in Bethel on 31 May 2011. High winds in the area prevented the start of the survey until 3 June, and again grounded the crew on 4-5 June. The crew was then able to complete the survey in six straight days of flying from 6-11 June. During the 27-year history of the survey, the maximum range of dates has been from 29 May to 24 June. Since 1993, the interval for flying the survey has been 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 rate 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. Nesting data for the present year is estimated based on plots searched by ground crews (see Fischer et al. 2010), but these data do not become available until after the aerial survey is completed. Therefore, to determine appropriate dates to start the survey we have relied on calculations made

by Robert Stehn (pers. comm.) using weather variables on the Yukon-Kuskokwim Delta to predict nest initiation. In 2011, Stehn predicted the average cackling goose nest initiation date to be 24 May that corresponds to starting the aerial survey on 2 June. Due to weather, we were unable to begin the survey this year until one day later. With the exception of 4-5 June, survey conditions were excellent with light (<10 kts), predominantly southwest winds and mostly overcast skies for all days of the survey. Overall, lighting and observation conditions were mostly excellent.

Nesting phenology has advanced at an average of -0.25 days per year during the interval from 1983-2009 (Fischer et al. 2010). In 1982, the average cackler clutch initiation date occurred on 5 June and in 2010, average initiation was 23 May, a difference of two weeks. Our aerial survey start dates have also generally advanced to occur earlier as the nesting phenology has advanced temporally. The effect of survey timing 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 also influence population indices because heavy 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 2011 based on ground-based nest searches (Fischer et al. 2011, in prep) will help verify the timing of the aerial survey relative to nesting phenology.

Cackling Canada Geese

In 2011, the indicated total birds for cackling geese was estimated to be $53,799 \pm 2,137$ [SE] and indicated breeding birds, $42,361 \pm 1,796$ on the Yukon-Kuskokwim Delta breeding grounds. These indices represent a decrease of 35% and 16% from the 2010 indices of $82,192 \pm 4,755$ and $50,232 \pm 2,200$, respectively (Tables 1, 2, 6). From 1985-1997, indicated total birds and indicated breeding birds growth rates were 1.173 ± 0.009 and 1.146 ± 0.010 , respectively. However, for the last 13 years (1998-2011), indicated total bird and indicated breeding bird annual growth rates were 1.003 ± 0.011 and 1.002 ± 0.007 , respectively suggesting a relatively stable population (Fig. 2).

In 2011, the U.S. Fish and Wildlife Service, Migratory Bird Management Office (Alaska) assessed alternative methods to estimate the fall population size of cackling geese (Stehn 2011). The method used to predict the fall population from 1998-2010 relied on a simple linear relationship between indicated total birds estimated from the Yukon-Kuskokwim Delta Coastal Zone Survey regressed on the 1985-98 fall coordinated count data (Pacific Flyway Council 1999, Bollinger and Hodges 2010). Using this method, the 2010 fall population estimate was 188,623 birds and the 3-year running average was 180,859 birds (Bollinger and Hodges 2010, Appendix 1a).

In March 2011, the Pacific Flyway Council adopted an interim (3-year) alternative population index that used ratio estimation to establish relationships between the indicated total bird index from the Yukon-Kuskokwim Delta Coastal Zone Survey and the fall population estimate based

on 1989-2003 mark-resight data. Using this method, the index ratio of 3.35 is applied to the indicated total bird index from the Yukon-Kuskokwim Delta Coastal Zone Survey producing a fall 2010 population estimate of $275,343 \pm 20,339$ birds and the 3-year (2008-10) average of $261,629 \pm 17,554$ birds (Appendix 1b).

Based on the interim alternative population index, the fall 2011 cackling Canada geese population estimate is $180,227 \pm 10,938$ birds, and the 3-year (2009-2011) running average is $227,158 \pm 15,661$ birds (Appendix 1b).

Pacific White-fronted Geese

In 2011, the Pacific white-fronted goose indicated total bird index was estimated to be $168,925 \pm 16,068$ and indicated breeding bird index, $84,551 \pm 8,127$. The indicated total bird index was 3.2% lower than that of 2010 ($174,556 \pm 21,450$), while the indicated breeding bird index was 13% higher than that of 2010 ($74,791 \pm 9,359$) (Tables 1, 2, 6). The estimate of 84,551 indicated breeding birds was the highest on record (Tables 2, 6). Annual growth rates for indicated total birds and indicated breeding birds measured 1.098 ± 0.006 and 1.103 ± 0.006 , respectively (Fig. 3). These remain the highest growth rates of the five goose species on the Yukon-Kuskokwim Delta. The annual growth rate for indicated total birds during the first 11 years of the survey (1985-1995) measured 1.159 ± 0.022 , as compared to 1.057 ± 0.006 during the last 16 years of the survey (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 Survey and the North American Waterfowl Breeding Pair and Habitat Survey that samples the interior Yukon-Kuskokwim Delta and Bristol Bay (Appendix 2; Mallek and Groves 2011, in prep). Earlier analysis of the two June aerial breeding birds surveys estimated that the Yukon-Kuskokwim Delta accounts for an average of nearly 97% of the Pacific white-front population (Eldridge and Dau 2002, Conant and Groves 2002). In 2011, the coastal Yukon-Kuskokwim Delta, the interior Yukon-Kuskokwim Delta, and Bristol Bay accounted for 81%, 16%, and 3%, of the total Pacific white-fronted goose population, respectively (Appendix 2). The combined index for indicated breeding birds set a new record high of 105,024 birds in 2011 in Alaska, as compared to the index of 101,350 birds in 2010 (Appendix 2). However, indicated total birds in Alaska in 2011 (209,009 birds) decreased from the record high of 226,881 set in 2010.

The fall population estimate for Pacific white-fronted geese is based on the correlation between indicated total birds from the combined Yukon-Kuskokwim Delta and Bristol Bay breeding pair surveys and fall counts from 1985-98. The 2011 fall estimate (604,270 birds) and the 3-year (2009-11) average (596,952 birds) decreased from 2010 fall estimate (649,840) and previous 3-year (2008-10) average (604,540; Appendix 3).

Emperor Geese

The 2011 emperor goose indices for indicated total birds ($21,223 \pm 1,284$) and indicated breeding birds ($14,730 \pm 828$) were 5.2% and 4.4% higher than the respective 2010 indices ($20,167 \pm 1,199$) and ($14,103 \pm 781$) (Tables 1-2, 6). From 1985-11, the population growth rates for indicated total birds (1.017 ± 0.004) and indicated breeding birds (1.025 ± 0.004) were positive (Fig. 5).

Black Brant

This Yukon Delta Coastal Breeding Waterfowl Survey was not specifically designed to assess the population of colonial nesting species, including Pacific black brant. However, we believe that these survey data are useful to help better understand 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 Mallek et al. 2010). 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, most notably since 2008. However, the Yukon Delta Coastal Breeding Waterfowl Survey indicates that indicated breeding pairs may be increasing, and that in recent years, the number of brant nesting outside of traditional nesting colonies on the Yukon-Kuskokwim Delta is increasing (R. Stehn, USFWS, unpub. data).

The 2011 black brant indicated total bird index ($16,156 \pm 2,014$) was 32% lower than the 2010 index ($23,897 \pm 2,947$) (Tables 3, 6). However, the indicated breeding bird index ($12,375 \pm 1,664$) was 44% higher than the 2010 index of $8,595 \pm 1,451$ (Tables 3, 6). The indicated total bird and indicated breeding bird annual growth rates were 1.010 ± 0.009 and 1.056 ± 0.009 , 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 were established to categorize Canada goose observations as either cacklers or Taverner's for population indices. The 2011 indicated total bird index ($5,952 \pm 1,732$) and the indicated breeding bird index ($4,543 \pm 1,381$) were 35% and 34% lower than 2010 indicated total bird ($8,981 \pm 2,715$) and the indicated breeding bird ($6,942 \pm 2,173$) indices, respectively (Tables 3, 6; Fig. 7). Annual growth rates measured 1.008 ± 0.006 and 1.003 ± 0.006 for indicated total birds and indicated breeding birds, respectively.

Tundra Swans

Total birds in 2011 ($33,451 \pm 4,399$) was 28% lower as compared to 2010 ($37,790 \pm 4,660$). However, the count for tundra swan singles and pairs for 2011 ($22,543 \pm 1,640$) was 6% higher than the 2010 count ($21,340 \pm 1,291$) (Tables 4, 6, Fig. 8). Annual growth rates measured 1.011 ± 0.004 and 1.026 ± 0.005 , respectively for total birds and for singles and pairs. The nest index in 2011 (5,974) was 28% higher than in 2010 (4,678), 60% greater than the long-term (1985-10) average, and 40% greater than the 10-year (2001-10) average (Tables 4, 6).

Sandhill Cranes

In 2011, the indices for indicated total birds ($13,138 \pm 1,178$) and for indicated breeding birds ($12,264 \pm 1,067$) were 28% and 31% lower than the respective 2010 indices ($18,926 \pm 2,074$) and ($17,087 \pm 1,805$) (Tables 5-6; Fig. 9). In 2011, total birds and pairs were 21% and 11%, below the long-term (1986-10) average, respectively. Annual growth rates for indicated total birds and indicated breeding birds numbered were 0.992 ± 0.004 and 0.997 ± 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 looking at the results of each individual year separately. Counts of cackling Canada geese in 2011 were down from 2010 as recorded by both right seat and left seat observers; however, the effect was greater for the right seat observer. Both observers on the 2011 survey were highly experienced; however, the right seat observer was new to counting geese on the survey. It is possible that an observer effect contributed to a lower count relative to previous years. It is also possible that the number of geese was lower in 2011. Most of the difference between 2010 and 2011 cackling Canada geese population indices was due to a reduced number of geese in flocks (i.e., young, non-breeders) in 2011 compared to higher estimates of flocked geese in 2006, 2008, and 2010.

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Table 1. Indicated total bird^a indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2011.

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	84,669	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

^a Indicated Total Birds = 2 x (singles + pairs) + birds in flocks

Table 2. Indicated breeding bird^a indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2011.

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

^a Indicated Breeding Birds = 2 x (singles + pairs)

Table 3. Black brant and Taverner's Canada geese on the Yukon-Kuskokwim Delta, 1985-2011.

Year	Black Brant		Taverner's Canada Geese	
	Indicated Breeding Birds ^a	Indicated Total Birds ^b	Indicated Breeding Birds ^a	Indicated Total Birds ^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
2011	12,375	16,156	4,543	5,952

^a Indicated Breeding Birds = 2 x (singles + pairs)

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

Table 4. Tundra swan population estimates on the Yukon- Kuskokwim Delta, 1985-2011.

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
2011	22,543	33,451	5,974

^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 Yukon-Kuskowim Delta, 1987-2011.

Year	Indicated Breeding Birds ^a	Indicated 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
2011	12,264	13,138

^a Indicated Breeding Birds = 2 x (singles + pairs)

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

Table 6. Comparison of the indicated total birds and indicated breeding birds indices from 2011 with indices from: i) the previous year (2010), ii) the 10-year average (2001-2010), and iii) the long-term average (26-yr: 1985-2010) for all species surveyed. For sandhill cranes, the long-term average is based on 24-yr from 1987-2010. Rankings of the indices for the years 1985-2011 (27 yrs) and 2001-2011 (11 yrs) are also presented, as well as annual growth rates.

	CCGO	WFGO	EMGO	BLBR	TCGO	TUSW	SACR ^a	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
2011	53,799	168,925	21,223	16,156	5,952	33,451	13,138	5,974
10-yr average	69,301	134,140	22,325	22,684	7,929	28,922	15,057	4,260
Long-term average	55,781	83,018	19,753	23,646	7,825	26,805	16,676	3,688
% Change from 2010	-34.5	-3.2	5.2	-32.4	-33.7	-11.5	-30.6	27.7
% Change: 10-yr ave	-22.4	25.9	-4.9	-28.8	-24.9	15.7	-12.7	40.2
% Change: LTA-26yrs	-3.6	103.5	7.4	-31.7	-23.9	24.8	-21.2	62.0
Rank - 27 yrs	16th of 27	3rd of 27	11th of 27	24th of 27	24th of 27	2nd of 27	24th of 25	1st of 27
Rank - 11 yrs	9th of 11	3rd of 11	7th of 11	11th of 11	11th of 11	2nd of 11	10th of 11	1st of 11
Annual Growth Rate	1.173 ^b 1.003 ^b	1.098	1.017	1.010	1.008	1.011	0.992	1.026
Indicated Breeding Birds								
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
2011	42,361	84,551	14,730	12,375	4,543	22,543	12,264	5,974
10-yr average	47,117	62,140	14,960	8,255	5,233	19,101	13,040	4,260
Long-term average	37,583	36,573	12,586	6,415	5,442	16,657		3,688
% Change from 2010	-15.7	13.0	4.4	44.0	-34.6	5.6	-28.2	27.7
% Change: 10-yr ave	-10.1	36.1	-1.5	49.9	-16.5	18.0	-6.0	40.2
% Change: LTA-26yrs	12.7	131.2	17.0	92.9	-17.2	35.3	-11.1	62.0
Rank - 27 yrs	13th of 27	1st of 27	7th of 27	72nd of 27	19th of 27	2nd of 27	2nd of 25	1st of 27
Rank - 11 yrs	8th of 11	1st of 11	4th of 11	2nd of 11	8th of 11	2nd of 11	1st of 11	1st of 11
Annual Growth Rate	1.146 ^b 1.002 ^b	1.103	1.025	1.056	1.003	1.023	0.997	1.026

^a Sandhill Crane: Numbers based on data from 1987-2011; LTA based on 24 yrs; Rank on 25-years

^b Annual Growth Rates for CCGO for the intervals 1985-1997 and 1998-2011.

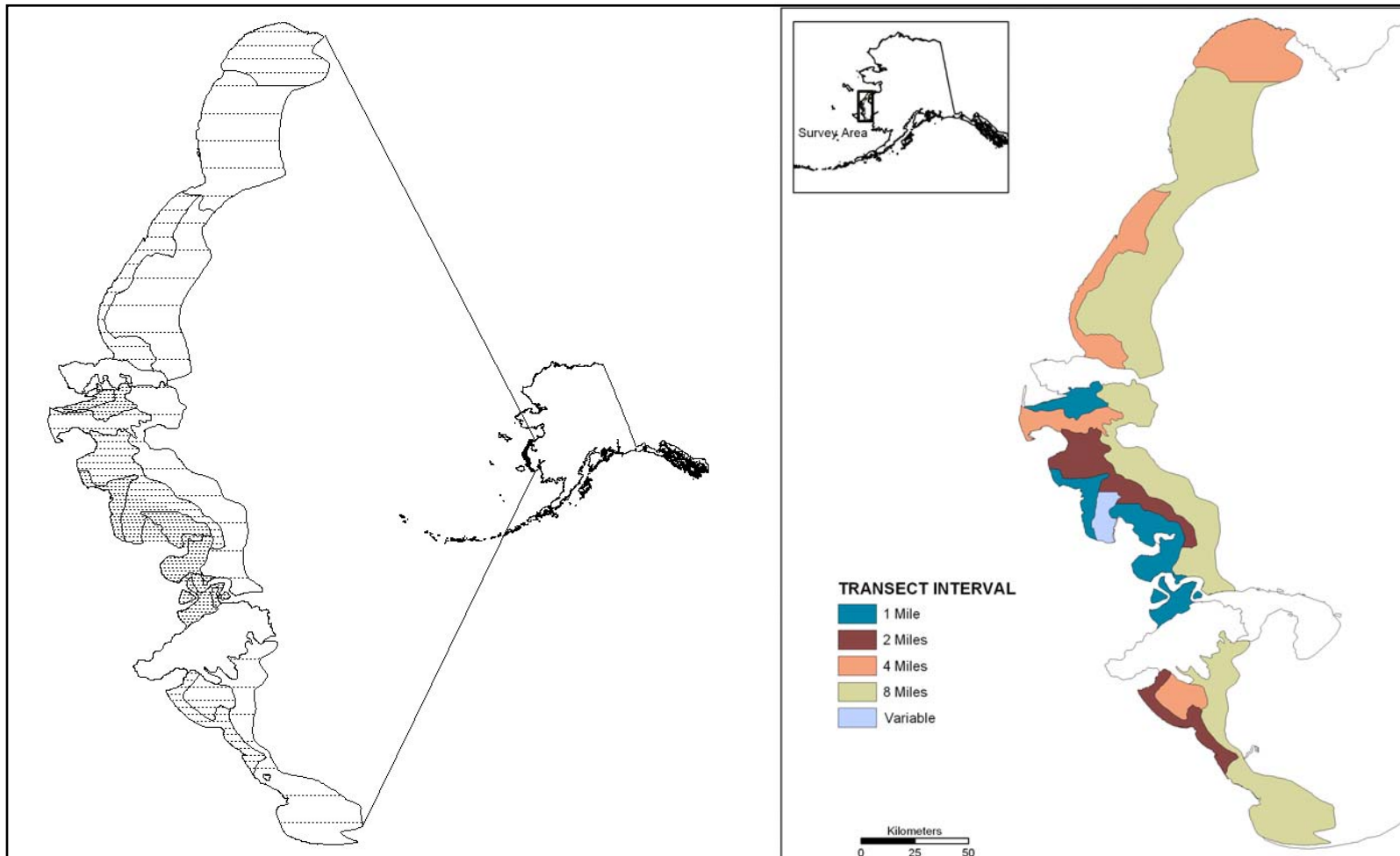


Figure 1. Flight lines (left side) and current 4-strata design (right side) for Yukon Delta aerial surveys.

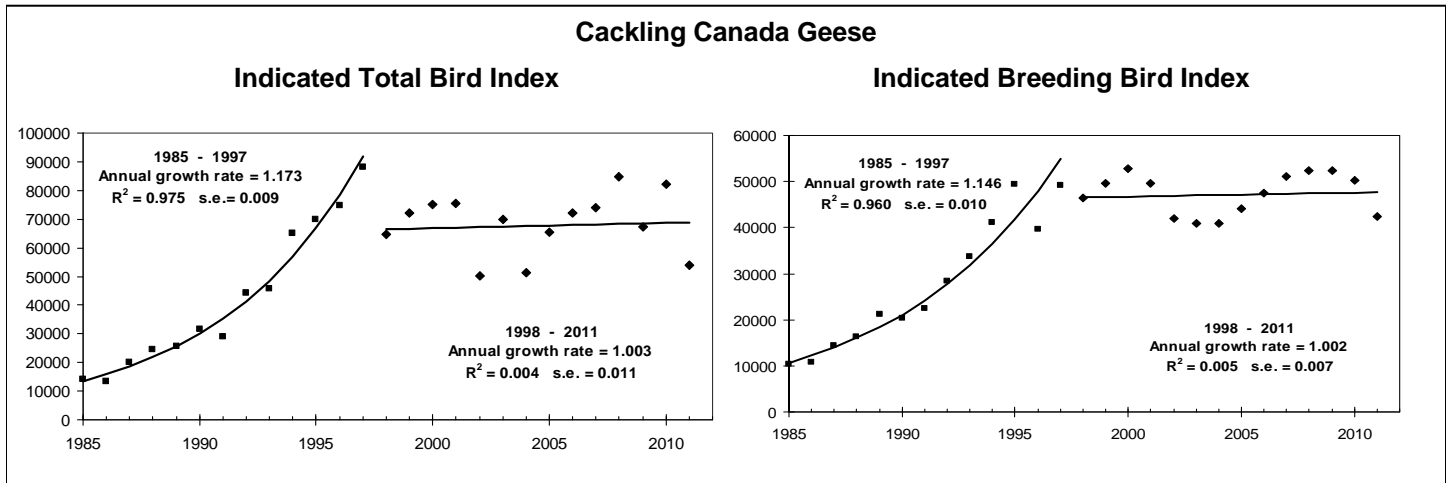


Fig. 2. Population index growth curves and average annual growth rates from log-linear regression for cackling Canada geese, for the first 13 years (1985-1997) and the last 13 years (1998-2011).

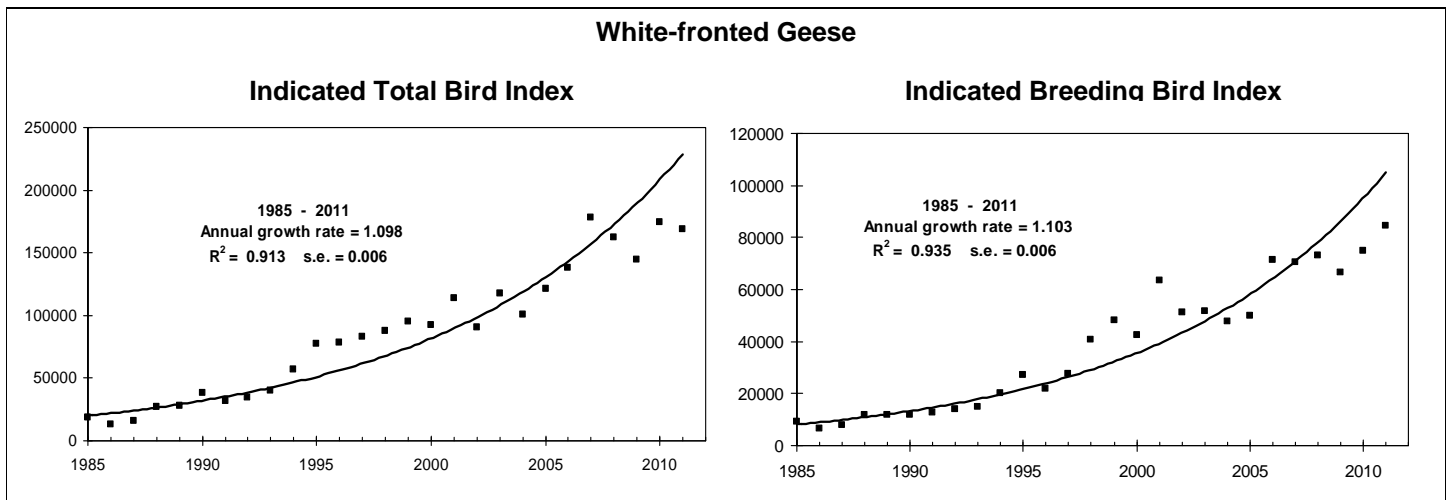


Fig. 3. Population index growth curves and average annual growth rates from log-linear regression for white-fronted geese, 1985-2011.

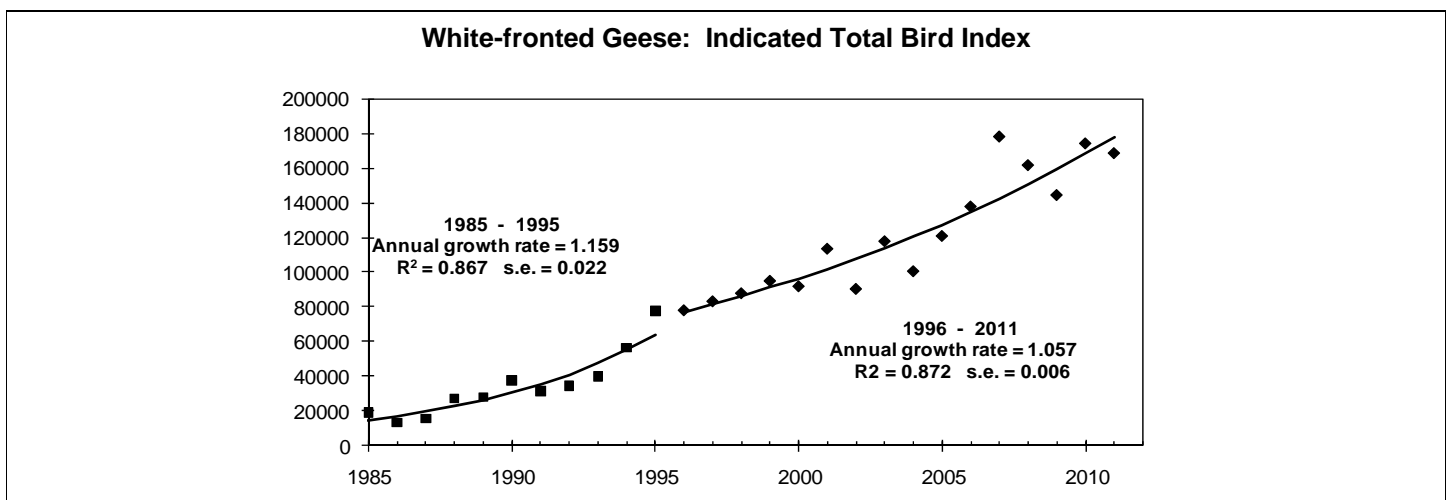


Fig. 4. Indicated total population index growth curves and average annual growth rates from log-linear regression for white-fronted geese based on the first 11 years (1985-1995) and the last 15 years (1996-2011).

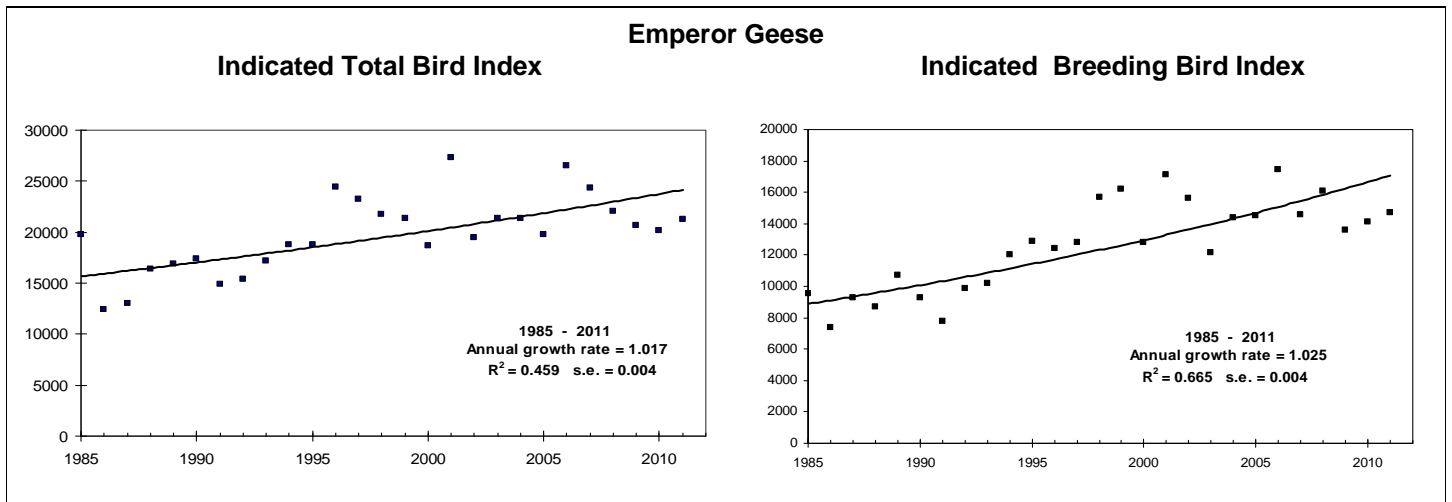


Fig. 5. Population index growth curves and average annual growth rates from log-linear regression for emperor geese, 1985-2011.

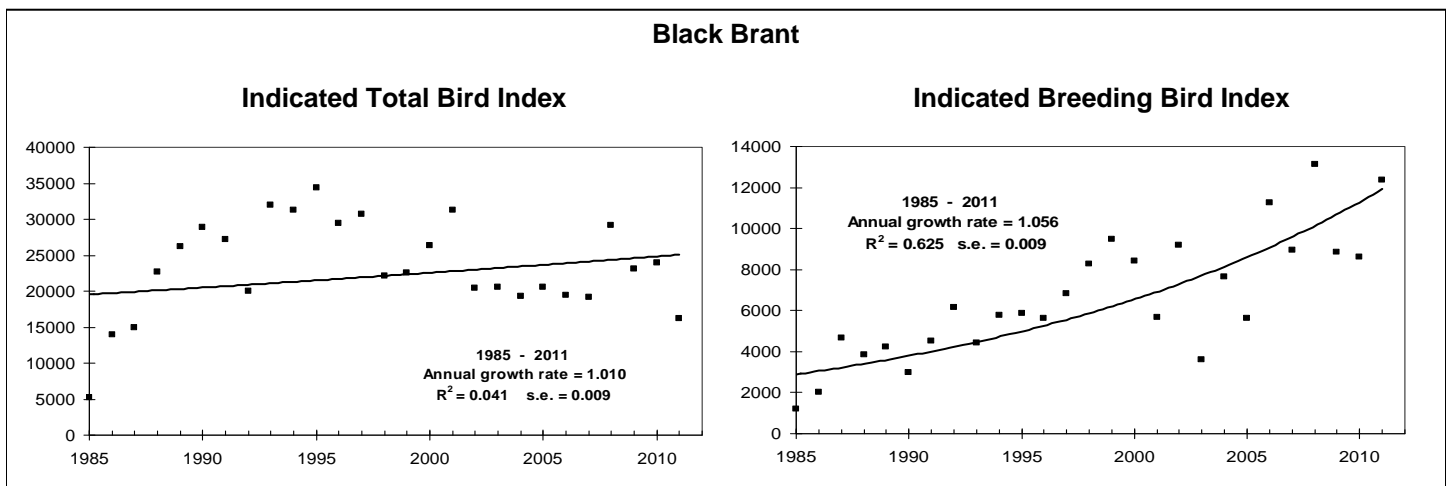


Fig. 6. Population index growth curves and average annual growth rates from log-linear regression for black brant, 1985-2011

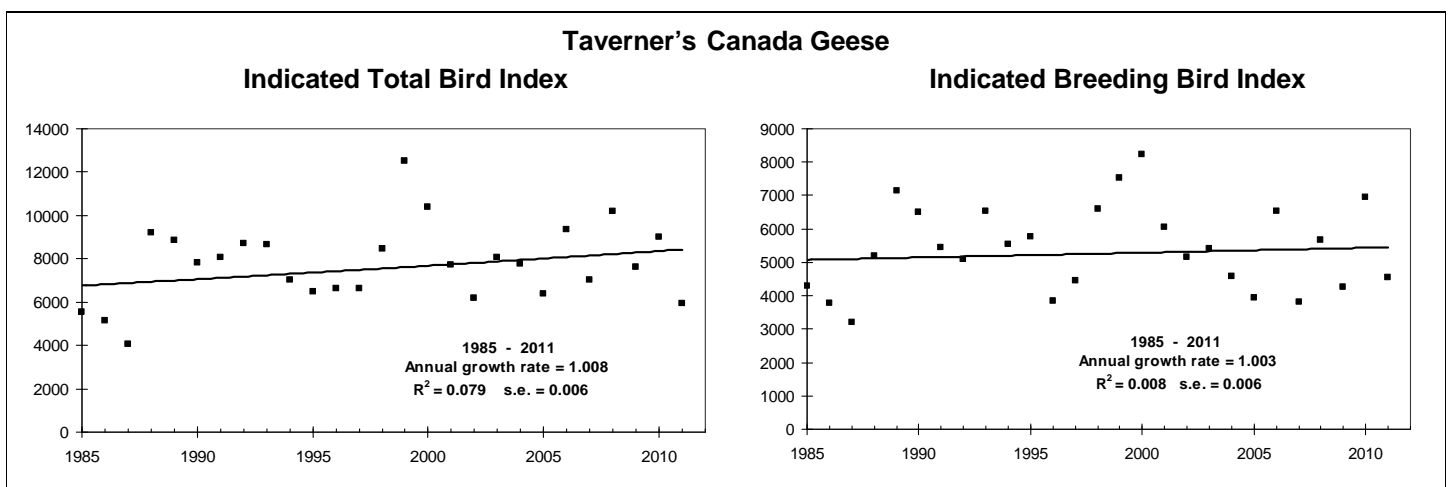


Fig. 7. Population index growth curves and average annual growth rates from log-linear regression for Taverner's Canada geese, 1985-2011.

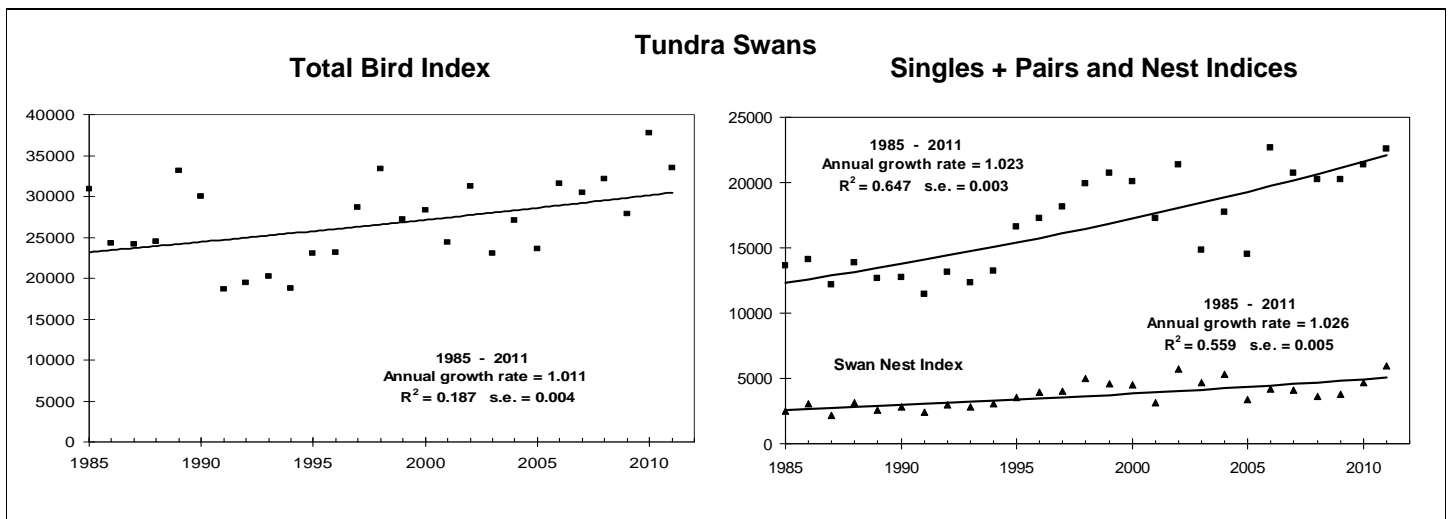


Fig. 8. Population index growth curves and average annual growth rates from log-linear regression for tundra swans, 1985-2011.

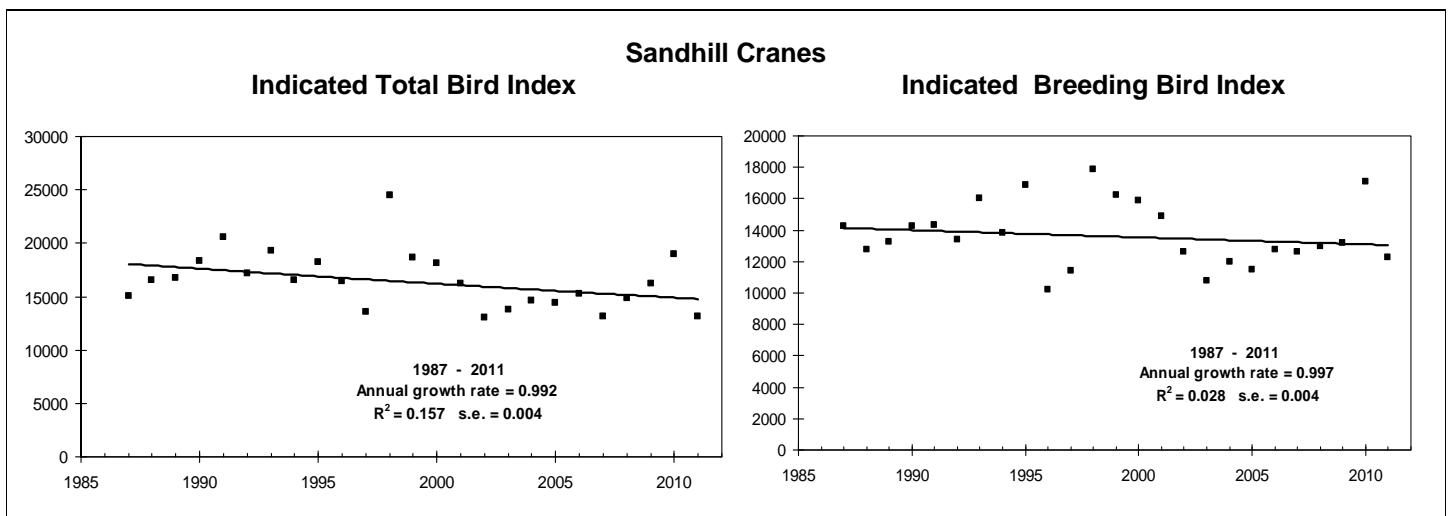
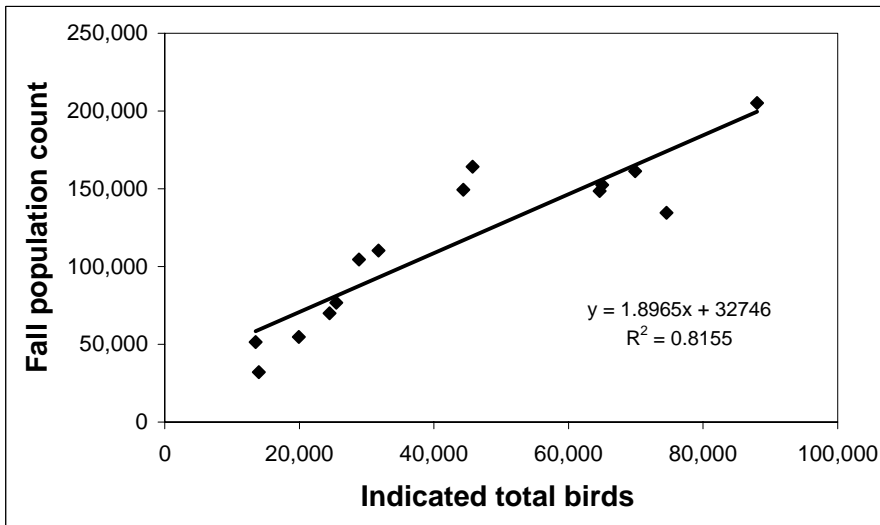


Fig. 9. Population index growth curves and average annual growth rates from log-linear regression for sandhill cranes, 1987-2011.

Appendix 1a. Cackling Canada goose fall population estimate based on the indicated total bird index from the Yukon-Kuskokwim Delta aerial survey and the 1985-1998 estimated fall counts. This method to estimate the fall population was used by the Pacific Flyway from 1998-2010.



Year	Fall count	Indicated total bird index ^a	Fall population 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
2011		53,799	134,776	161,345

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

^b Fall population = 1.8965 x indicated total bird index + 32,746.

Appendix 1b. Cackling Canada geese fall population estimate based on total indicated bird index from the Yukon-Kuskokwim Delta aerial survey and the 1989-2003 mark-resight estimates of fall population. This method was adopted by the Pacific Flyway in 2011.

Year	Indicated total bird index ^a	Mark-resight population estimate	Fall population estimate ^b	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

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

^b Fall Population = 3.35 x 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 2011; Mallek and Groves 2011, in prep.).

Year	Y-K Delta		Y-K Interior		Bristol Bay		Y-K Total		All PF White-fronts	
	Singles + Pairs	Indicated Total	Singles + Pairs	Indicated Total	Singles + Pairs	Indicated Total	Singles + Pairs	Indicated Total	Singles + Pairs	Indicated Total
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

Appendix 3. Pacific White-fronted goose fall population estimates based on the relationship between indicated total bird aerial indices and fall coordinated survey counts 1985-1998. Indicated total birds are based on June aerial surveys from the Yukon-Kuskokwim Delta coast, the YKD interior, and Bristol Bay wetlands.

Year	Indicated total bird index ^a	Fall survey count	Fall population estimate ^b	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

^a Indicated total bird index = 2 x (singles + pairs) + birds in flocks.

^b Fall population estimate = 2.5498 x Indicated total bird index + 71,339.