

Memorandum

To: Todd Sanders, Pacific Flyway Representative, USFWS-DMBM

From: Anna J. Anderson, USFWS-MBM, Region 7
John I. Hodges, USFWS-MBM, Region 7 (retired)

Through: Chief, Migratory Bird Management - Region 7

Subject: 2015 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 4-11 June 2015, representing the 31st consecutive year the U.S. Fish and Wildlife Service (USFWS) has conducted this project. Goose species surveyed include cackling Canada geese (*Branta canadensis 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 canadensis taverneri*). Species nomenclature follows common names recognized by the Pacific Flyway and scientific names recognized by the USFWS (Department of the Interior 2010, p.9). 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). A Cessna 206 on amphibious floats was used to fly the survey in 2015. All previous surveys had been flown using a Cessna 206 as the survey platform except in 2012 when a Quest Kodiak was used. During the survey, the aircraft was 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's Global Positioning System (GPS) was used to navigate the aircraft to transect "start" and "end" waypoints and maintain the aircraft along the transect centerline. During 2012-2014, only the front right-seat observer recorded observations of geese, swans, and cranes that were used for analysis. In 2015 and prior to 2012, 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 2015 John Hodges, USFWS-MBM (retired), served as front right-seat observer for the sixth year and Anna Anderson, USFWS-MBM, served as biologist-pilot and front left-seat observer for the first time. Both recorded observations of all geese, swans, and cranes. Tamara Zeller, USFWS-MBM, served as rear right-seat observer, for

the first time, counting other water bird species including ducks, loons, gulls, terns, and jaegers. Only observations of geese, swans, and cranes are presented in this memo. With software developed by John Hodges, each observation was 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 was 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 was then used for data analyses.

Population Indices

Population indices used in this report were 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. Although 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 so the number of single swans is not doubled as it is with geese and cranes.

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).

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. 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 variable spacing between transects for several years.

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 the 1.6 km 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; 2006-2009, the third; and 2010-2013, the fourth complete four-year rotation. The year 2015 represents the second year of the fifth, four-year rotation. In 2015, aircraft maintenance problems and restricted hours available on the airplane resulted in a 21% reduction in survey effort. We reduced the survey effort by removing a complete transect line every 16 miles. Specifically we excluded transects 2, 7, 15, 16, 33, 34, 50, 65, 74, 83, 87, 91, 95, 101 and 105. We surveyed 1937 linear km of the 2450 km total designed transect lines.

RESULTS AND DISCUSSION

We intended to begin the 2015 survey on 27 May due to early spring breakup; however, we were delayed until 4 June due to multiple aircraft maintenance needs. By the time we started the survey, the tundra was completely snow-free and ponds and marshes were ice-free. There was little indication of any flooding on the survey area, but there were very high tides during the survey period. High winds caused us to return to Bethel during the first part of the survey. Heavy rain showers reduced visibility towards the end of the survey.

The potential effects of survey timing relative to nesting phenology on population estimates is not completely understood; however, we assume 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. Poor nesting success may also increase the number of birds seen in flocks due to failed breeding attempts.

Cackling Canada Geese

In 2015, indicated total cackling Canada geese was $101,408 \pm 6,144$ (SE); and indicated breeding birds, $55,937 \pm 2,732$ (SE). These indices represent increases of 20.8% and 0.4% from the 2014 indices, respectively (Tables 1, 2, 6). Growth rates were calculated separately for the time periods when cackler numbers were rapidly increasing (1985-1997) and the time period when the population growth slowed (1998-2015). From 1985-1997, indicated total birds and indicated breeding birds growth rates were 1.173 and 1.146, respectively. However, for the last 18 years (1998-2015), indicated total birds and indicated breeding birds annual growth rates were 1.015 and 1.012, respectively, suggesting the growth of the population slowed in recent decades (Fig. 2).

In March 2011, the Pacific Flyway Council adopted a new method for estimating the fall population of cackling Canada geese (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). The new adopted method to estimate fall population uses ratio estimation to establish the relationship between the indicated total bird index from the Yukon-Kuskokwim Delta breeding ground survey (i.e., this aerial survey) and 1989-2003 mark-resight. An index ratio of 3.35 is applied to the indicated total bird index from the Yukon-Kuskokwim Delta Coastal Zone Survey to derive a fall population index.

Using this method, the 2015 cackling Canada goose fall population is 339,717 birds and the 3-year (2013-2015) average is 311,079 birds (Appendix 1). These estimates are 21% and 17% higher than indices reported in 2014, respectively.

Pacific White-fronted Geese

In 2015, the Pacific white-fronted goose indicated total birds index was $140,313 \pm 14,159$ (SE) and indicated breeding bird index, $60,708 \pm 6,751$ (SE) (Tables 1, 2, 6). The indicated total birds index and the indicated breeding birds index were 31.6% lower and 29.5% lower, respectively, than those of 2014. This change may have been due to the late timing of the survey relative to the early spring phenology, although this explanation does not account for the observed increase in cackling Canada geese. The average annual white-fronted goose growth rate for indicated total birds for the first 22 years of the survey (1985-2006) measured 1.11 as compared to 1.0 for the last 8 years of the survey (2007-2015) (Fig. 3). The average annual growth rate for indicated breeding birds for the years 1985-2000 measured 1.131, and slowed to 1.037 for the years 2001-2015 (Fig. 3).

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 Waterfowl Breeding Population and Habitat Survey (Groves and Shults, 2015)) and counts from the fall survey (1985-1998). The 2015 fall estimate (479,085 birds) and the 3-year average (565,403 birds) were 25% and 10% lower than indices reported in 2014, respectively, (Appendix 3).

Emperor Geese

The 2015 emperor goose indices for indicated total birds ($26,235 \pm 1,581$ (SE)) and indicated breeding birds ($14,647 \pm 832$ (SE)) were 19.4% lower and 9.5% lower than the respective 2014 indices. From 1985-2015, the average annual population growth rate for indicated total birds was 1.018 and for indicated breeding birds, 1.024 (Fig. 4).

Black Brant

The Yukon Delta Coastal Zone 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 useful in assessing the general population trends and distribution.

The 2015 indicated total birds index (19,753) was 30% lower than the 2014 index and the 2015 indicated breeding birds index (3,844) was 5% lower than the 2014 index (Tables 3, 6). Low numbers of indicated breeding birds may have resulted observers recording multiple single brant observations into a single group record. Distinguishing single brant from groups is difficult in

areas of high density. Alternatively the low indicated breeding bird index may reflect that fewer brant attempted to nest. Average (1985-2015) annual growth rates for indicated total birds and indicated breeding birds over the last 31 years were 1.007 and 1.042, respectively (Fig. 5).

Taverner's Canada Geese

Taverner's Canada geese are found primarily interior to the coastal zone surveyed, but some overlap with cackling Canada geese 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 2015, the indicated total birds index (10,864) and the indicated breeding birds index (6,779) were 17% lower and 26% lower, respectively, than in 2014 (Tables 3, 6). Average (1985-2015) annual growth rates measured 1.013 and 1.006 for indicated total birds and indicated breeding birds, respectively (Fig. 6).

Tundra Swans

Swan indices were lower in 2015 compared to 2014. In 2015 total birds (23,000) were 16% lower; singles and pairs (11,077), 40% lower; and the nest index (3,448), 31% lower than 2014 respectively (Tables 4, 6). Average annual growth rates for total birds, singles and pairs, and nests were 1.007, 1.016, and 1.019 respectively (Fig. 7).

Sandhill Cranes

In 2015, the indices for indicated total birds (12,282) and for indicated breeding birds (10,500) were 18% and 21% lower than the respective 2014 indices (Tables 5, 6). Average (1985-2015) annual growth rates for both indicated total birds and indicated breeding birds were 0.992 and 0.997, respectively (Fig. 8).

SURVEY RECOMMENDATIONS

Most geese flush at the approach of the survey aircraft and fly perpendicular to the transect line requiring the observer to subjectively determine if these geese were originally within the 200 m transect prior to flushing. To minimize observer variability we recommend: 1) increased training for new observers; 2) maintain the same observers as long as possible; and 3) use two observers rather than one so that the biases of either observer might be tempered in results.

ACKNOWLEDGMENTS

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Table 1. Indicated total^a population indices for cackling Canada, white-fronted, and emperor geese on the Yukon-Kuskokwim Delta, 1985-2015.

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
2012	60,395	2,663	181,519	15,461	20,388	1,554
2013	93,200	5,202	164,399	18,318	29,840	2,222
2014	83,970	4,225	205,081	31,834	32,550	2,973
2015	101,408	6,144	140,313	14,159	26,235	1,581

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

Table 2. Indicated breeding bird^a indices for cackling Canada, white-fronted, and emperor geese on the Yukon-Kuskokwim Delta, 1985-2015.

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
2012	51,729	2,349	97,654	8,422	17,207	1,307
2013	67,328	3,512	93,823	12,704	19,372	1,326
2014	55,733	2,736	86,079	12,013	16,188	1,132
2015	55,937	2,732	60,708	6,751	14,647	832

^a Indicated breeding bird index = 2 x (singles + pairs)

Table 3. Indicated breeding bird and indicated total bird population indices for black brant and Taverner's Canada geese on the Yukon-Kuskokwim Delta,

	Black Brant		Taverner's Canada Geese	
Year	Indicated Breeding Bird ^a	Indicated Total ^b	Indicated Breeding Bird ^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
2011	12,375	16,156	4,543	5,952
2012	17,541	21,912	6,680	8,980
2013	13,104	24,048	4,073	9,283
2014	4,040	28,283	9,183	13,115
2015	3,844	19,753	6,779	10,864
^a Indicated breeding bird index = 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, 1985-2015.

Year	Singles and Pairs ^a	Indicated 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
2012	26,201	39,291	4,275
2013	17,900	19,635	3,643
2014	18,367	27,413	4,965
2015	11,077	23,000	3,448
^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-Kuskokwim Delta, 1987-2015.

Year	Indicated Breeding Bird ^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
2012	16,916	18,990
2013	12,771	13,830
2014	13,220	14,925
2015	10,500	12,282
^a Indicated Breeding Bird Index = 2 x (singles + pairs)		
^b Indicated Total Birds = 2 x (singles + pairs) + birds in flocks		

Table 6. Comparison of 2015 indicated total birds, indicated breeding birds, and tundra swan nests with 2014 numbers and with the previous 30-year, 25-year, and 10-year means for all species surveyed.

	CCGO ^a	GWFG	EMGO	BLBR	TCGO	TUSW	SACR ^b	TUNE ^c
Indicated Total Birds								
2013	93,200	164,399	29,840	24,048	9,283	19,635	13,830	3,643
2014	83,970	205,081	32,550	28,283	13,115	27,413	14,925	4,965
2015	101,408	140,313	26,235	19,753	10,864	23,000	12,282	3,448
30-yr mean: 1985-2014	58,056	95,946	20,586	23,507	8,026	27,224	- - - -	3,825
25-yr mean: 1990-2014	65,774	111,006	21,562	24,887	8,319	27,191	16,511	4,050
10-yr mean: 2005-2014	73,731	163,874	23,767	22,574	8,691	30,331	15,378	4,265
% Change from 2014	20.8	-31.6	-19.4	-30.2	-17.2	-16.1	-17.7	-30.6
% Change: 25-yr mean	54.2	26.4	21.7	-20.6	30.6	-15.4	-25.6	-14.9
% Change: 10-yr mean	37.5	-14.4	10.4	-12.5	25.0	-24.2	-20.1	-19.2
Rank - 31 yrs	1	9	5	24	3	26	29	19
Annual Growth Rate			1.018	1.007	1.013	1.007	0.992	1.019
Growth Rate Early ^d	1.173	1.111						
Growth Rate - Late ^e	1.050	1.000						
Indicated Breeding Birds								
2013	67,328	93,823	19,372	13,104	4,073	17,900	12,771	
2014	55,733	86,079	16,188	4,040	9,183	18,367	13,220	
2015	55,937	60,708	14,647	3,844	6,779	11,077	10,500	
30-yr mean: 1985-2014	39,811	43,767	13,158	7,128	5,532	17,270	- - - -	
25-yr mean: 1990-2014	44,856	50,606	13,962	7,917	5,695	18,065	13,838	
10-yr mean: 2005-2014	51,483	76,897	15,779	10,348	5,559	20,483	13,525	
% Change from 2014	0.4	-29.5	-9.5	-4.9	-26.2	-39.7	-20.6	
% Change: 25-yr mean	24.9	20.0	4.9	-51.4	19.0	-38.7	-24.1	
% Change: 10-yr mean	8.7	-21.1	-7.3	-62.9	21.9	-45.9	-22.4	
Rank - 31 yrs	2	11	11	26	6	31	28	
Annual Growth Rate			1.023	1.042	1.006	1.016	0.997	
Growth Rate Early ^f	1.146	1.131						
Growth Rate - Late ^g	1.012	1.037						
^a CCGO = cackling Canada goose								
^b Sandhill Crane - rank for 29-year interval.								
^c TUNE = Tundra Swan Nests								
^d Early = 1985-1997 CCGO; 1985-2006 GWFG								
^e Late = 1998-2015 CCGO; 2007-2015 GWFG								
^f Early = 1985-1997 CCGO; 1985-2000 GWFG								
^g Late = 1998-2015 CCGO; 2001-2015 GWFG								

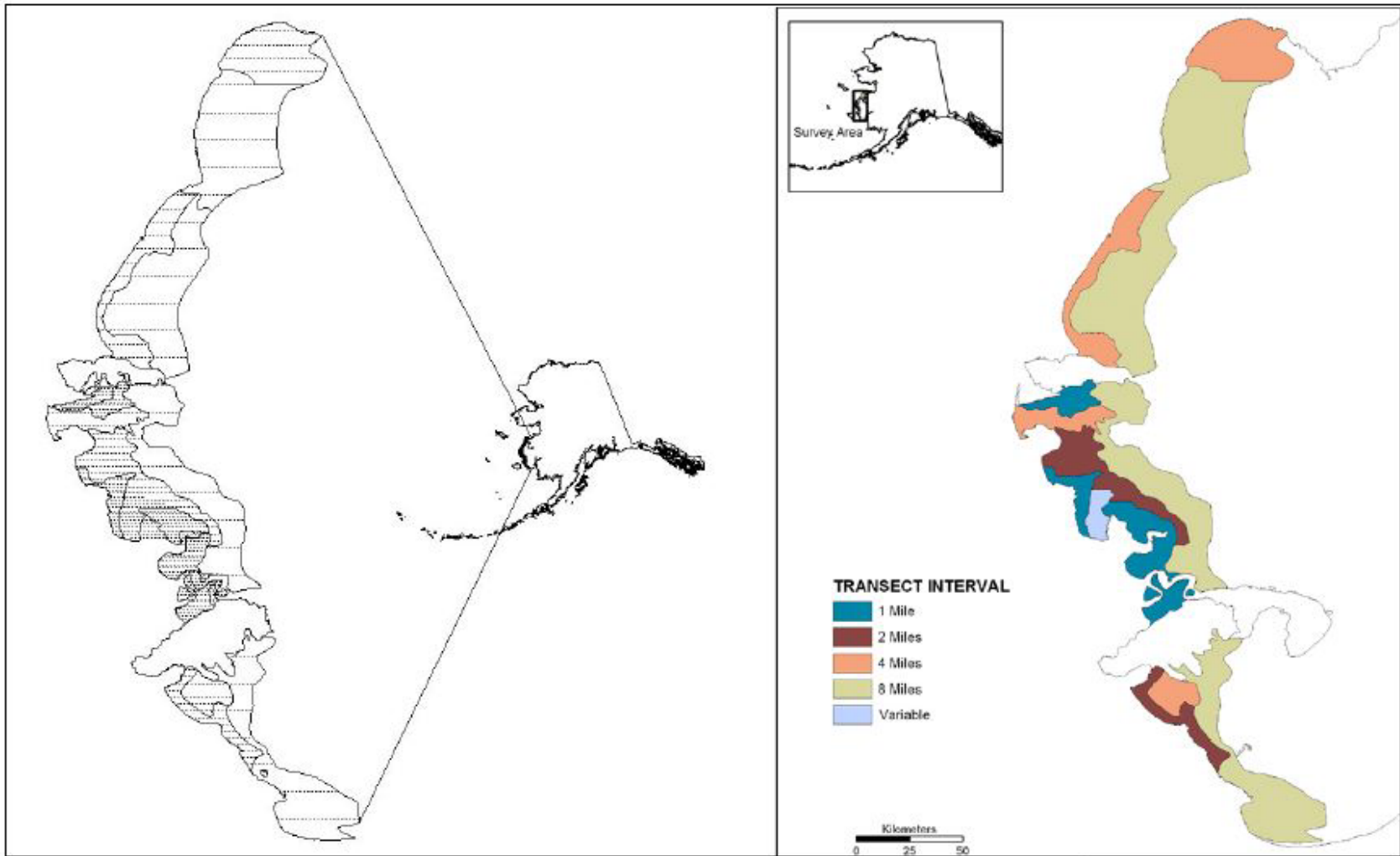


Figure 1. Yukon-Kuskokwim Delta (YKD) Coastal Zone Aerial Survey study area showing flight lines (left panel) and stratification (right panel).

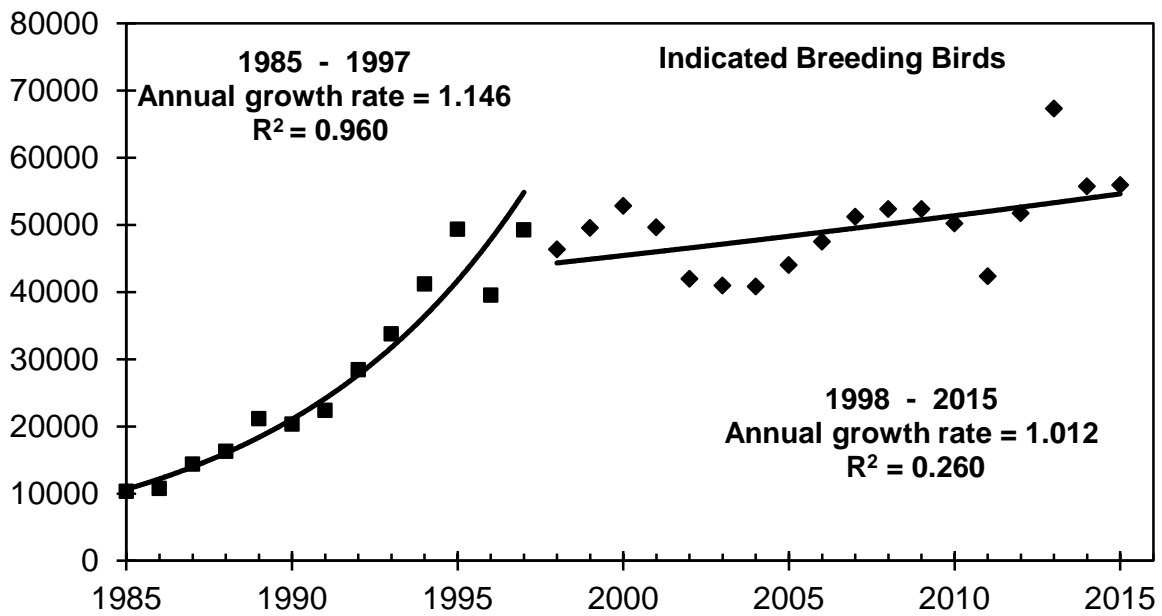
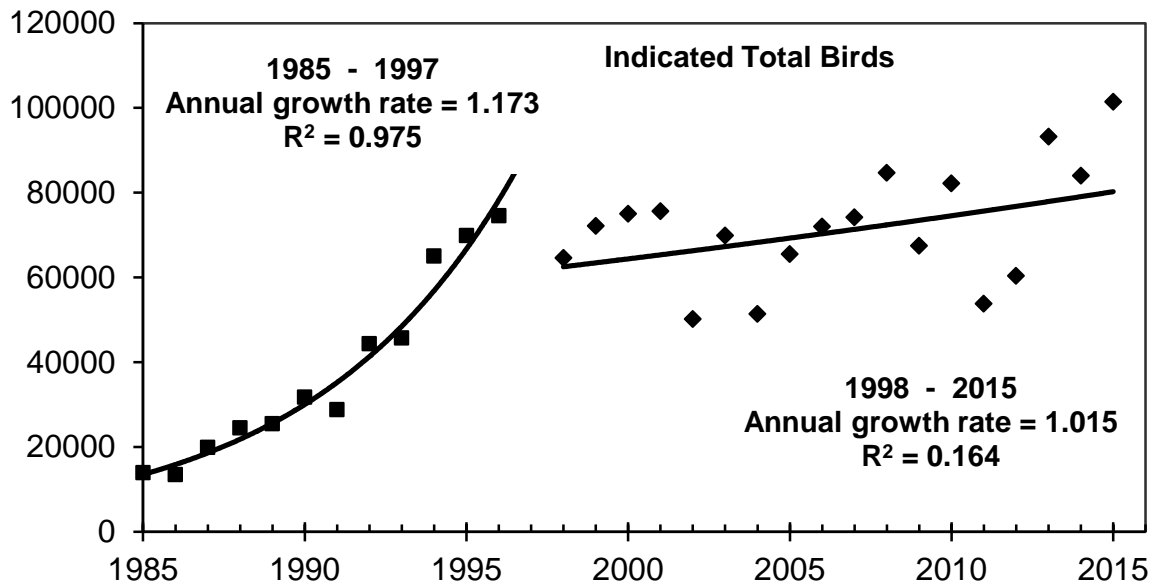


Figure 2. Population index growth curves and average annual growth rates from loglinear regression for cackling Canada geese, for the first 13 years (1985-1997) and the last 18 years (1998-2015).

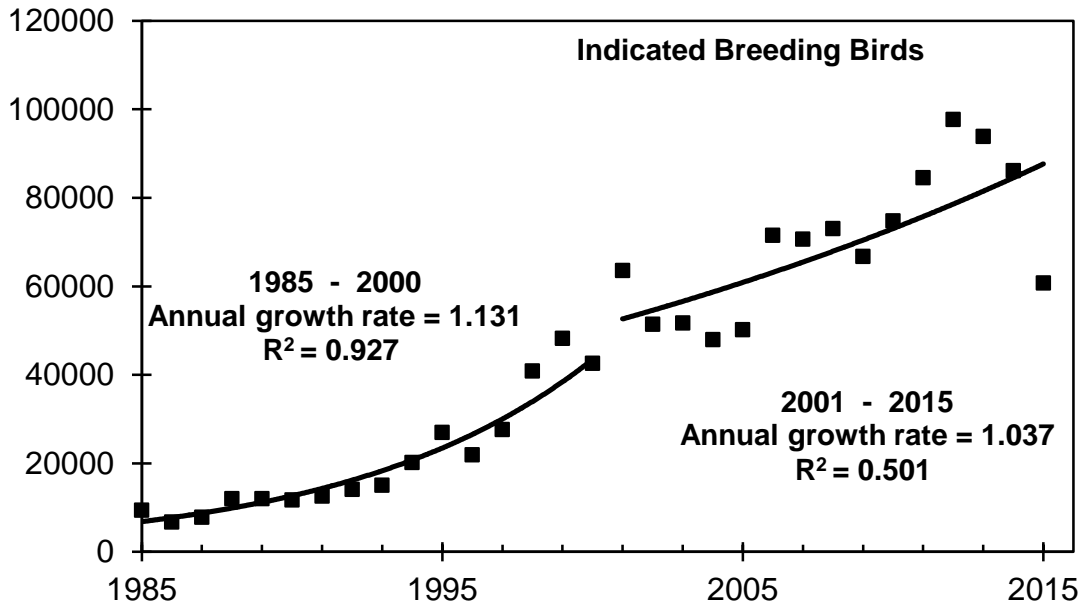
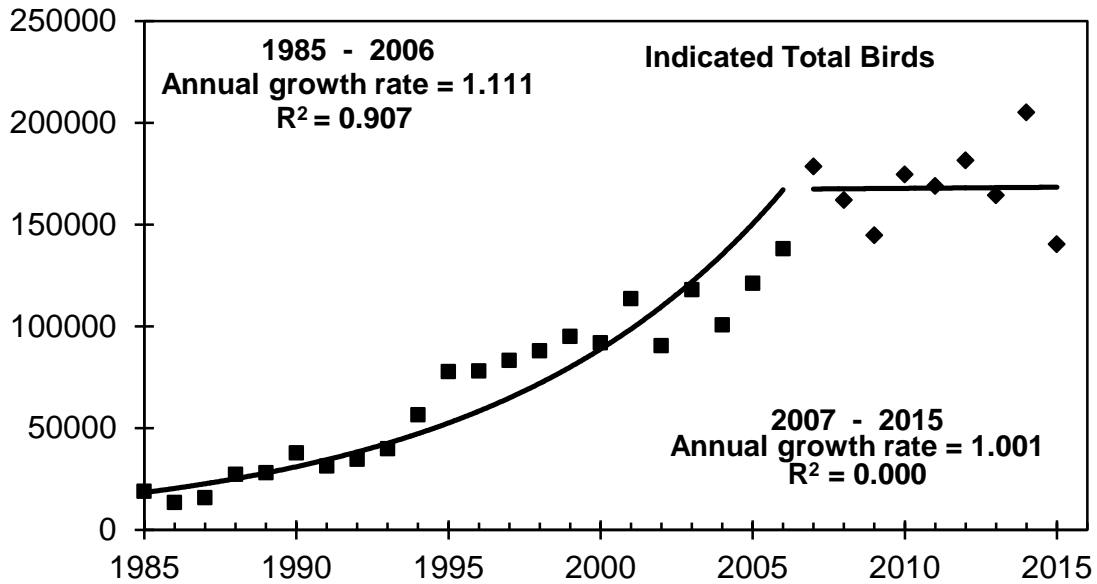


Figure 3. Population index growth curves and average annual growth rates from loglinear regression for total greater white-fronted geese during the first 22 years (1985-2006) and the last 9 years (2007-2015), and for indicated breeding white-fronted geese for the first 16 years (1985-2000) and last 15 years (2001-2015).

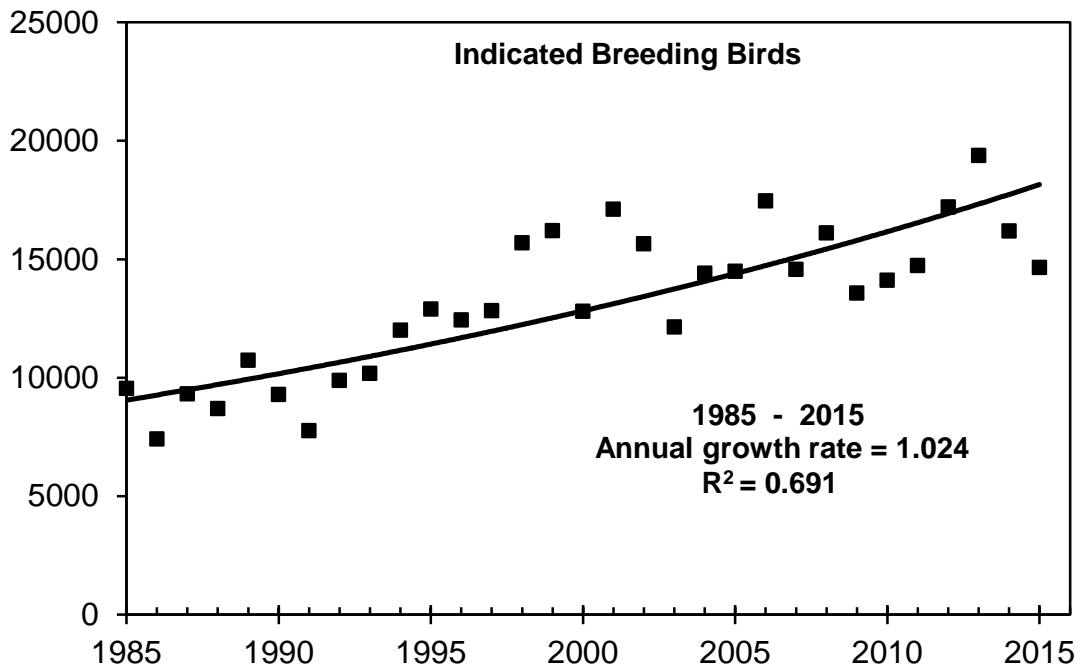
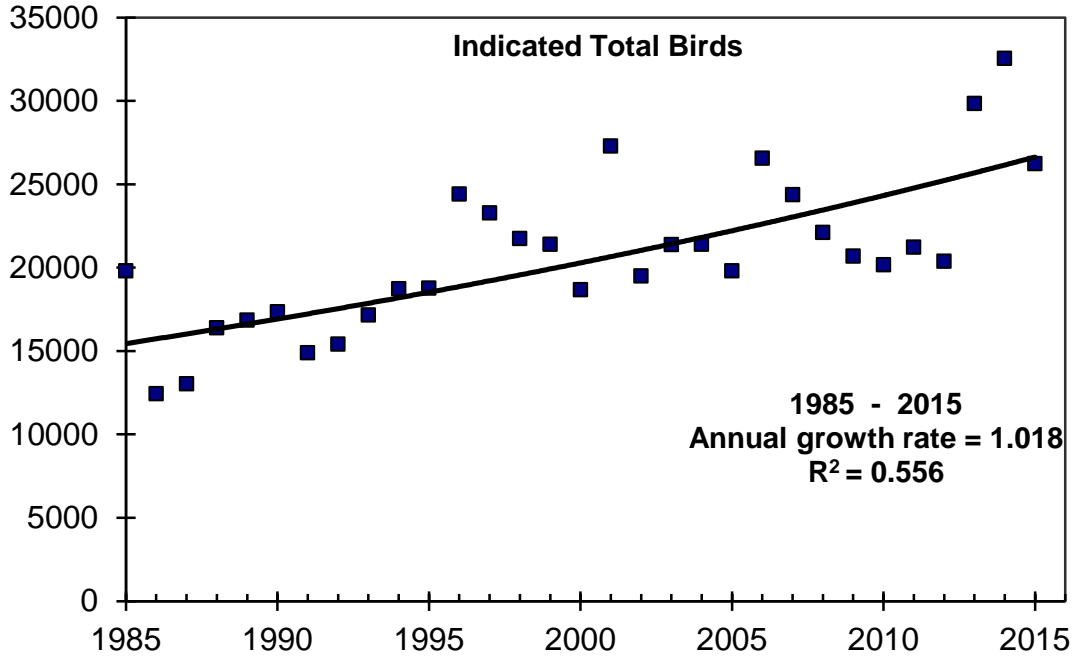


Figure 4. Population index growth curves and average annual growth rates from loglinear regression for emperor geese, 1985-2015.

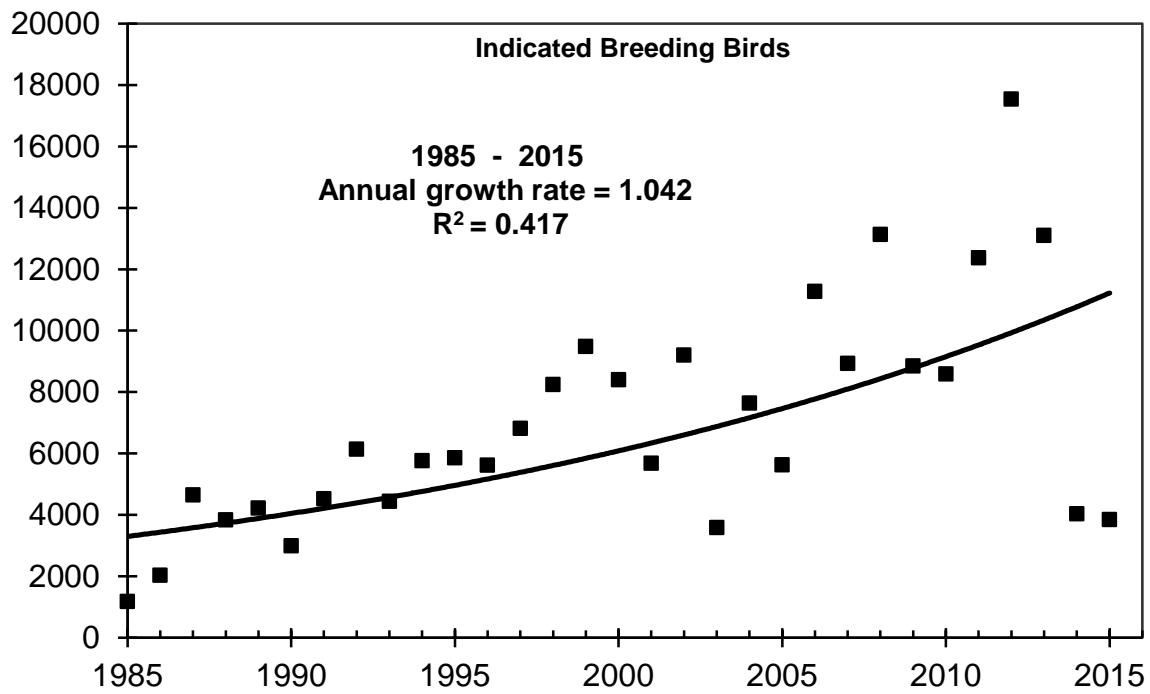
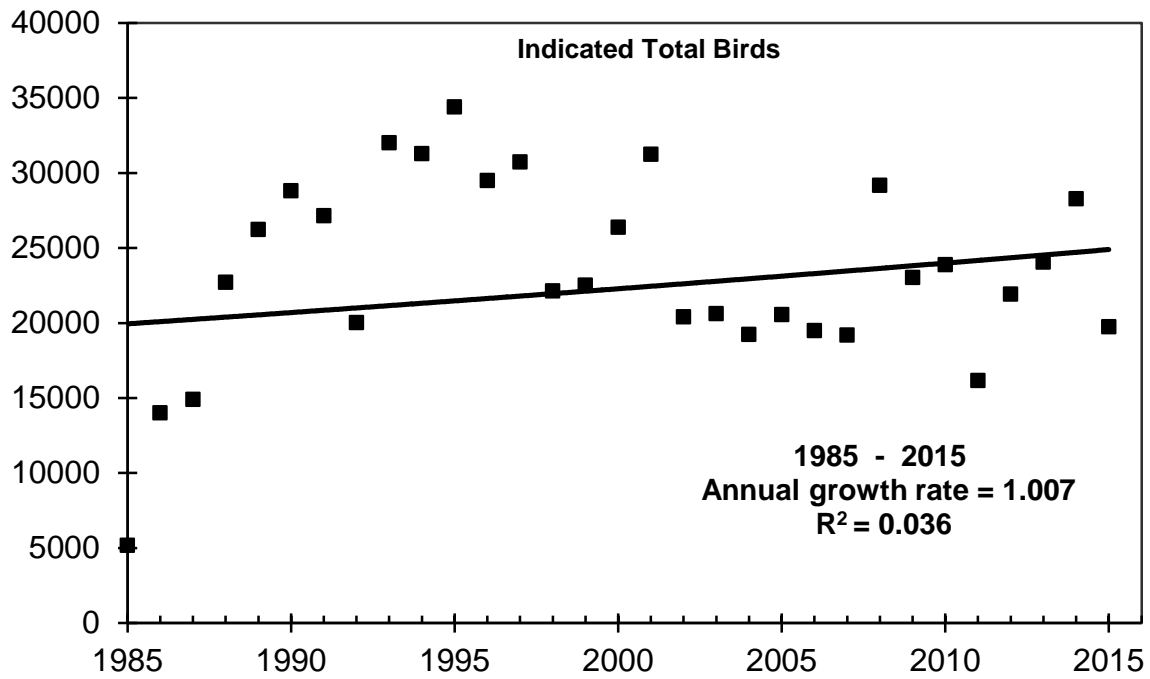


Figure 5. Population index growth curves and average annual growth rates from loglinear regression for black brant, 1985-2015.

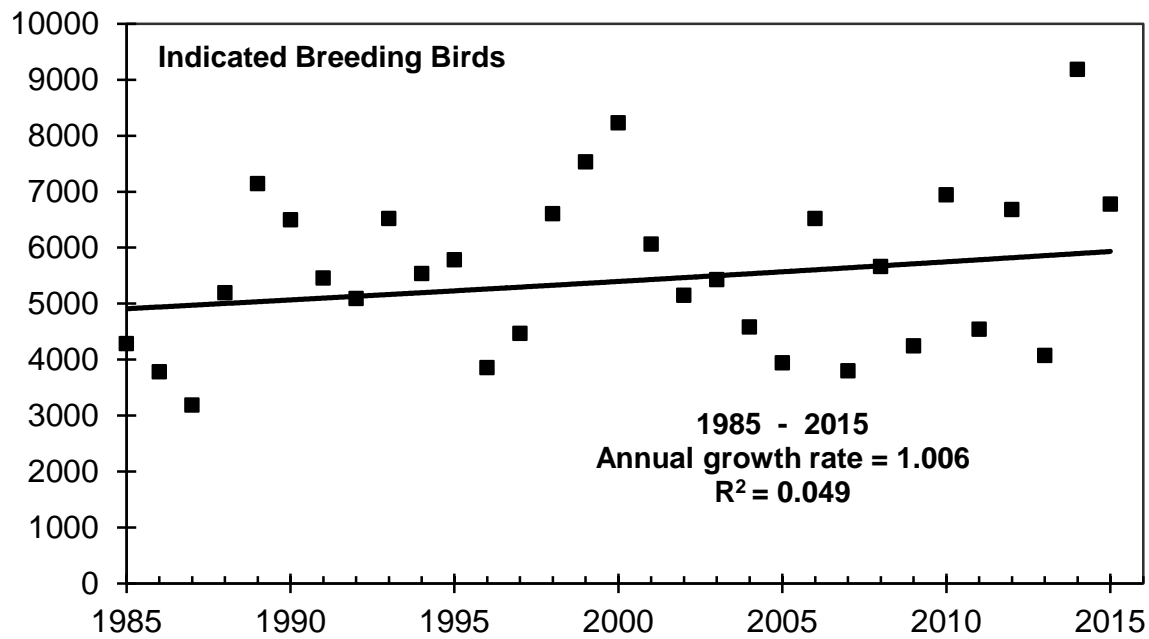
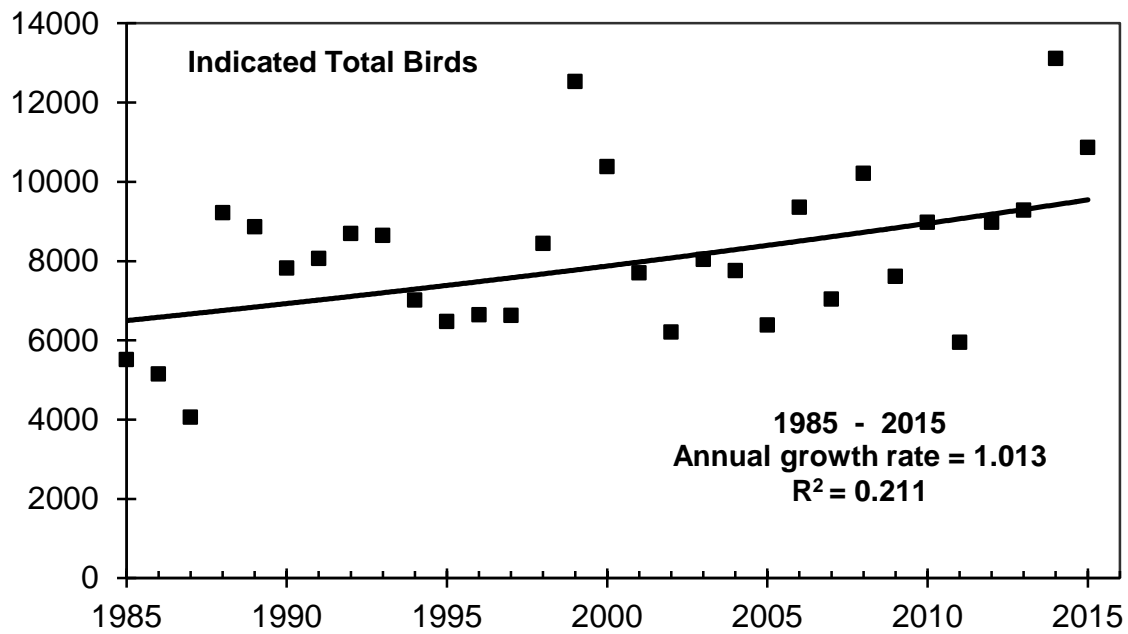


Figure 6. Population index growth curves and average annual growth rates from loglinear regression for Taverner's Canada goose, 1985-2015.

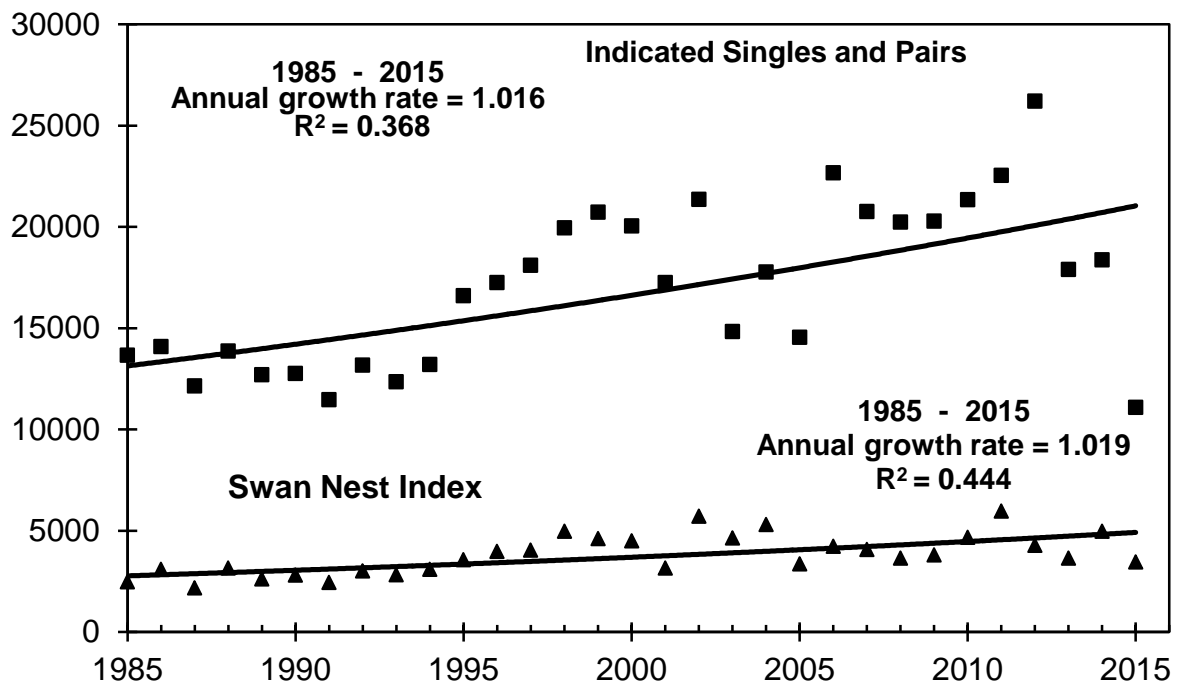
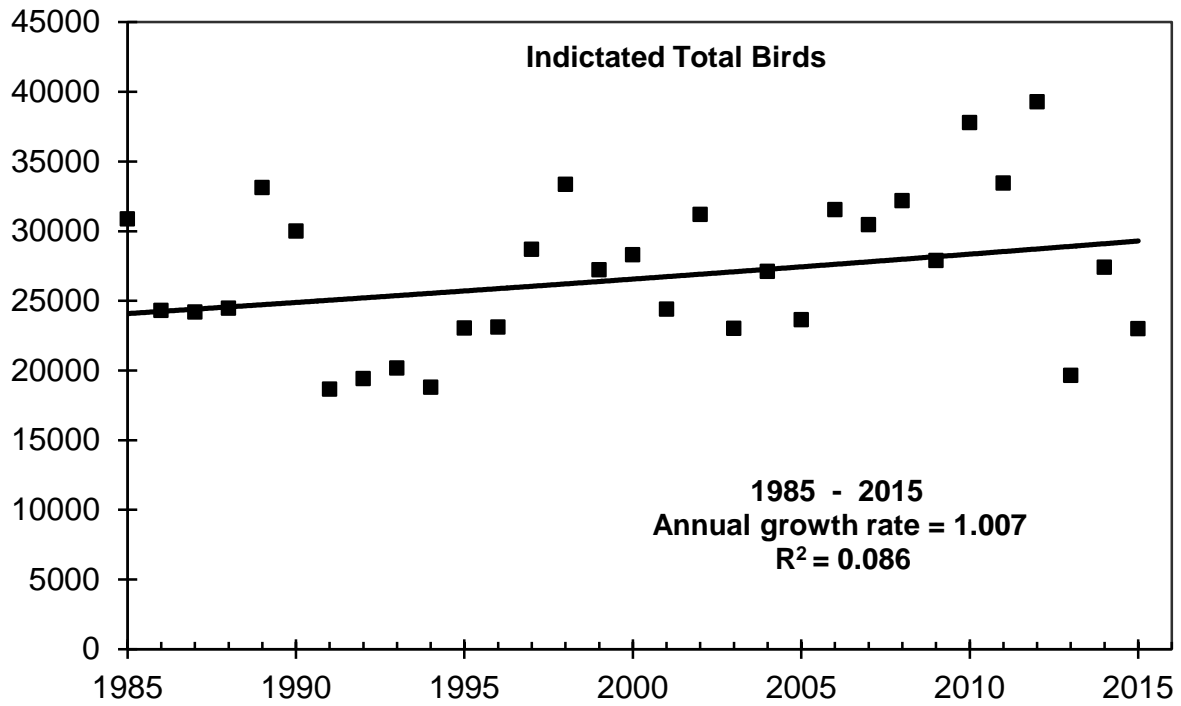


Figure 7. Population index growth curves and average annual growth rates from loglinear regression for Tundra Swans and nests, 1985-2015.

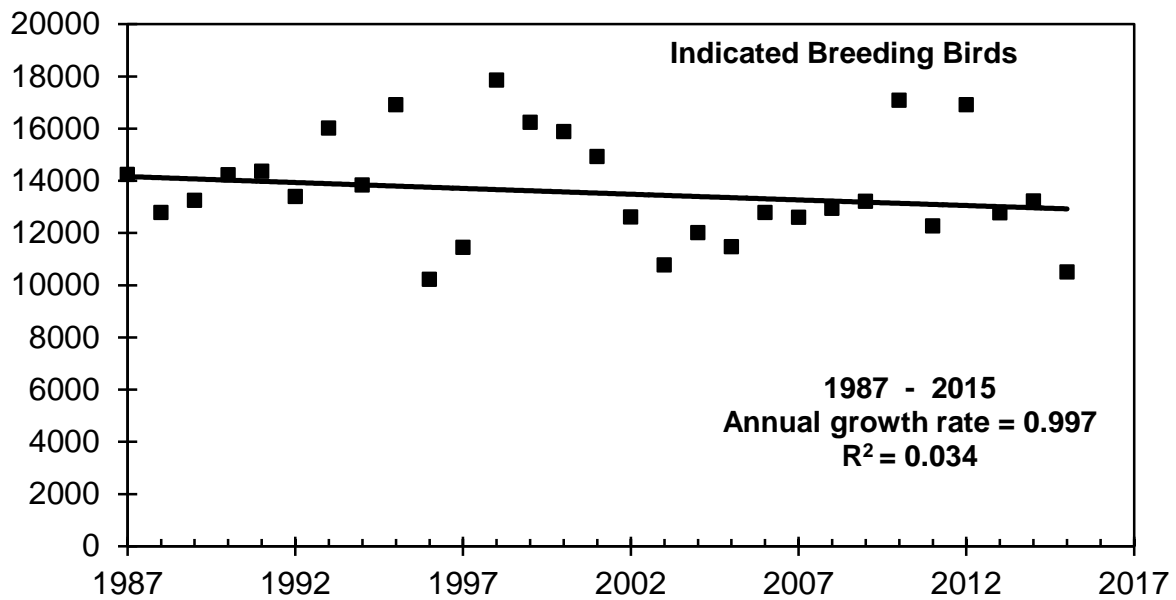
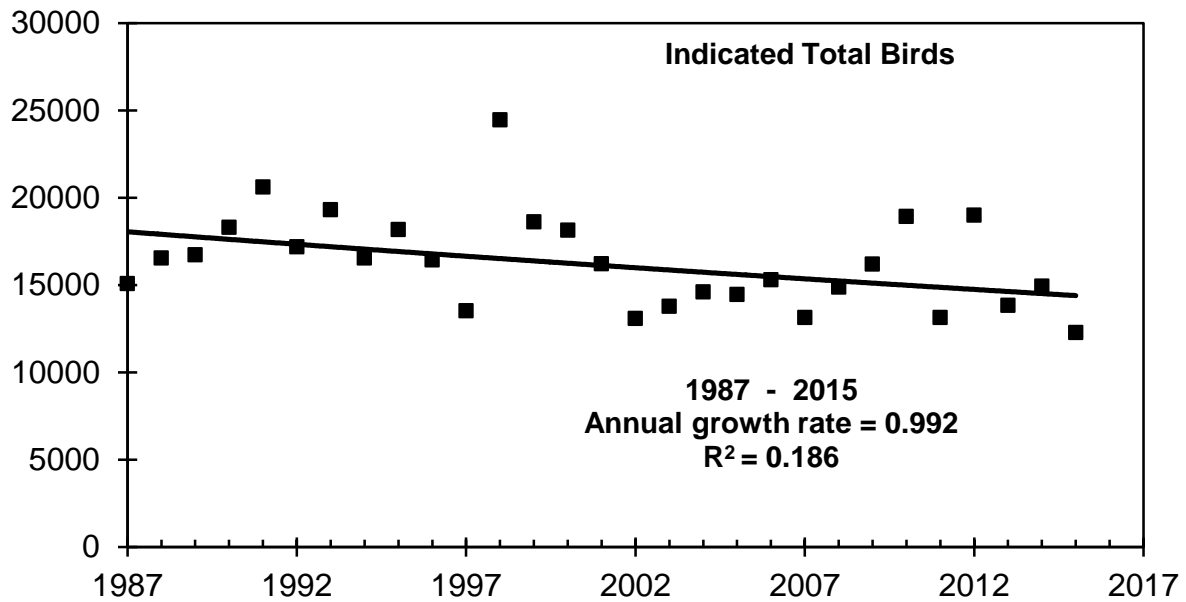


Figure 8. Population index growth curves and average annual growth rates from loglinear regression for Sandhill Cranes, 1987-2015.

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 running average is also presented.

Year	Total Indicated Birds ^a	Mark Resight Estimate	Fall Population Index - Adopted 2011	3-year Running 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
2012	60,395		202,323	219,298
2013	93,200		312,220	231,590
2014	83,970		281,300	265,281
2015	101,408		339,717	311,079

^a Total Indicated Birds (TIB) = 2 x (pairs + singles) + group birds Yukon-Kuskokwim Delta.

^b Fall Population Index = (TIB x 3.35)

Appendix 2. Indices of Pacific white-fronted geese as indicated breeding birds (IBB: 2 x singles + paired) and indicated total birds (ITB) from June aerial surveys of the Yukon-Kuskokwim Delta and Bristol Bay Lowlands.

	Yukon-Kuskokwim Delta		Yukon-Kuskokwim Interior		Bristol Bay		Yukon-Kuskokwim Total		All Pacific White-fronts	
Year	IBB	ITB	IBB	ITB	IBB	ITB	IBB	ITB	IBB	ITB
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
2012	97,654	181,519	23,380	47,250	1,045	3,744	121,034	228,769	122,079	232,513
2013	93,823	164,399	14,342	29,568	1,219	5,485	108,165	193,967	109,384	199,452
2014	86,079	205,081	9,823	16,503	348	348	95,902	221,584	96,250	221,932
2015	60,708	140,313	8,654	18,468	871	1,132	69,362	158,781	70,233	159,913

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	Fall Survey	Fall	3-year Average
	Indicated Birds ^a		Population Index ^b	
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
2012	232,513		664,201	639,437
2013	199,452		579,902	616,124
2014	221,932		637,221	627,108
2015	159,913		479,085	565,403

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

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