FWS/MBM

Memorandum

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

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

Through: Chief, Migratory Bird Management - Region 7

Subject: 2014 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 2-8 June 2014, representing the 30th 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 2014. 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. In surveys 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. During 2012 and 2013, only the front right-seat observer recorded observations of geese, swans, and cranes that were used for analysis. Personnel for the survey for 2014 were:

1) John Hodges, USFWS-MBM (retired) served as front right-seat observer counting all geese, swans, and cranes; 2) Anna Anderson served as pilot-biologist and recorded observations as a first time observer; and 3) Bob Platte, USFWS-MBM served as rear right-seat observer, counting other water bird species including ducks, loons, gulls, terns, and jaegers. Those results will be presented in a separate report. The front right-seat and rear right-seat observers have 5 and 24 years' experience in conducting this survey, respectively. With programs 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 are calculated for the following species or groups of species as follows:

All Geese and Sandhill Cranes

indicated breeding birds = 2 x (singles + pairs [a])
indicated total birds = 2 x (singles + pairs) + birds in flocks

Tundra Swans

total birds = singles + (2 x pairs) + birds in flocks
singles and pairs = singles + (2 x pairs)
nests = number of active nests observed

[a] *pairs = 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). 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. Indices for both indicated breeding birds and indicated total birds were recalculated for the entire history of the survey to reflect the new 4+1 stratification design.

The survey design was standardized in 1998 after slight changes were made over the years in the number and placement of transects. Beginning that year, the survey used a stratified sampling design with four sampling intensities related to goose densities with 1.6 km (1 mi) intervals between transects in higher goose density areas and 3.2 km (2 mi), 6.4 km (4 mi) and 12.9 km (8 mi) intervals in successively less dense areas (Fig. 1). Transects were systematically placed in an east-west orientation from a randomly selected starting point. To obtain optimal distribution data and more complete coverage, four sets of unique transect lines were drawn. During the four-year survey rotation of these unique sets, nearly complete coverage of 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; and 2006-2009, the third complete four-year rotation. The year 2014 represents the first year of the fifth, four-year rotation. These same transects were flown in the years 2002, 2006, and 2010. All of the 110 transects designed for this survey were flown in 2014 and totaled 2,515 km linear distance resulting in a sample percentage of 3.9%.

RESULTS

We intended to begin the survey on 28 May 2014 due to a very early spring breakup; however, we were unable to get the survey aircraft to Bethel until 2 June 2014 due to weather. We also began the survey on 2 June 2014. The tundra was completely snow-free and ponds and marshes were mostly 100% ice-free. There was no indication of any flooding on the survey area. Visibility and wind conditions were good throughout the survey.

The variation in survey timing relative to nesting phenology 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. Differences in nesting success could also complicate this relationship because predation increases the number of birds seen in flocks due to failed breeding attempts. We also do not know the impact of late springs on bird behavior related to nesting, such as percentage that don't nest or flocking behavior.

Cackling Canada Geese

In 2014, the indicated total birds for cackling geese was estimated to be 83,970 ± 4,225 [SE]; and indicated breeding birds, 55,733 ± 2,736 on the Yukon-Kuskokwim Delta breeding grounds. These indices represent decreases of 9.9% and 17.2% from the 2013 indices, respectively (Tables 1, 2, 6). Different growth rates were calculated for the time period when cackler numbers were rapidly increasing (1985-1997) versus the time period when the population appears to have stabilized (1998-2014). From 1985-1997, indicated total birds and indicated breeding birds growth rates were 1.173 and 1.146, respectively. However, for the last 17 years (1998-2014), indicated total birds and indicated breeding birds annual growth rates were 1.010 and 1.012, respectively, suggesting a stabilizing population (Fig. 2).

In March 2011, the Pacific Flyway Council adopted a new method for estimating the fall population index of cackling geese, after assessment of alternative methods by the U.S. Fish and Wildlife Service, Migratory Bird Management Office - Alaska (Stehn 2011). The original method, used to predict the fall population from 1998-2010, relied on a simple linear relationship between indicated total birds on the Yukon-Kuskokwim Delta breeding grounds (i.e., this aerial survey) regressed on the 1985-1998 fall coordinated count data (Pacific Flyway Council 1999). The new adopted method 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 data to estimate a fall population size. 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. The 2014 cackler population index is 281,300 birds and the 3-year (2012-2014) average is 265,281 birds (Appendix 1). These estimates are 10% below and 15% above, respectively, those reported in 2013.

Pacific White-fronted Geese

In 2014, the Pacific white-fronted goose indicated total birds index was 205,081 ± 31,834 and indicated breeding bird index, 86,079 ± 12,013. The indicated total birds index and the indicated breeding birds index were 24.7% higher and 8.3% lower, respectively, than those of 2013 possibly due to the late timing of the survey relative to the early spring phenology (Tables 1, 2, 6). The average annual growth rate for indicated total birds for the first 22 years of the survey (1985-2006) measured 1.105 as compared to 1.020 for the last 8 years of the survey (2007-2014) (Fig. 3). The average annual growth rate for indicated breeding birds for the years 2001-2014 measured 1.050 (Fig. 4).

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, 2014)) and counts from the fall survey (1985-1998). The 2014 fall estimate (637,221 birds) and the 3-year average (627,108 birds) were the third and second highest recorded, respectively (Appendix 3). These estimates were 10% and 20% higher, respectively, than those reported in 2013.

Emperor Geese

The 2014 emperor goose indices for indicated total birds (32,550 ± 2,973) and indicated breeding birds (16,188 ± 1,132) were 9.1% higher and 16.4% lower than the respective 2013 indices. However, confidence intervals overlap for indicated breeding birds (Tables 1, 2, 6) indicating no significant change in this index. From 1985-2014, the average annual population growth rate for indicated total birds was 1.018 and for indicated breeding birds, 1.025 (Fig. 5).

Black Brant

This Yukon Delta Coastal Breeding Waterfowl Survey was not specifically designed to assess the population of colonial nesting species, such as Pacific black brant. However, we believe that these survey data are useful in assessing the general population trends and distribution.

The 2014 indicated total birds index (28,283) was 17.8% higher than the 2013 index and the 2014 indicated breeding birds index (4,040) was 69.2% lower than the 2013 index (Tables 3, 6). The apparent decline of singles and pairs relative to 2013 may have been due to the way the observer grouped large numbers of brant standing on the ground or may indicate that fewer brant attempted to nest. Average annual growth rates for indicated total birds and indicated breeding birds were 1.009 and 1.049, respectively (Fig. 6).

Taverner's Canada Geese

This subspecies is found primarily interior to the coastal zone surveyed, but some overlap occurs on the eastern, northern, and southern portions of the survey area. Lines have been established to categorize Canada goose observations as either cacklers or Taverner's for population indices. In 2014, the indicated total birds index (13,115) and the indicated breeding birds index (9,183) were 26.9% higher and 125.5% higher, respectively, than in 2013 (Tables 3, 6). Average annual growth rates measured 1.012 and 1.005 for indicated total birds and indicated breeding birds, respectively (Fig. 7).

Tundra Swans

All swan indices were higher in 2014 compared to 2013. Total birds (27,413) were 33.1% higher; singles and pairs (18,367), 2.6% higher; and the nest index (4,965), 27.7% higher (Tables 4, 6). Average annual growth rates for total birds, singles and pairs, and nests were positive (1.008, 1.020, and 1.021 respectively) (Fig. 8).

Sandhill Cranes

In 2014, the indices for indicated total birds (14,925) and for indicated breeding birds (13,220) were 1.6% and 3.5% higher than the respective 2013 indices (Tables 5, 6). Average annual growth rates for both indicated total birds and indicated breeding birds were 0.993 and 0.998, 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, trends in population numbers represent more useful information than the results of each individual year.

Nesting phenology and bird behavior

In contrast to the last 2 years, spring was very early in southwest Alaska in 2014. We were unable to begin the survey as early as we would have liked in order to maintain consistent timing relative to phenology. Total bird indices for white-fronted geese, emperor geese, and brant were higher than 2013 but lower for cackling Canada geese. Pair indices for these 4 species were all lower than in 2013, suggesting that the survey was flown late in the spring, relative to other years.

Survey sampling intensity

In 2012 and 2013, the survey was flown with only one observer, sitting in the right front seat. This results in a sampling effort of 50% of all previous years and increases confidence intervals. Total sampling percentage of the survey area falls below 5% with only one observer as opposed to two observers. We recommend evaluating the one-observer sampling effort compared to two observers. The 2014 survey pilot-biologist flew the survey for the first time and practiced recording data that was not used for analysis except on Transect 71 to replace data missing from the right front seat observer.

Observer variability

A potential problem results from determining which birds are in or out of the 200m transect. Most geese, probably 80% or more, respond to the plane by flying at its approach and continuing flight away from the transect line on a 90° angle. Reaction to the aircraft sometimes occurs at a distance of up to a mile away. By the time the aircraft is opposite these geese, the observer must subjectively determine if these geese were originally within the 200 m transect width or not when they began flight. To minimizing observer variability we recommend the Service: 1) increase training for new observers; 2) keep 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

The Yukon Delta National Wildlife Refuge-USFWS provided logistical support. We thank Charles Rodgers, Aircraft Mechanic – YDNWR, for providing valuable hangar and aircraft support.

LITERATURE CITED

Butler, W.I. 1988. Relative abundance and distribution of geese, swans and sandhill cranes on the coastal zone of the Yukon-Kuskokwim Delta. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management. 1011 E. Tudor Rd, Anchorage, Alaska. U.S. Fish and Wildlife Service, Migratory Bird Management, Juneau, Alaska.

Department of the Interior. 2010. Federal Register Vol. 75. No 39. Part II, 50 CFR Parts 10 and 21, General Provisions, Migratory Birds Revised List and Permits; Final Rules. 34pp.

Groves, D.J. and Shults, B., 2014. Alaska-Yukon waterfowl breeding population survey. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 3000 Vintage Blvd, Suite 240 Juneau, Alaska 99801, Alaska. In prep.

Pacific Flyway Council. 1999. Pacific Flyway management plan for the cackling Canada goose. Unpubl. Report. Cackling Canada Goose Subcommittee, Pacific Flyway Study Comm., USFWS, Portland, Oregon. 36 pp. + appendices.

Stehn, R., 2011. Monitoring the population of cackling geese. Interim report for the Pacific Flyway Study Committee. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, 1011 E. Tudor Road, Anchorage, Alaska.

U.S. Fish and Wildlife Service and Canadian Wildlife Service. 1987. Standard operating procedures for aerial waterfowl breeding ground population and habitat surveys. Unpubl. manual as revised, U.S. Fish and Wildlife Service, Laurel, Maryland.

Table 1. Indicated total[a] population indices for cackling Canada, emperor, and white-fronted geese on the Yukon-Kuskokwim Delta, 1985-2014.

	Cackling Canada Geese		White-fronted Geese		Emperor Geese	
Year	**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**

[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, 1985-2014.

	Cackling Canada Geese		White-fronted Geese		Emperor Geese	
Year	**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**

[a] Indicated pairs = 2 x (singles + pairs)

Table 3. Indicated pair and total population indices for black brant and Taverner's Canada geese on the Yukon-Kuskokwim Delta, 1985-2014.

	Black Brant			Taverner's Canada Geese	
Year	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
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**

[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, 1985-2014.

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
2012	26,201	39,291	4,275
2013	17,900	19,635	3,643
2014	**18,367**	**27,413**	**4,965**

[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, 1987-2014.

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
2011	12,264	13,138
2012	16,916	18,990
2013	12,771	13,830
2014	**13,220**	**14,925**

[a] Indicated Pairs = 2 x (singles + pairs)

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

Table 6. Comparison of 2014 indicated total birds, indicated pairs, and tundra swan nests with 2013 numbers and with the 29-year, 25-year, and 10-year means for all species surveyed.

	CCGO	WFGO	EMGO	BLBR	TCGO	TUSW	SACR [a]	TUNE
Indicated Total Birds								
2012	60,395	181,519	20,388	21,912	8,980	39,291	18,990	4,275
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**
29-yr mean: 1985-2013	57,162	92,183	20,173	23,342	7,850	27,217	- - - -	3,786
25-yr mean: 1989-2013	63,434	103,923	20,935	24,805	8,149	27,419	16,582	3,956
10-yr mean: 2004-2013	70,473	153,428	22,652	21,670	8,155	30,299	15,346	4,299
% Change from 2013	-9.9	24.7	9.1	17.8	26.9	33.1	1.6	27.7
% Change: 25-yr mean	32.4	97.3	55.5	14.2	44.6	-4.7	-15.3	17.6
% Change: 10-yr mean	19.2	33.7	43.7	30.8	44.5	-13.7	-8.5	8.2
Rank - 30 yrs	4	1	1	9	2	17	22	6
Rank - 11 yrs	3	1	1	2	1	9	8	4
Annual Growth Rate			1.018	1.009	1.012	1.008	0.993	1.021
Growth Rate - Early [b]	1.173	1.105						
Growth Rate - Late [c]	1.010	1.020						
Indicated Pairs								
2012	51,729	97,654	17,207	17,541	6,680	26,201	16,916	
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**	
29-yr mean: 1985-2013	39,262	42,308	13,053	7,235	5,406	17,232	- - - -	
25-yr mean: 1989-2013	43,474	47,642	13,744	7,924	5,613	17,838	13,839	
10-yr mean: 2004-2013	49,995	73,082	15,601	10,709	5,099	20,422	13,206	
% Change from 2013	-17.2	-8.3	-16.4	-69.2	125.5	2.6	3.5	
% Change: 25-yr mean	28.2	80.7	17.8	-49.0	63.6	3.0	-4.5	
% Change: 10-yr mean	11.5	17.8	3.8	-62.3	80.1	-10.1	0.1	
Rank - 30 yrs	2	3	6	25	1	12	15	
Rank - 11 yrs	2	3	4	11	1	8	3	
Annual Growth Rate			1.025	1.049	1.005	1.020	0.998	
Growth Rate - Early [d]	1.146	1.131						
Growth Rate - Late [e]	1.012	1.050						

[a] Sandhill Crane - rank for 28-year interval.

[b] 1985 - 1997 Cackling Canada geese, 1985 - 2006 White-fronted geese

[c] 1998 - 2014 Cackling Canada geese, 2007 - 2014 White-fronted geese

[d] 1985 - 2000 White-fronted geese

[e] 2001 - 2014 White-fronted geese

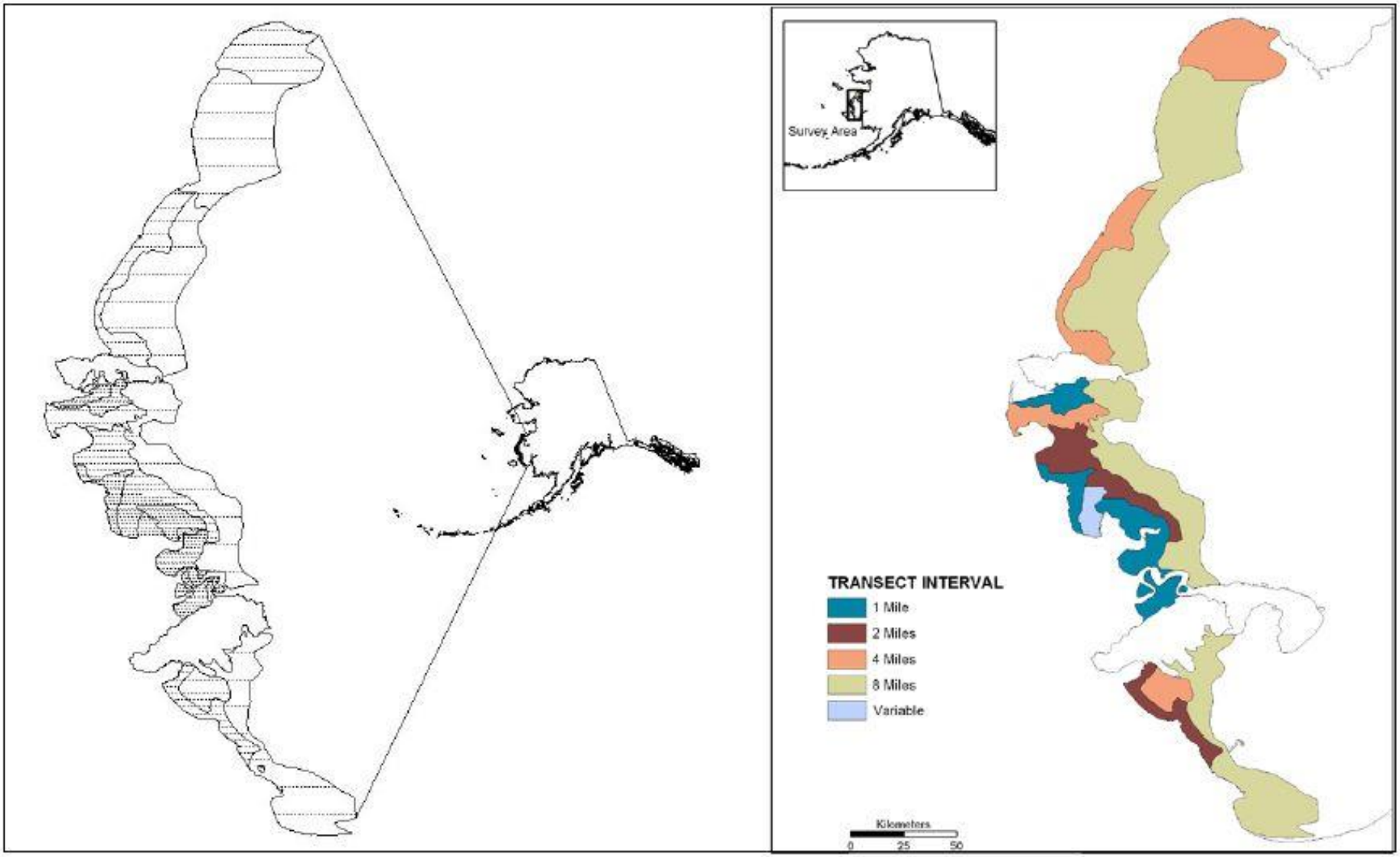

Figure 1. Flight lines (left side) and current 4-strata design (right side) for Yukon Delta aerial surveys.

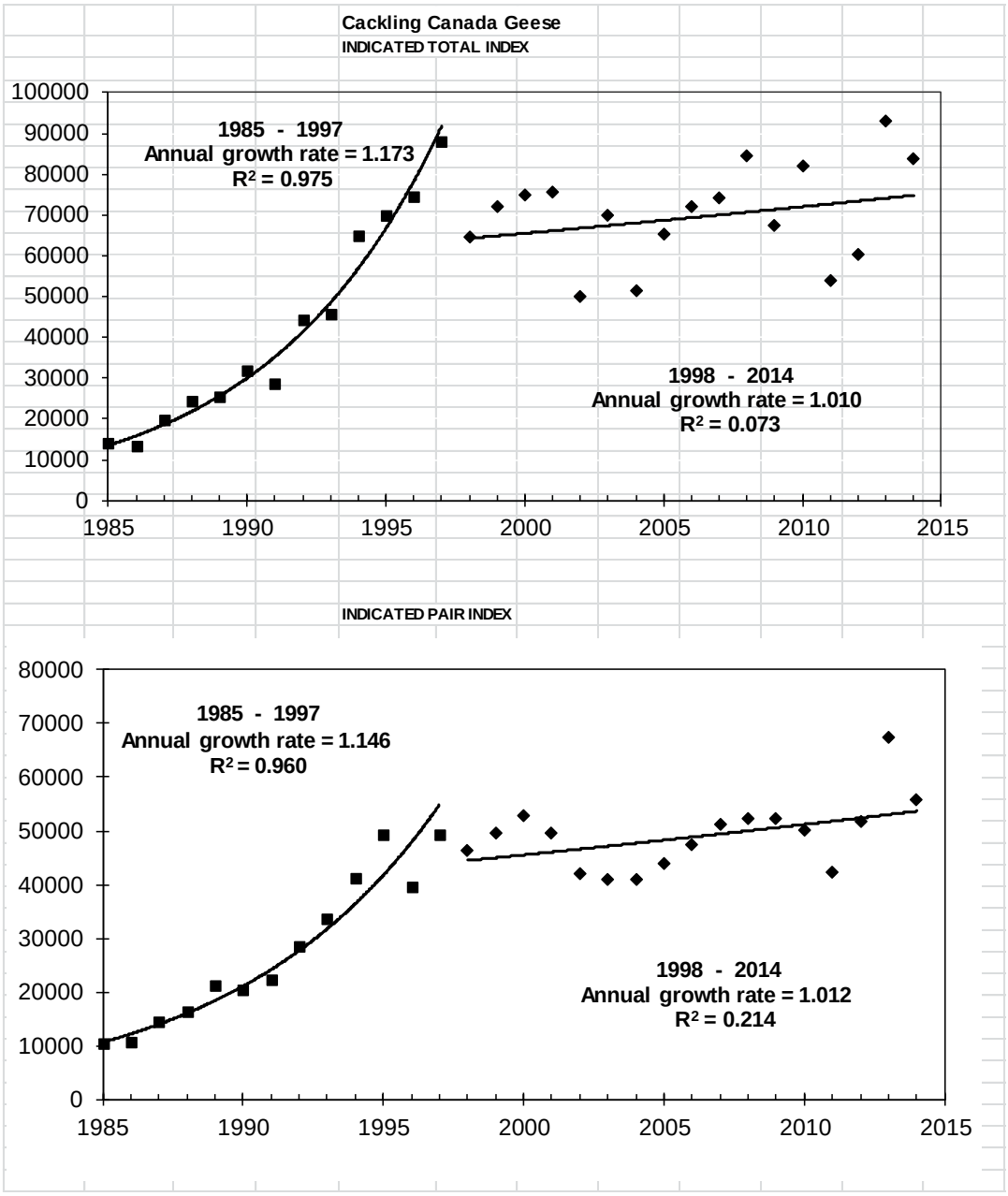

Figure 2. Population index growth curves and average annual growth rates from loglinear regression for cackling Canada geese, for the first 13 years (1985-1997) and the last 17 years (1998-2014).

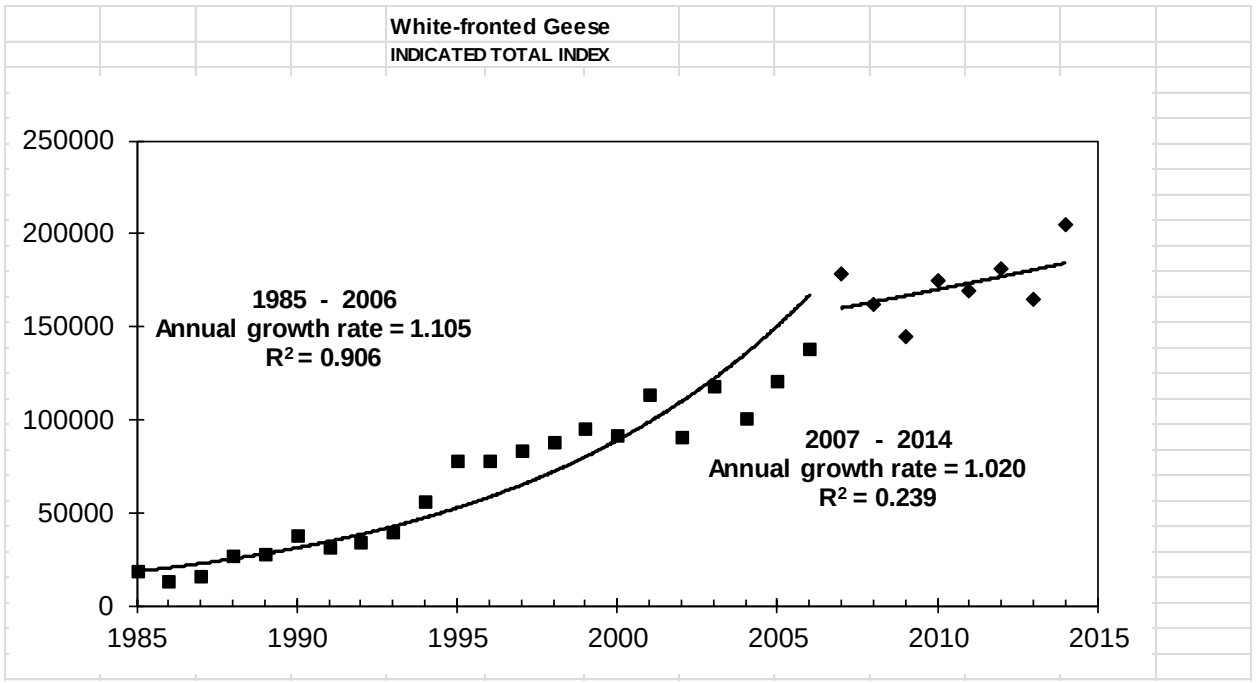

Figure 3. Indicated total population index growth curves and average annual growth from log-linear regression for white-fronted geese based on the first 22 years (1985-2006) and the last 8 years (2007-2014).

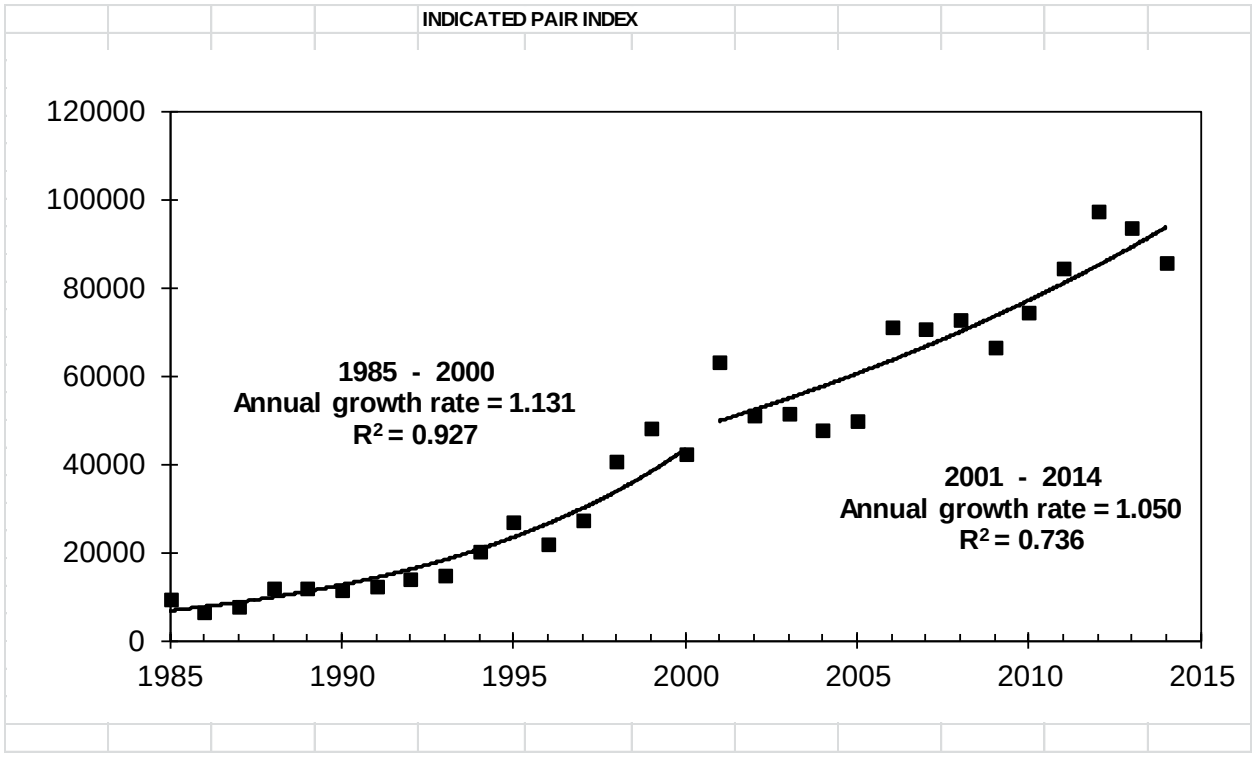

Figure 4. Indicated pairs index growth curve and average annual growth rate from log-linear regression for white-fronted geese, 1985-2014.

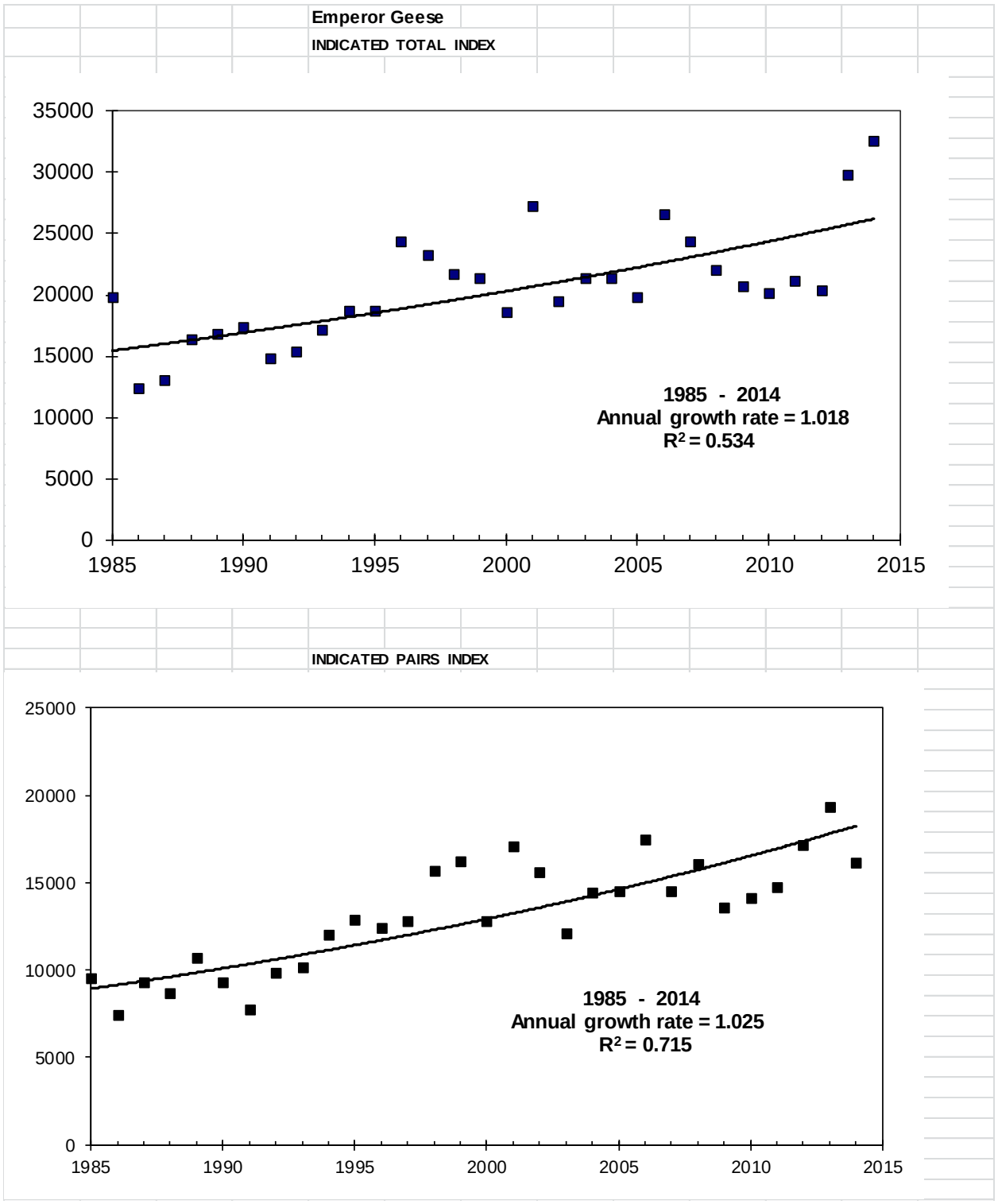

Figure 5. Population index growth curves and average annual growth rates from log-linear regression for emperor geese, 1985-2014.

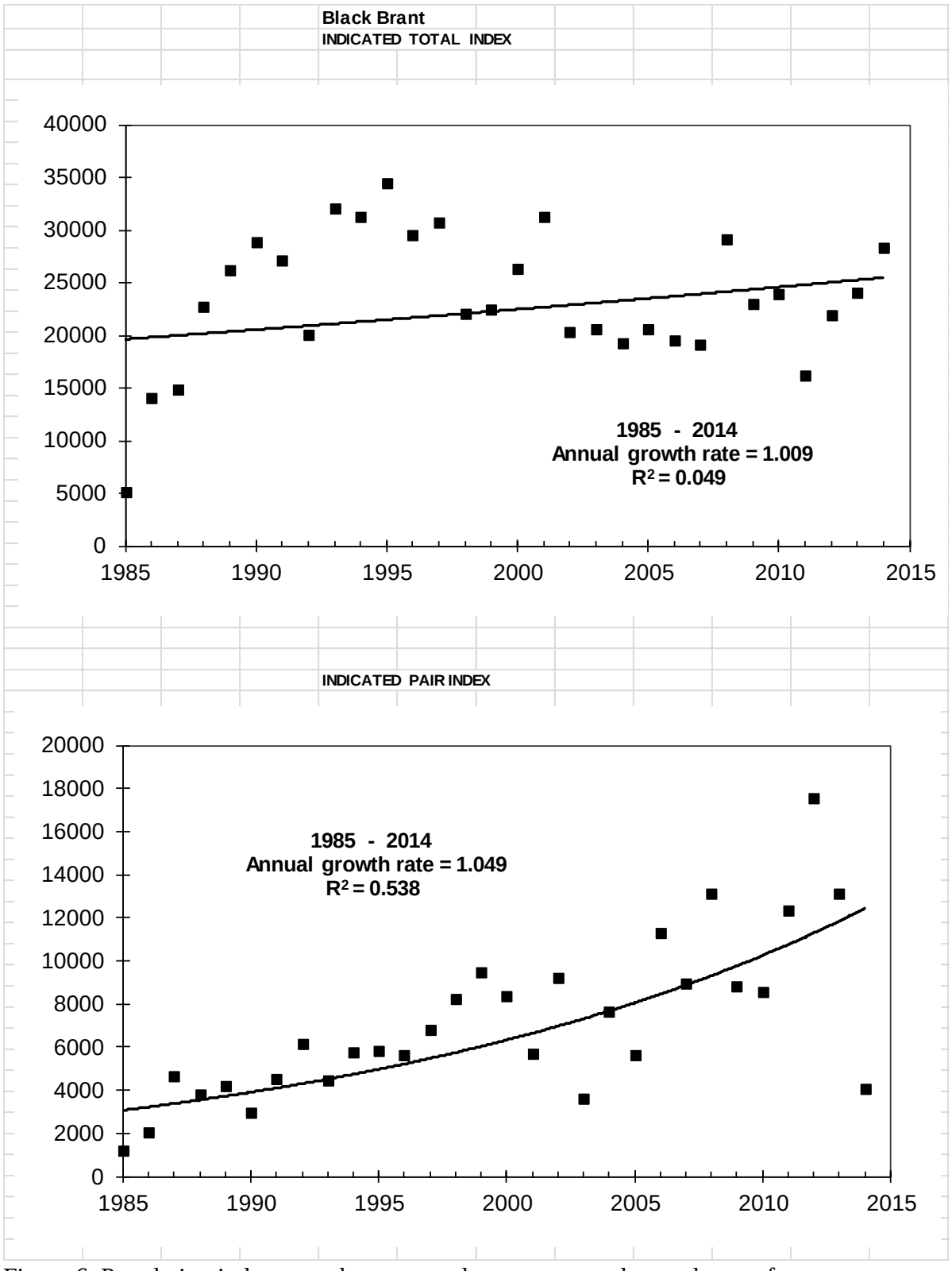

Figure 6. Population index growth curves and average annual growth rates from log-linear regression for black brant, 1985-2014.

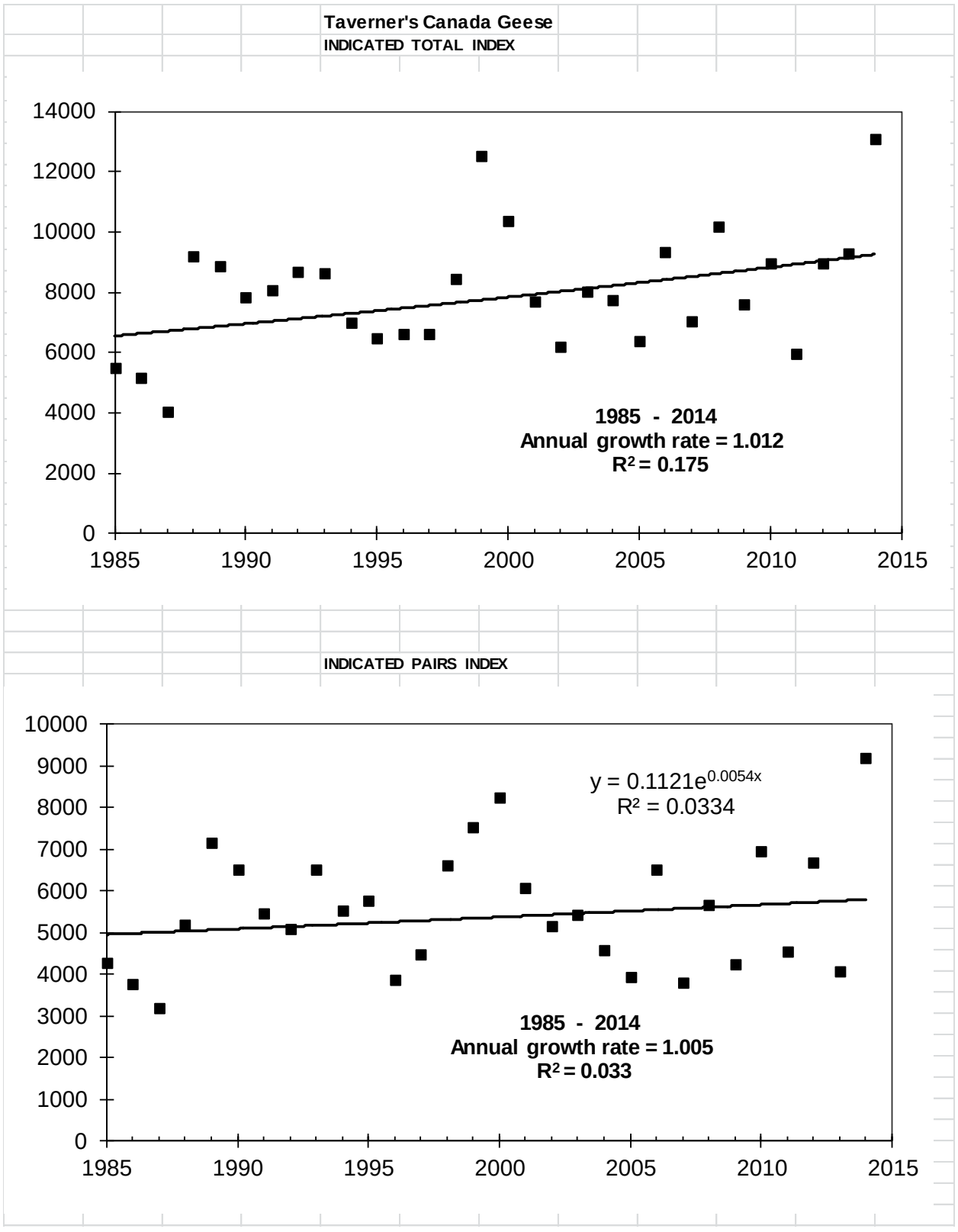

Figure 7. Population index growth curves and average annual growth rates from log-linear regression for Taverner's Canada geese, 1985-2014.

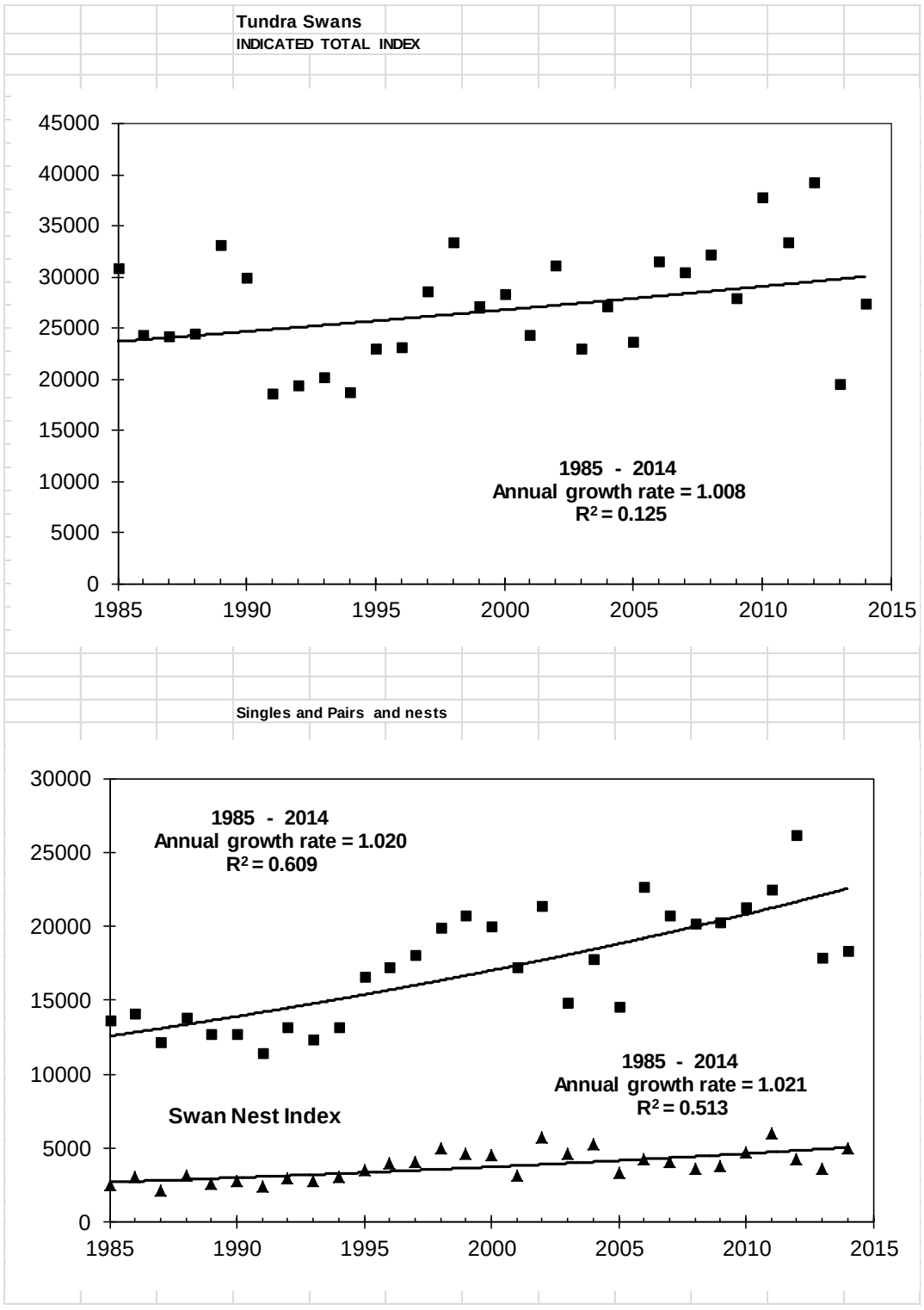

Figure 8. Population index growth curves and average annual growth rates from log-linear regression for tundra swans, 1985-2014.

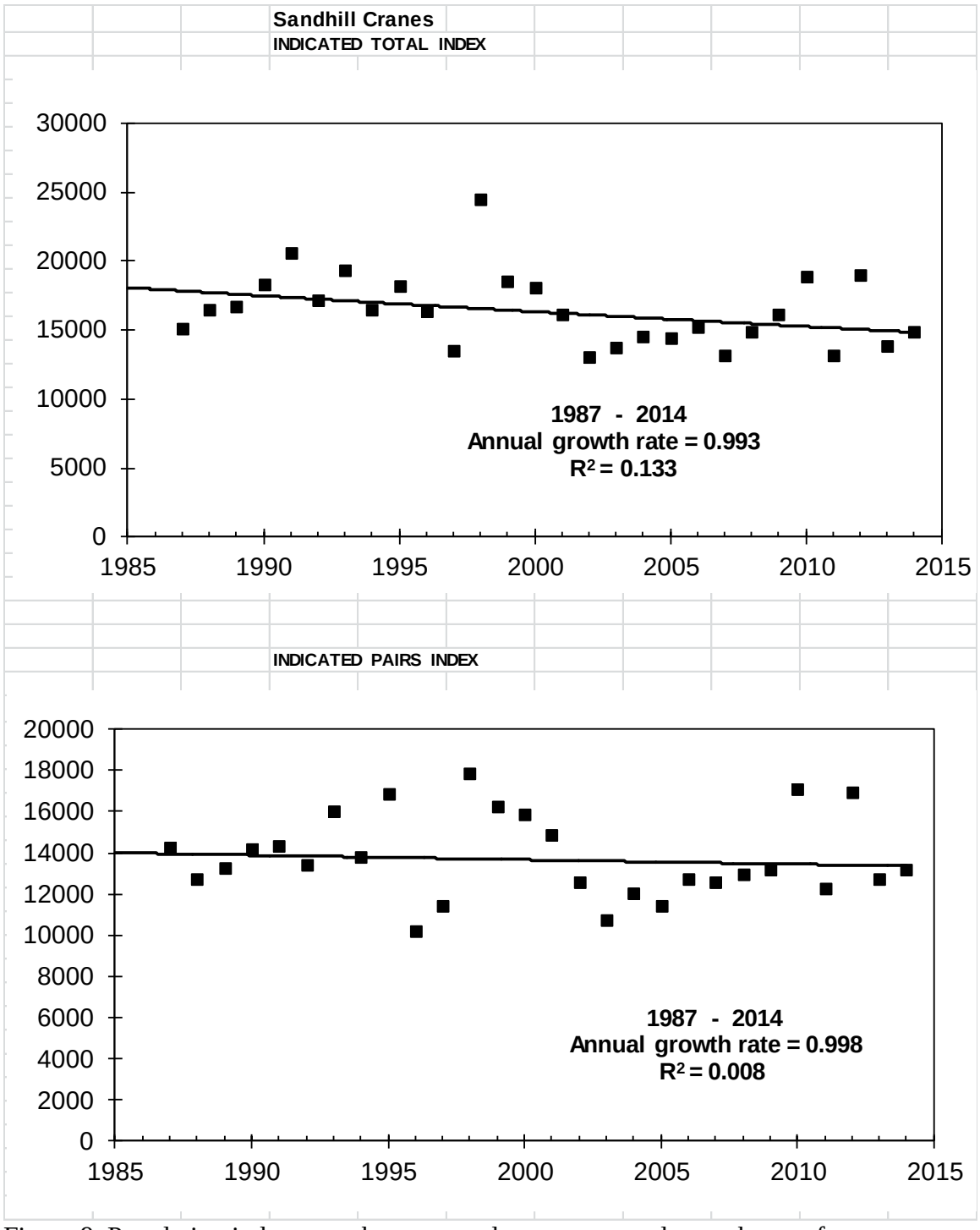

Figure 9. Population index growth curves and average annual growth rates from log-linear regression for sandhill cranes, 1987-2014.

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**

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

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

Year	Total Indicated Birds [a]	Fall Survey	Fall Population Index [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
2012	232,513		664,201	639,437
2013	199,452		579,902	616,124
2014	**221,932**		**637,221**	**627,108**

[a] Total Inidcated Birds = 2 x (pairs + singles) + group birds - Pacific Flyway - Yukon-Kuskokwim Delta and Bristol Bay.

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