POPULATION INDICES, TRENDS AND DISTRIBUTION OF GEESE, SWANS AND CRANES ON THE YUKON-KUSKOKWIM DELTA FROM AERIAL SURVEYS, 1985-2002

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Population Indices, Trends and Distribution of Geese, Swans and Cranes on the Yukon-Kuskokwim Delta from Aerial Surveys, 1985-2002

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Abstract: An aerial breeding survey of swans, geese and cranes was conducted for the 18th consecutive year from 30 May-7 June 2002. Spring conditions were relatively normal and nesting habitat was available much earlier than 2001. Indicated total bird and indicated singles and pairs population indices for greater white-fronted, emperor and cackling Canada geese were lower than in 2001 but similar to other recent years and all indices indicated positive population trends. The indicated pairs index for black brant was the highest recorded since 1985, but the indicated total bird index showed no trend with variable data. Indices for Taverner's Canada geese were similar to recent years but data were highly variable. Population indices for tundra swan singles and pairs, nests and total birds were among the highest recorded since 1985 and trends were positive. The indicated total index for sandhill cranes was the lowest recorded since 1985 but data are highly variable. Growth trend graphs are provided for all species and indices. Contour maps of indicated pair densities are provided for cackling Canada, emperor and greater white-fronted geese from combined data 1998-2001, and point location maps of 2002 observations are provided for black brant, Taverner's Canada geese, tundra swans and sandhill cranes.

Key Words: aerial breeding bird survey, Yukon Delta coast, population indices, swans, geese, cranes **April, 2003**

INTRODUCTION

Intensive aerial surveys to monitor goose populations in the coastal zone of the Yukon-Kuskokwim Delta (YKD)(Fig. 1) were developed in 1985 (Butler 1988) in response to concerns over declining populations of four goose species in the Pacific Flyway (Raveling 1984, King and Derksen 1986). The coastal zone is higher density goose nesting habitat and existing surveys did not sufficiently sample this area to accurately monitor local population trends. This survey was modified over time and is now standardized to produce annual breeding population index estimates for cackling Canada geese (*Branta canadensis minima*), emperor geese (*Chen canagica)*, Greater white-fronted geese (*Anser albifrons frontalis*), black brant *(B. bernicla nigricans*), Taverner's Canada geese (*B. c. taverneri*), tundra swans (*Cygnus columbianus*) and sandhill cranes (*Grus canadensis*). Observations of other waterbirds were collected by a rear-seat observer and are presented elsewhere (Platte and Stehn 2003). The 2002 survey was the 18th annual survey.

STUDY AREA:

The 12,852 km^2 study area is located along the coast of the YKD National Wildlife Refuge in southwestern Alaska (Fig. 1). The coastal zone was selected because it comprised the highest density nesting habitat for species of concern, as well as a high proportion of the total nesting habitat for the target species, particularly cackling Canada and emperor geese. The study area consists of federally-owned lands, village and native corporation lands, and private in-holdings.

METHODS:

Survey Platform and Technique

A Cessna 206 on amphibious floats has been the survey platform for all years. Survey methodology followed U.S. Fish and Wildlife Service (USFWS) protocol for waterfowl breeding

pair surveys (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). A right front seat observer and the pilot counted geese, swans, cranes and spectacled eiders in a 200 m transect on each side of the plane, flying at an altitude of approximately 40 m and 160 km/hr. Since 1998 observations have been recorded directly into laptop computers using a program developed by John Hodges (USFWS, MBM, Region 7, Juneau). Each laptop was linked to the airplane Global Positioning System (GPS) so that each observation received a coordinate location. Prior to 1998 observations were recorded with cassette recorders on continuously running tapes (Butler et. al 1995) using either LoranC or GPS unit for navigation. The survey is generally conducted during the first 14 days of June and generally corresponds with early incubation.

Survey Design

The survey extended from the coast to approximately 50 km inland from Kuskokwim Bay in the south to Norton Sound in the north (Fig. 1). 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. The entire coastal zone was divided into 16 strata based on physiogeograhic regions determined from unclassified LANDSAT images (Butler 1988). The survey has been standardized with a 4-year rotation of flight lines so that near complete coverage of the 1.6 km interval zone is obtained with one 4-year rotation by moving transects 0.4 km each year. Transects are proportionately adjusted in the less intensively surveyed areas in each of the four years to obtain optimal coverage over the four year survey rotation. The survey was flown from 30 May to 7 June 2002, along 106 transects totaling 2,533 km which resulted in an approximate 8% sample of the study area.

Data Analysis

Population Indices

A data transcription program developed by John Hodges (USFWS, MBM, Region 7 Juneau) provides a coordinate location and time for each observation. Programs developed by Robert Stehn (USFWS, MBM, Region 7-Anchorage) allow interpolations of the geographic location along the flight line using elapsed time from start to end of transect and also analyze data using standard strip-census statistical techniques. The mean and variance of aerial observation densities were calculated as ratio estimates (Cochran 1977) where birds detected and area sampled were summed for all transect sections by stratum. Data from both left and right seat observer were combined. The mean density multiplied by the stratum area provided the population index for each stratum. The variance of the density was multiplied by the square of the stratum area, and population index and variance were summed across all strata.

To standardize reporting of survey results for geese we have adopted **new population indices** which alter numbers previously reported to the Pacific Flyway annual memos. Previously we have used the following two indices for total birds observed, and singles and pairs, calculated as follows:

Total Birds Observed = singles + (2 x pairs) + birds in flocks
Singles and Pairs = Number of single observations + number of paired observations

The new indices are calculated as follows:

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

The new indices are based on the assumption that a single goose observed represents a pair, with the unseen mate on a nest. Numbers of geese in all years were converted to the new indices for this report.

Population indices for tundra swans and sandhill cranes have historically been calculated differently than geese due to visibility differences from size and color. However, an evaluation of the existing indices for these species has resulted in the following changes:

The historic indices for tundra swans were:

Total Birds = singles + (2 x pairs) + birds in flocks
Pairs = Singles/2 + pairs
Nests = Number of active nests observed

The only change in **tundra swans** will be for Pairs, which will now be called Singles and Pairs and calculated as follows:

Singles and Pairs = singles + (2 x pairs)

The historic indices for sandhill cranes were calculated as follows:

Singles and Pairs = singles + pairs
Total Birds = singles + (2 x pairs) + birds in flocks

The new indices for **sandhill cranes** are calculated as follows

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

Changes in indices for tundra swans and sandhill cranes were made to reflect more realistic visibility characteristics and to standardize indices. Although larger, visibility of sandhill cranes is probably more similar to geese due to the coloration. We rarely see crane nests, and it is likely that an observation of a single represents a pair with an unseen mate on the nest.

GIS Methods

Goose observations from all years were generated as an ARC/INFO point coverage for use in a geographic information system (GIS). The point location data from 1998-2001, representing the first complete four-year rotation of survey transects, were converted to densities. A grid consisting of 1600 x 1600 m polygons was overlain on the 400 m wide flight line polygon strips and the point locations. Number of birds by species and area searched by the strip transects were summed for each square. The bird density for each square was calculated by dividing the sum of birds by the sum of the areas searched for all years. The resulting density values were assigned

to the centers of the squares. A triangulated irregular network (TIN) was created from the density points. The TIN was then converted to a lattice, which was then contoured. Density polygon classes were determined by using the Natural Breaks classification in Arcview of the contours and final density polygons were created from the lattice. The 1600m cell size was chosen because that size enabled inclusion of four strip transects (one for each year) in most cells in the 1mi intensity strata.

RESULTS

Population indices from the 2002 survey are compared to previous years in Tables 1-5 and Figures 2-8. Geographic distribution of observations of target species are presented in Figures 9-13.

Cackling Canada Geese

Both indices for cackling Canada geese dropped substantially in 2002 (Tables 1 and 2, Fig. 2). There was a dramatic decrease in numbers of nests in 2001 (Bowman et al. 2002) which resulted in poor production that may be reflected in the indices this year. Nest numbers rebounded to 2000 levels in 2002 (Bowman et al. 2002). While the all-year population growth rates for indicated total birds was positive, the 10-year growth rate was less and varied considerably (Fig. 2), indicating that this population may be reaching a plateau. An estimate of the fall population based on the 1985-98 correlation between indicated total bird index and fall count is listed in Appendix 1.

Density contours of indicated pairs of cackling Canada geese, from 1998-2001 combined data sets representing the first complete 4-year rotation of the standardized survey, are presented in Figure 9. Kigikik Island, the Naskonet Peninsula, and Kokechik Bay were consistently high density nesting areas for cackling Canada geese.

Emperor Geese

The emperor goose singles and pairs and total bird indices decreased from the high values of 2001 but were similar to years prior to 2001 (Tables 1 and 2, Fig. 3.). This decrease corresponded with a 30% decrease in 2002 from 2001 on the spring survey of the Alaska Peninsula (Dau and Mallek 2001, 2002). The decreases in emperor indices in 2002 were not reflected in the numbers of nests, which rebounded to 2000 levels from 2001 (Bowman et al. 2002). The increase may partially be explained by the extreme differences in nesting conditions between years or sampling error in nest plots. Decreases in both aerial indices from this survey as well as the spring Alaska Peninsula aerial emperor goose survey indicate that it is likely a real population decrease occurred. However, both 10-year and all-year population growth rates are slightly positive for both indices (Fig. 3).

Density contours of indicated pairs of emperor geese, from 1998-2001 combined data sets, are presented in Figure 10. The Naskonet Peninsula, Kigigik Island, and Kokechik Bay coastal marshes were higher density emperor goose nesting areas.

Greater White-fronted Geese

The singles and pairs and total bird indices for whitefronts were much lower in 2002 than 2001 but similar to recent years prior to 2001 (Tables 1 and 2, Fig. 4.). Both 10-year and all-year growth rates are positive for both indices, but the 10-year rate is lower and more variable (Fig.

4.). More years are needed to determine if this population is reaching a plateau. Nest numbers for whitefronts also rebounded from 2001, similar to other species, reflecting the better nesting conditions (Bowman et al. 2002).

Density contours of indicated pairs of white-fronted geese, from 1998-2001 combined data sets, are presented in Figure 11. White-fronted geese were more widely distributed than the other goose species in the study area and breed throughout the interior of the YKD and south to Bristol Bay. The higher density whitefront nesting areas within the coastal zone were generally interior to the other goose species, however, the coastline south of Nelson Island, the Naskonet Peninsula and Kokechik Bay were also higher density nesting areas.

Pacific Black Brant

This survey is not designed for colonial nesting species such as Pacific black brant however it provides useful information on distribution. Pacific black brant indices were reduced in 2002 from recent years (Table 3, Fig. 5.). The singles and pairs index indicates a more positive growth trend and Pacific black brant breeding numbers in major colonies are currently determined through aerial videography (Anthony 2003).

Point locations for Pacific black brant observations from the 2002 survey are presented in Figure 12. Readers are referred to Anthony (2002) for official colony census results, however, many brant observations occur outside of the main colony areas We are currently attempting to combine data from this survey with the aerial videography to obtain a YKD-wide population census, but results are not yet available.

Taverner's Canada Geese

This subspecies was found primarily interior to the coastal zone surveyed, but some overlap occurred on the eastern, northern and southern portions of the survey area. For these areas arbitrary lines were established to divide cackler and Taverner's observations for population index estimates. We realize some overlap between subspecies occurs but we do not consider it to be substantial or highly variable between years. Results for indicated total and indicated pairs indices are presented in Table 3 and Fig. 5. Point locations for observations of this species are presented in Fig. 12. Geographic boundaries and population indices for this subspecies are being re-evaluated.

Tundra Swans

Indices for tundra swan nests, singles and pairs, and total birds were substantially higher than 2001 and the highest recorded since 1985 (Table 4, Fig. 7.). Population trends for total birds is slightly positive with a weak correlation coefficient, but singles and pairs and nests have gradually increased since 1985 with stronger correlation coefficients (Fig. 7.). The number of active swan nests from random ground plots was also higher than 2001 (Bowman et al. 2002).

Point locations of tundra swan observations from the 2002 survey are presented in Figure 13. Breeding tundra swans are widely distributed but a higher proportion of flocked observations, which could be failed or non-breeders, occurs in the coastal habitat of Hazen Bay, which is also preferred goose habitat.

Sandhill Cranes

The indicated single and pairs and indicated total bird indices for sandhill cranes were the second lowest recorded since 1985 (Table 4, Fig. 8.). Population indices were highly variable for

this species and no definite trends were indicated since 1985 (Fig. 8.). Point locations of sandhill cranes observations from 2002 are presented in Figure 13 and indicated that cranes were widely but sparsely distributed throughout the study area.

DISCUSSION

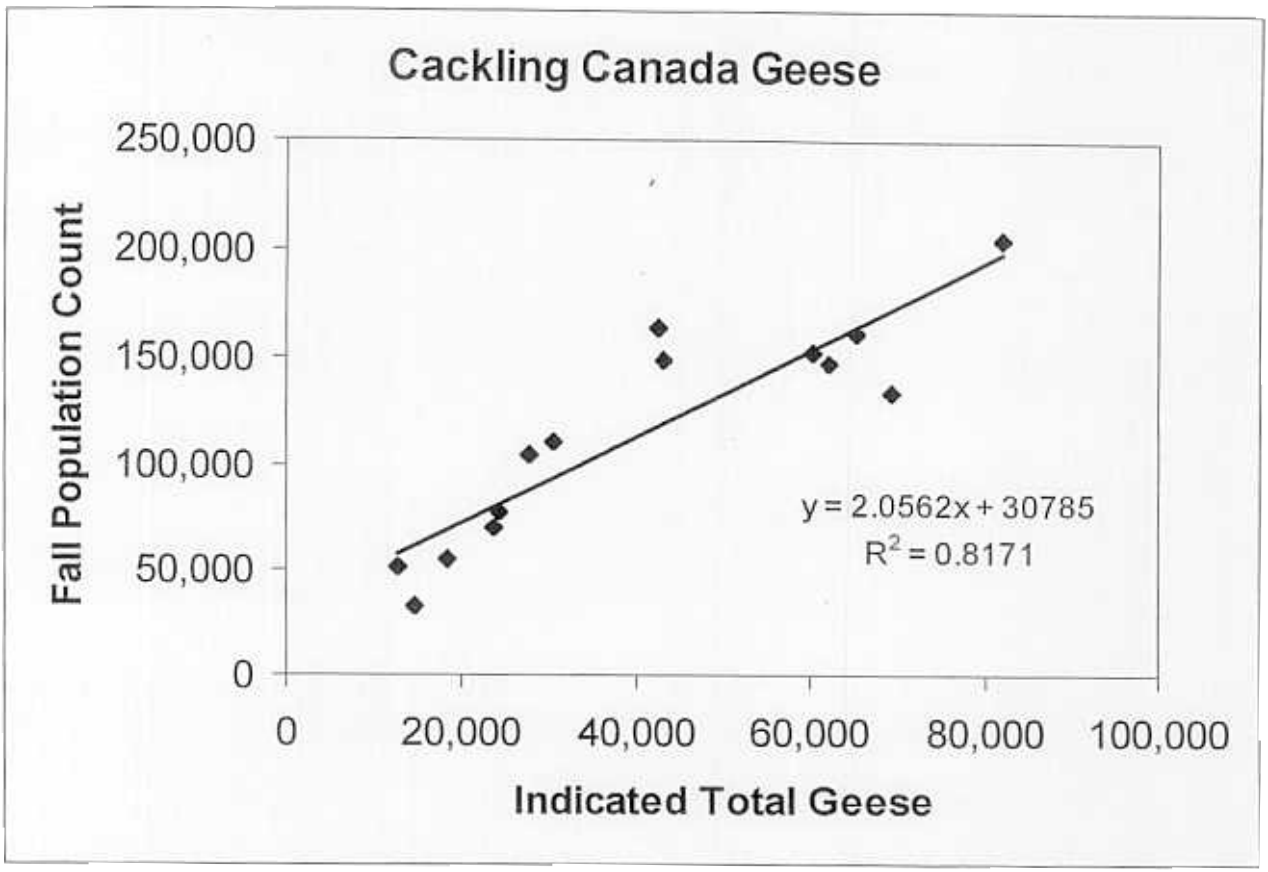
Generally, declines occurred from 2001 to 2002 in population indices for emperor, cackling Canada, and white-fronted geese. An explanation for these declines is likely due in part to poor production in 2001 combined with normal mortality. However, we believe that other factors may have played a role in the declines indicated. One factor is survey timing. It is possible that the 2002 survey was conducted phenologically earlier than other years, related to nesting but also perhaps to the arrival of non-breeding birds on the breeding grounds. We noticed more geese on the primary nesting areas during our second rotation of transects through these areas, approximately 4 to 5 days after the first pass through. An analysis of populations using just the latter transects also reveals declines in the indices from 2001, but of a lesser magnitude than with all data. A second factor may be the opposite extreme nesting conditions between 2001 and 2002 and the effect on visibility of birds. 2001 was a very late year with poor nesting conditions and poor production which resulted in fewer nesting birds, more failed breeders early, and high numbers of pairs seen versus singles. The opposite extreme occurred in 2002. While our data in the past have indicated no significant differences in the numbers of nests per aerial pair observed between poor and good production analyzed with several years, we have not analyzed that ratio between 2001 and 2002 when more extreme nesting conditions and predation levels existed between years. We do not attribute a significant portion of the variability between 2001 and 2001 indices to the change in pilot/observer in 2001 because the ratios of observations to the right seat observer, who was the same for both years, are similar.

RECOMMENDATIONS

This survey is now standardized with a 4-year rotation of transect lines to optimize coverage of the study area. Unless economic or priority considerations require changes, or unless a change in distributions of the target species is suspected, we recommend that this survey continue with the current transect design. A review of stratification used for population analyses is suggested.

ACKNOWLEDGMENTS

We thank the staff of the YKD National Wildlife Refuge for logistical support. Dr. Robert Stehn provided programming for population analysis and assisted with analysis of historical data for the new indices. Robert Platte provided geographic-based figures for this report and logistical support during the survey. Christian Dau (USFWS, MBM-Region 7, Anchorage) was the pilot/observer from 1997-2000 and 2002. William Butler (USFWS, Region 2, Albuquerque) originally developed the project and was primary pilot/observer from 1985-1996. John Hodges (USFWS, MBM-Region 7, Juneau) was the pilot/observer in 2000. Dr. Richard Maleki (University of New York at Cornell) was right seat observer in 1985 and Dr. Calvin Lensink (USFWS, retired) was right seat observer in 1986.



Year	Fall Count	Indicated Total	Fall Estimate
1985	32,100	14,542	60,686
1986	51,400	12,828	57,162
1987	54,800	18,362	68,541
1988	69,900	23,742	79,603
1989	76,800	24,292	80,734
1990	110,200	30,482	93,462
1991	104,600	27,608	87,553
1992	149,300	43,035	119,274
1993	164,300	42,416	118,001
1994	152,500	60,183	154,533
1995	161,400	65,315	165,086
1996	134,600	69,157	172,986
1997	205,087	81,938	199,266
1998	148,564	62,192	158,664
1999	NA	73,235	181,371
2000	NA	71,598	178,005
2001	NA	75,914	186,879
2002	NA	**51,194**	**136,050**

Appendix 1. Fall counts regressed against indicated total index and converted to a fall population estimate for Cackling Canada geese.

Table Indicated total* population indices for cackling Canada, emperor, and white-fronted geese from 1985-2002 on the YKD Coastal Zone.

	Cackling Canada Geese		Emperor Geese		White Fronted Geese	
Year	Index	SE	Index	SE	Index	SE
1985	**14,542**	822	**18,614**	1,594	**17,381**	1,197
1986	**12,828**	711	**10,876**	786	**12,639**	940
1987	**18,362**	1,045	**11,664**	808	**14,530**	1,063
1988	**23,742**	1,014	**14,781**	942	**24,893**	1,556
1989	**24,292**	1,186	**15,921**	858	**26,362**	1,844
1990	**30,482**	1,680	**16,535**	1,172	**36,556**	2,753
1991	**27,608**	1,397	**13,909**	1,166	**30,282**	1,741
1992	**43,035**	2,295	**14,408**	770	**32,533**	2,452
1993	**42,416**	1,944	**16,870**	1,210	**40,367**	2,604
1994	**60,183**	2,583	**18,002**	1,047	**56,373**	3,246
1995	**65,315**	3,118	**18,526**	1,042	**78,179**	4,733
1996	**69,157**	3,161	**24,663**	2,800	**78,480**	4,666
1997	**81,938**	3,505	**22,701**	1,394	**83,650**	5,085
1998	**62,192**	2,925	**21,748**	1,289	**87,192**	4,339
1999	**73,235**	3,326	**21,322**	1,553	**95,516**	7,731
2000	**71,598**	3,018	**18,336**	914	**92,279**	5,120
2001	**75,914**	3,312	**27,625**	1,491	**112,001**	5,216
2002	**51,194**	2,475	**19,883**	1,172	**89,990**	5,531

*Indicated Total = 2 x (singles + pairs) + birds in flocks

Table 2. Indicated singles and pairs **indices for cackling Canada, emperor and white-fronted geese from 1985-2002 on the YKD Coastal Zone.

	Cackling Canada Geese		Emperor Geese		White Fronted Geese	
Year	Index	SE	Index	SE	Index	SE
1985	**10,776**	774	**8,421**	750	**8,600**	739
1986	**10,030**	664	**5,884**	502	**6,026**	456
1987	**13,142**	842	**7,709**	610	**7,072**	549
1988	**15,818**	761	**7,144**	627	**10,309**	772
1989	**19,736**	1,098	**9,252**	555	**10,946**	800
1990	**19,372**	1,229	**8,165**	721	**10,655**	793
1991	**21,588**	1,251	**6,678**	481	**11,939**	788
1992	**27,216**	1,615	**8,169**	533	**12,777**	944
1993	**31,556**	1,615	**9,942**	802	**15,391**	998
1994	**38,172**	1,955	**11,585**	734	**20,270**	1,228
1995	**46,024**	2,735	**12,611**	794	**27,124**	1,605
1996	**36,390**	2,148	**12,083**	628	**22,313**	1,332
1997	**45,416**	2,254	**12,410**	705	**27,830**	1,242
1998	**44,868**	2,185	**15,723**	881	**40,710**	2,326
1999	**50,738**	2,361	**16,485**	1,240	**48,409**	3,156
2000	**49,749**	2,208	**12,841**	631	**43,091**	1,932
2001	**50,056**	2,025	**17,507**	940	**62,946**	3,004
2002	**43,141**	1,979	**15,947**	1,049	**51,401**	3,020

**Singles and Pairs = 2 x (singles + pairs)

Table 3. Indicated Singles and Pairs and Indicated Total population indices for black brant and Taverner's Canada Geese from 1985 to 2002 on the YKD Coastal Zone.

	Black Brant				Taverner's Canada Geese			
	Singles & Pairs*		Indicated Total**		Singles & Pairs*		Indicated Total**	
Year	Index	SE	Index	SE	Index	SE	Index	SE
1985	**1,073**	239	**5,388**	2,115	**4,622**	1,563	**5,971**	1,742
1986	**2,045**	365	**13,337**	3,182	**3,508**	608	**4,436**	702
1987	**4,072**	602	**12,323**	1,907	**2,978**	654	**3,750**	781
1988	**3,489**	458	**18,623**	2,676	**4,611**	739	**8,504**	2,290
1989	**3,808**	472	**23,705**	3,156	**7,054**	1,396	**8,642**	1,376
1990	**2,720**	296	**26,506**	3,576	**6,538**	1,689	**7,841**	2,070
1991	**4,087**	562	**19,655**	2,869	**5,192**	804	**7,498**	1,157
1992	**5,581**	631	**17,860**	2,108	**4,920**	1,006	**7,735**	1,464
1993	**3,942**	416	**27,062**	4,188	**6,825**	2,019	**9,087**	2,856
1994	**5,020**	476	**26,885**	3,716	**5,749**	1,231	**7,275**	1,528
1995	**5,159**	508	**28,282**	4,207	**6,064**	1,337	**6,801**	1,463
1996	**4,856**	548	**25,314**	2,708	**4,148**	666	**7,056**	1,302
1997	**6,002**	760	**27,151**	4,636	**4,533**	843	**6,869**	1,215
1998	**8,096**	851	**22,162**	2,837	**7,224**	1,846	**9,132**	2,116
1999	**8,738**	738	**21,077**	2,268	**7,622**	1,347	**12,500**	1,939
2000	**8,008**	747	**23,466**	3,518	**8,456**	1,940	**10,955**	2,718
2001	**5,166**	614	**29,997**	3,602	**6,156**	1,569	**7,958**	1,681
2002	**9,194**	914	**20,079**	1,960	**5,347**	1,114	**6,775**	1,327

*Indicated Singles and Pairs = singles + pairs
**Indicated Total = 2 x (singles + pairs) + flocks

Table 4. Singles and Pairs, Total Birds and Nests population indices for tundra swans from 1985-2002 on the YKD Coastal Zone.

	Singles and Pairs*		Total Birds**		Nests***	
Year	Index	SE	Index	SE	Index	SE
	12,143	850	**27,422**	5,182	**2,216**	206
	13,113	738	**23,366**	3,113	**2,803**	212
	11,686	560	**23,211**	3,496	**2,126**	166
	13,314	805	**23,863**	3,262	**2,978**	249
	11,804	698	**31,630**	6,115	**2,397**	167
	12,176	608	**28,864**	5,152	**2,672**	190
	10,845	586	**17,852**	2,339	**2,287**	174
	12,450	700	**18,612**	1,911	**2,758**	224
	12,234	694	**19,547**	1,805	**2,807**	194
	13,216	771	**18,418**	1,513	**3,082**	290
	16,606	1,010	**22,794**	1,895	**3,571**	301
	17,004	884	**22,788**	1,562	**3,918**	285
	18,024	872	**28,266**	3,914	**4,037**	231
	22,297	1,240	**32,180**	3,564	**4,895**	428
	20,980	1,039	**27,652**	1,873	**4,683**	373
	20,063	1,037	**28,058**	2,939	**4,489**	379
	17,237	922	**23,554**	1,743	**3,171**	305
	21,481	1,176	**31,953**	5,237	**5,773**	381

*Singles and Pairs = singles + (2x pairs)
**Total Birds= singles + (2 x pairs) + birds in flocks
***Nests= number of active nest observations

Table 5. Indicated Singles and Pairs and Indicated Total Bird Indices 1987-2002 for sandhill cranes on the YKD Coastal Zone.

	Singles and Pairs*		Indicated Total Birds**	
Year	Index	SE	Index	SE
1987	**13,354**	925	**14,212**	983
1988	**12,150**	1,044	**15,898**	2,029
1989	**13,074**	776	**16,637**	1,403
1990	**13,851**	1,058	**17,805**	1,652
1991	**14,092**	961	**20,163**	1,787
1992	**12,910**	940	**16,761**	1,272
1993	**16,286**	1,001	**19,876**	1,763
1994	**14,098**	913	**16,946**	1,137
1995	**17,124**	1,237	**18,405**	1,289
1996	**10,640**	753	**17,369**	2,439
1997	**11,577**	923	**13,828**	1,621
1998	**19,698**	1,354	**26,340**	2,537
1999	**16,317**	1,337	**18,595**	1,662
2000	**16,219**	1,205	**18,466**	1,684
2001	**14,808**	1,114	**16,105**	1,208
2002	**12,551**	1,269	**12,993**	1,209

*Indicated Singles and Pairs= 2 x (singles + pairs)
**Indicated Total Birds = singles + (2 x pairs) + birds in flocks

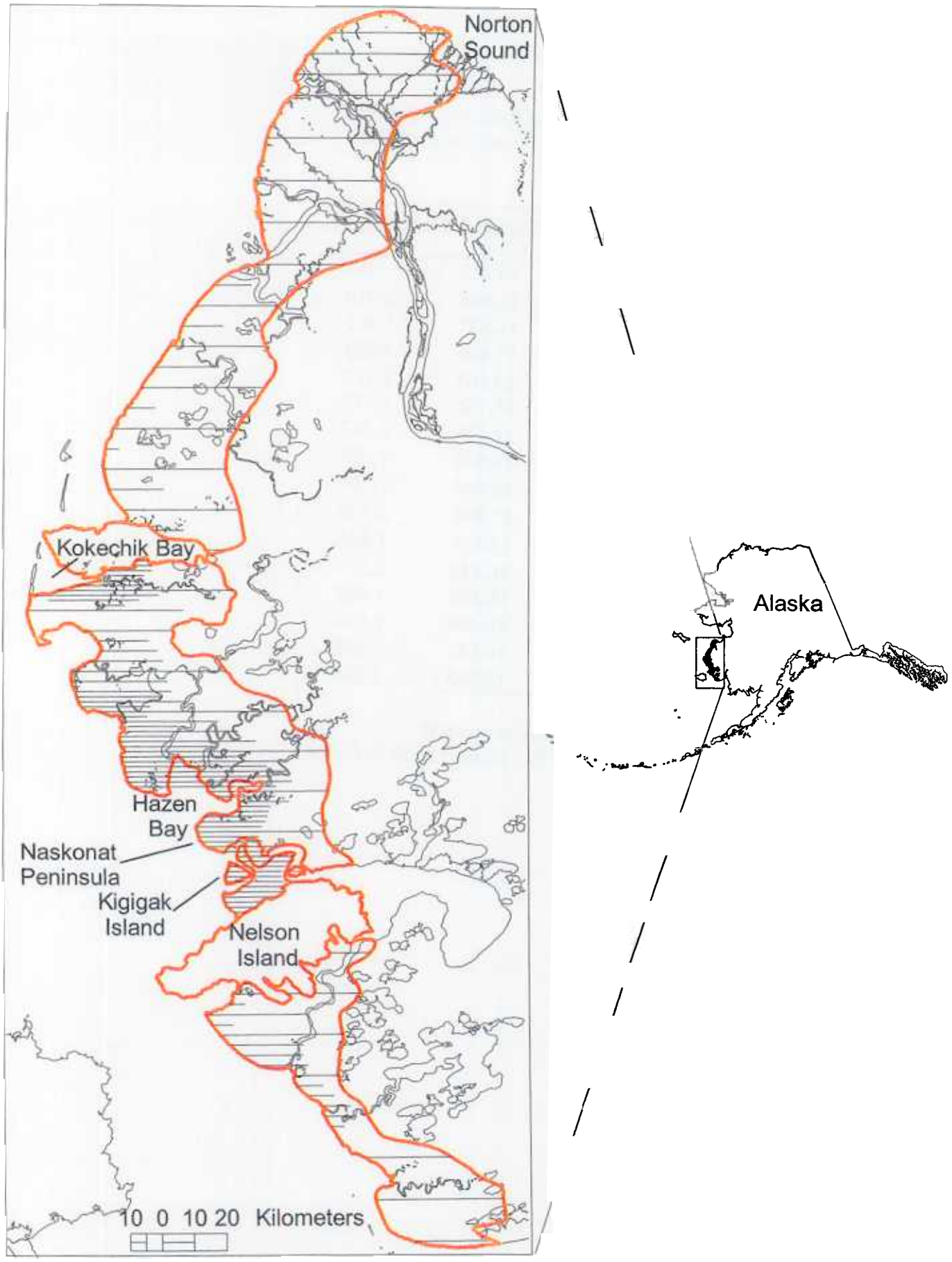


Fig. 1. 2002 aerial strip transects of 400 meter width (horizontal lines) on the coastal zone of Yukon Delta NWR, Alaska.

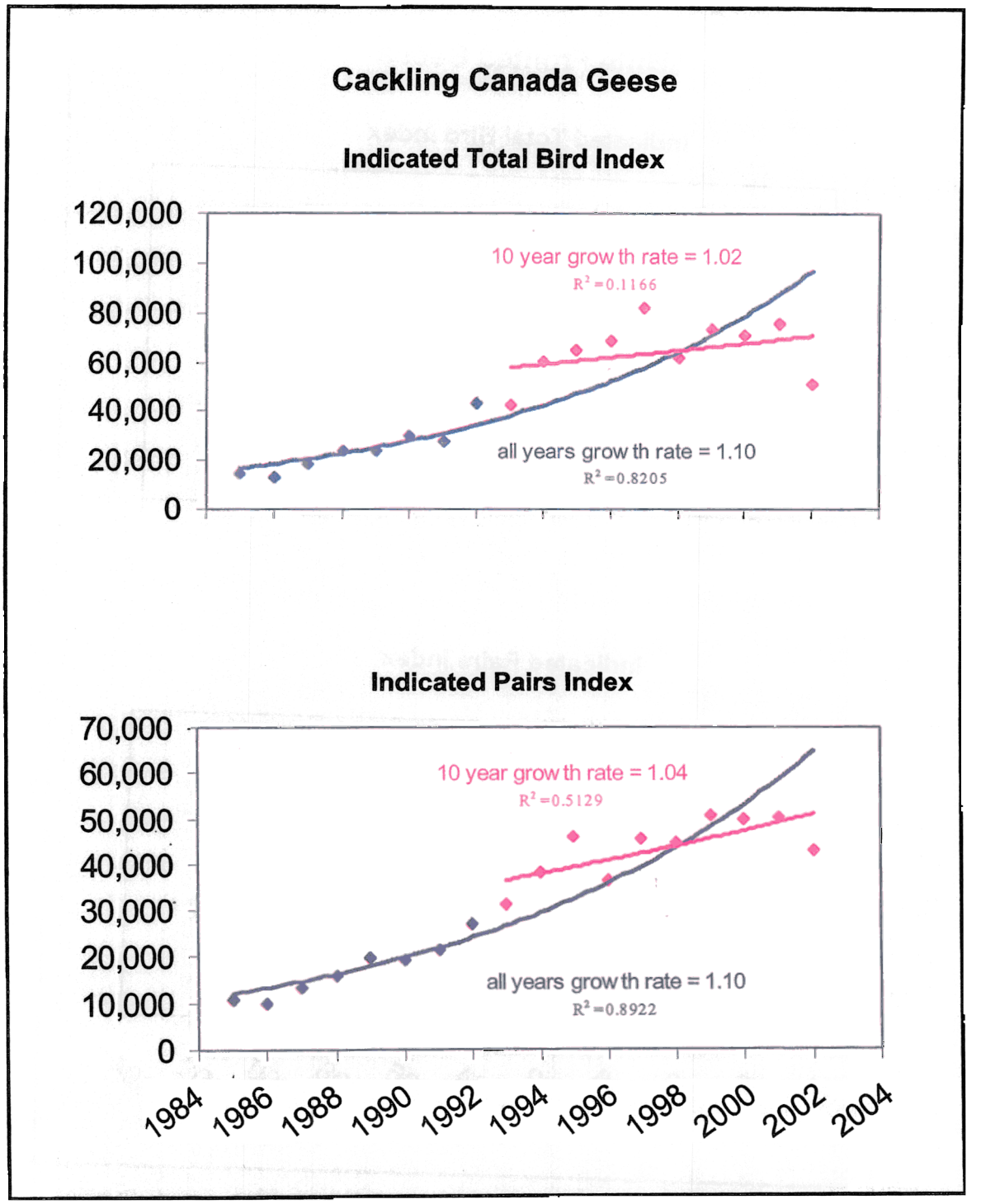


Fig. 2. Population index growth curves and average annual growth rates from log-linear regression for all-years and the last 10 years for cackling Canada geese.

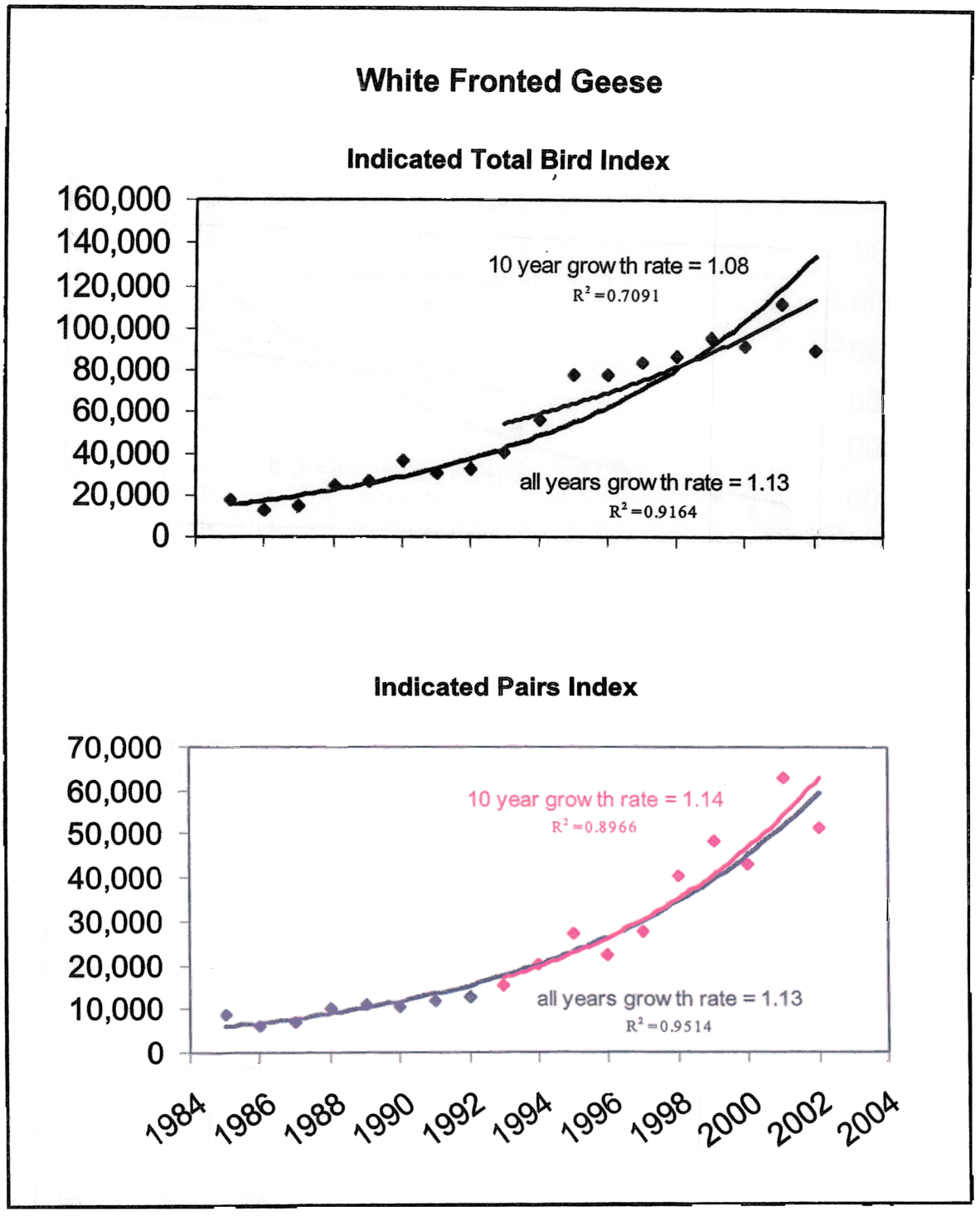


Fig. 3. Population index growth curves and average annual growth rates from log-linear regression for all-years and the last 10 years for greater white-fronted geese

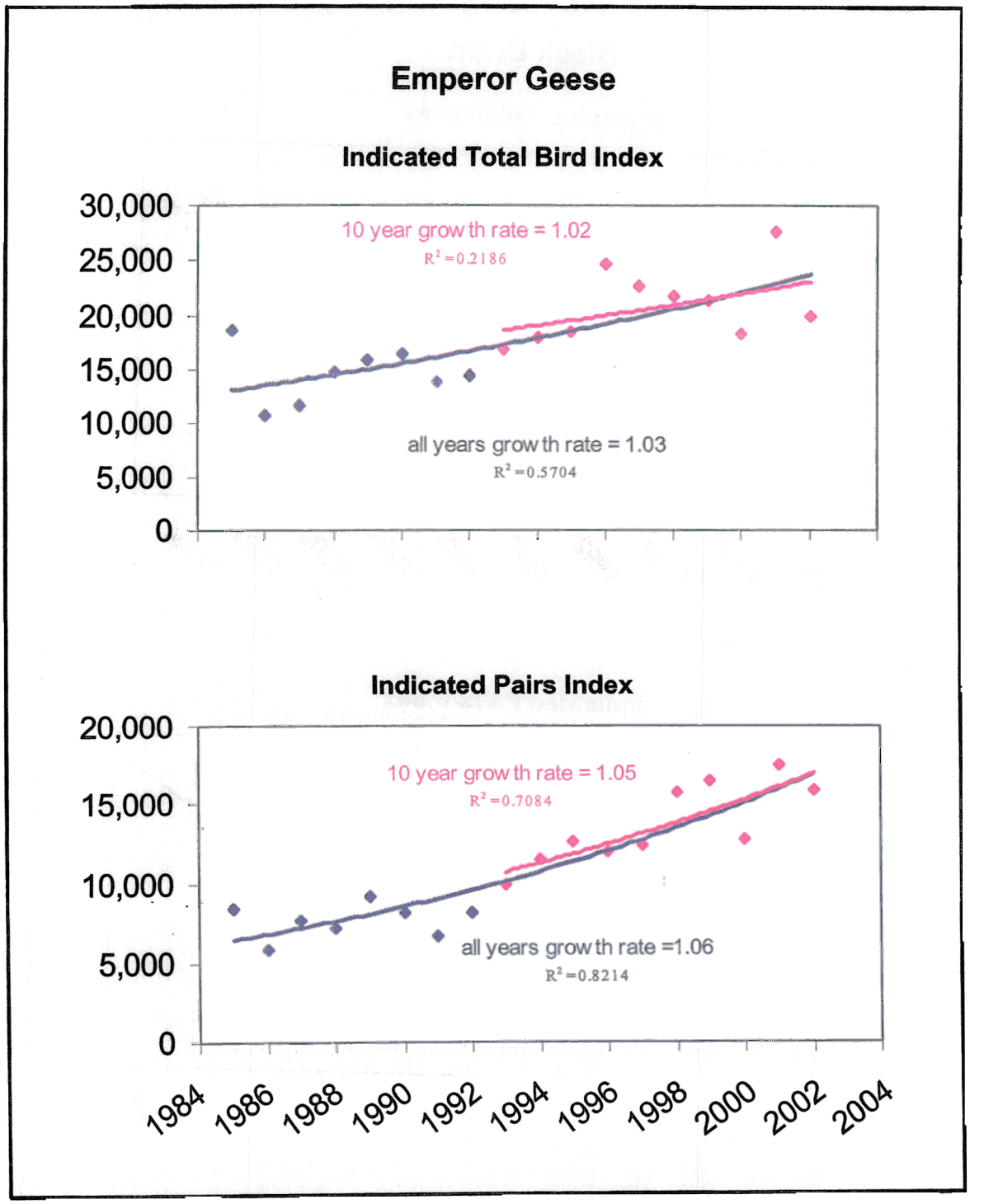


Fig. 4. Population index growth curves and average annual growth rates from long-linear regression for all-years and the last 10 years for emperor geese

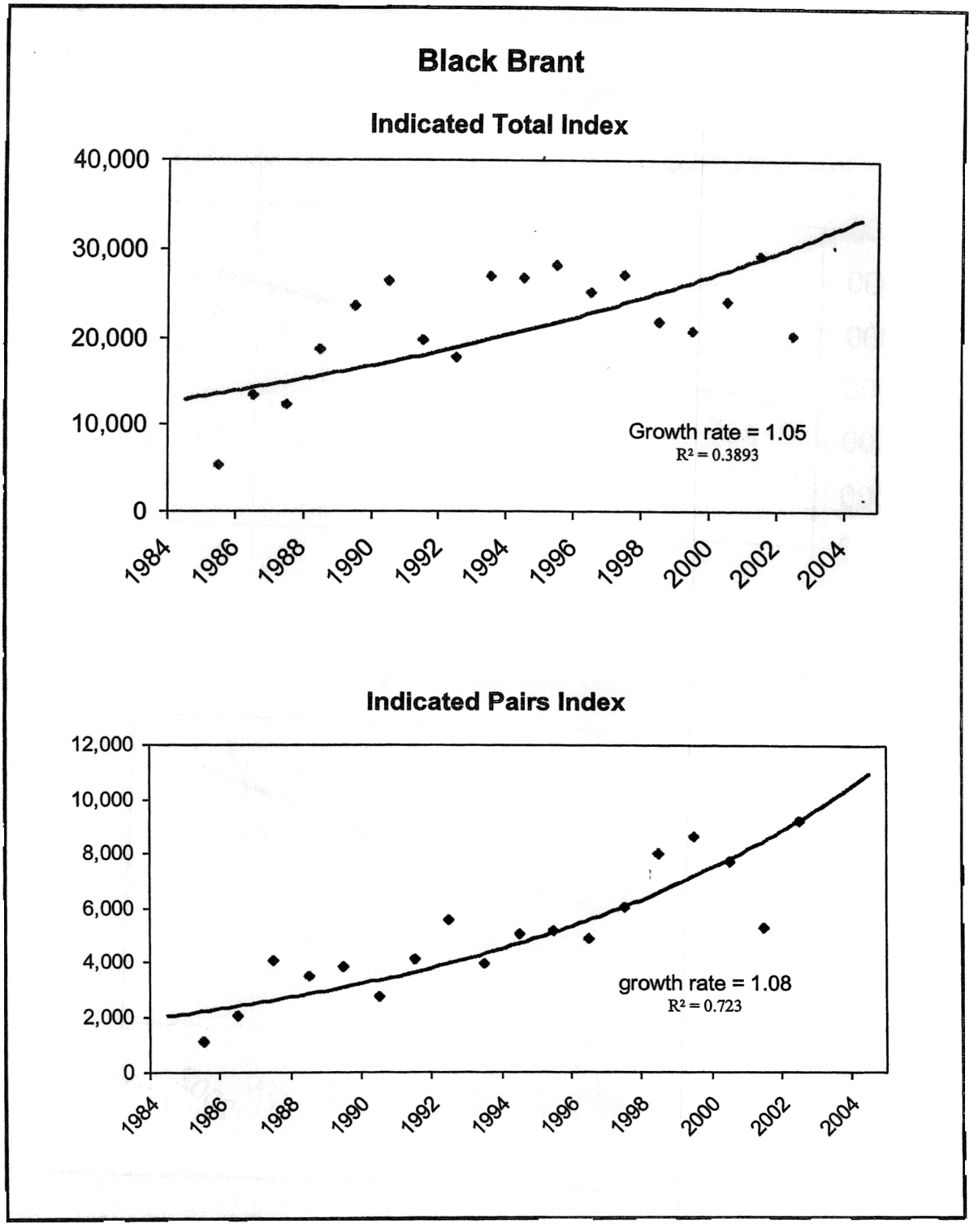


Fig. 5. Population index growth curves and average annual growth rates from log-linear regression for black brant.

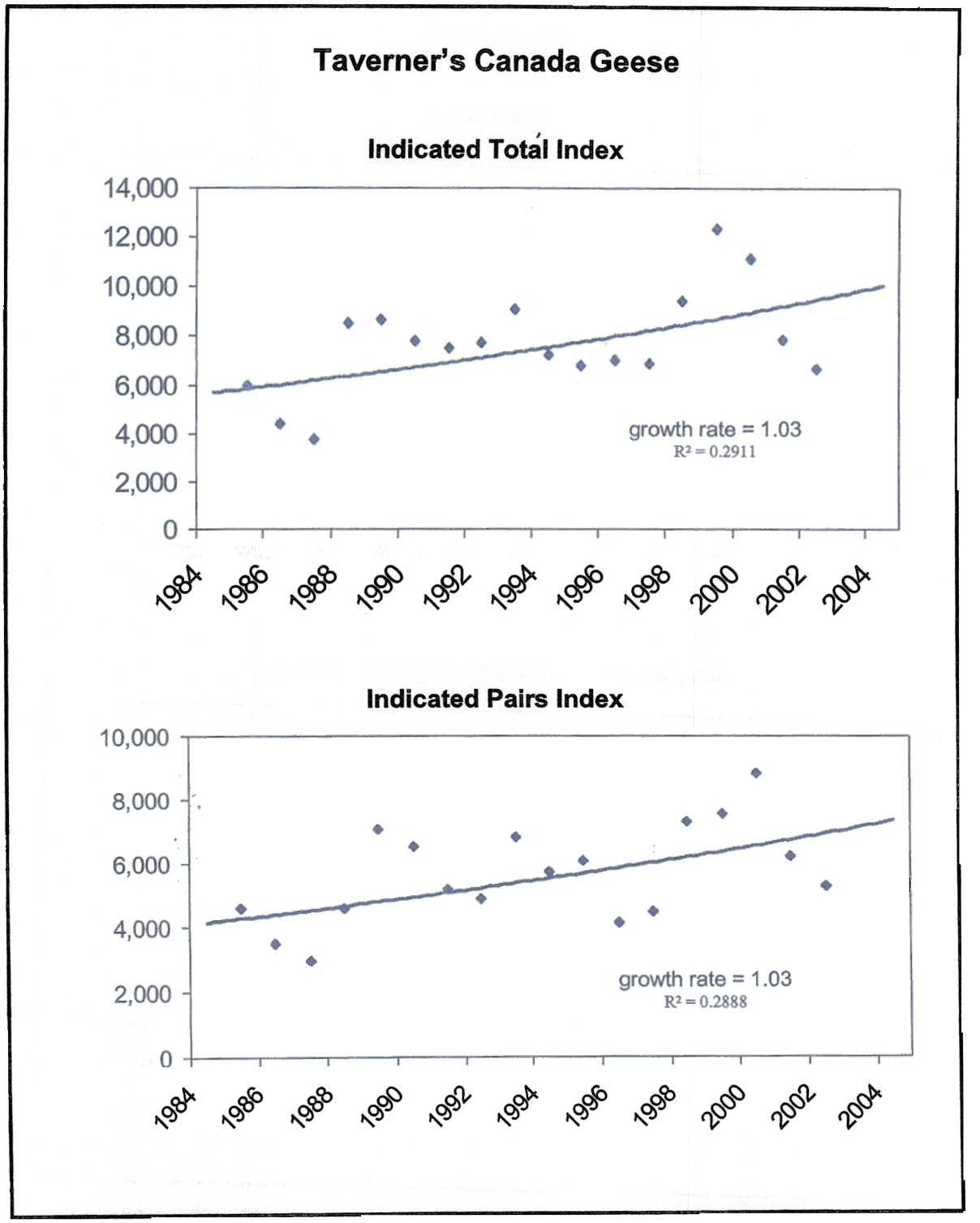


Fig. 6. Population index growth curves and average annual growth rates from log-linear regression for Taverner's Canada geese.

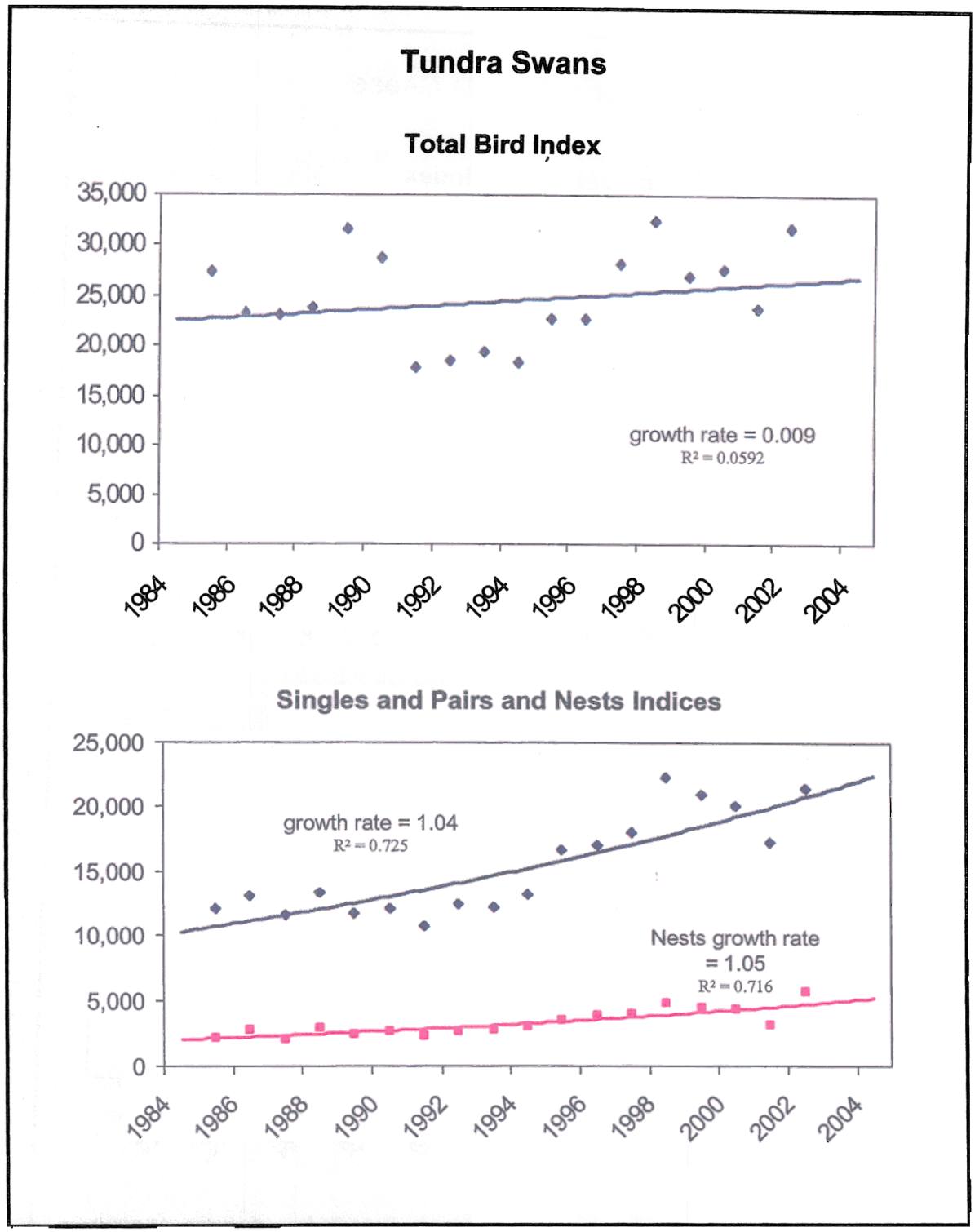


Fig. 7. Population index growth curves and average annual growth rates from log-linear regression for tundra swans.

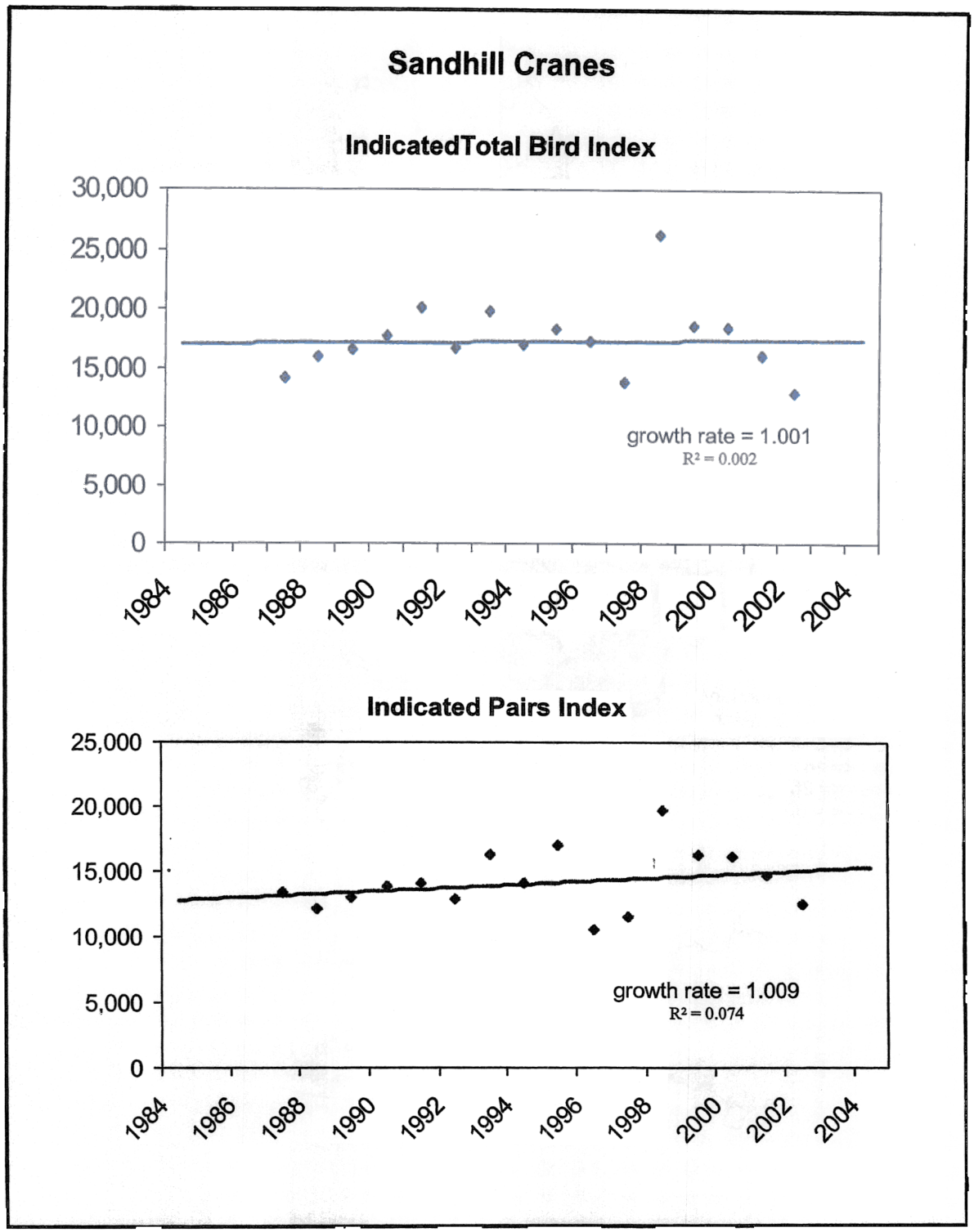


Fig. 8. Population index growth curves and average annual growth rates from log-linear regression for sandhill cranes.

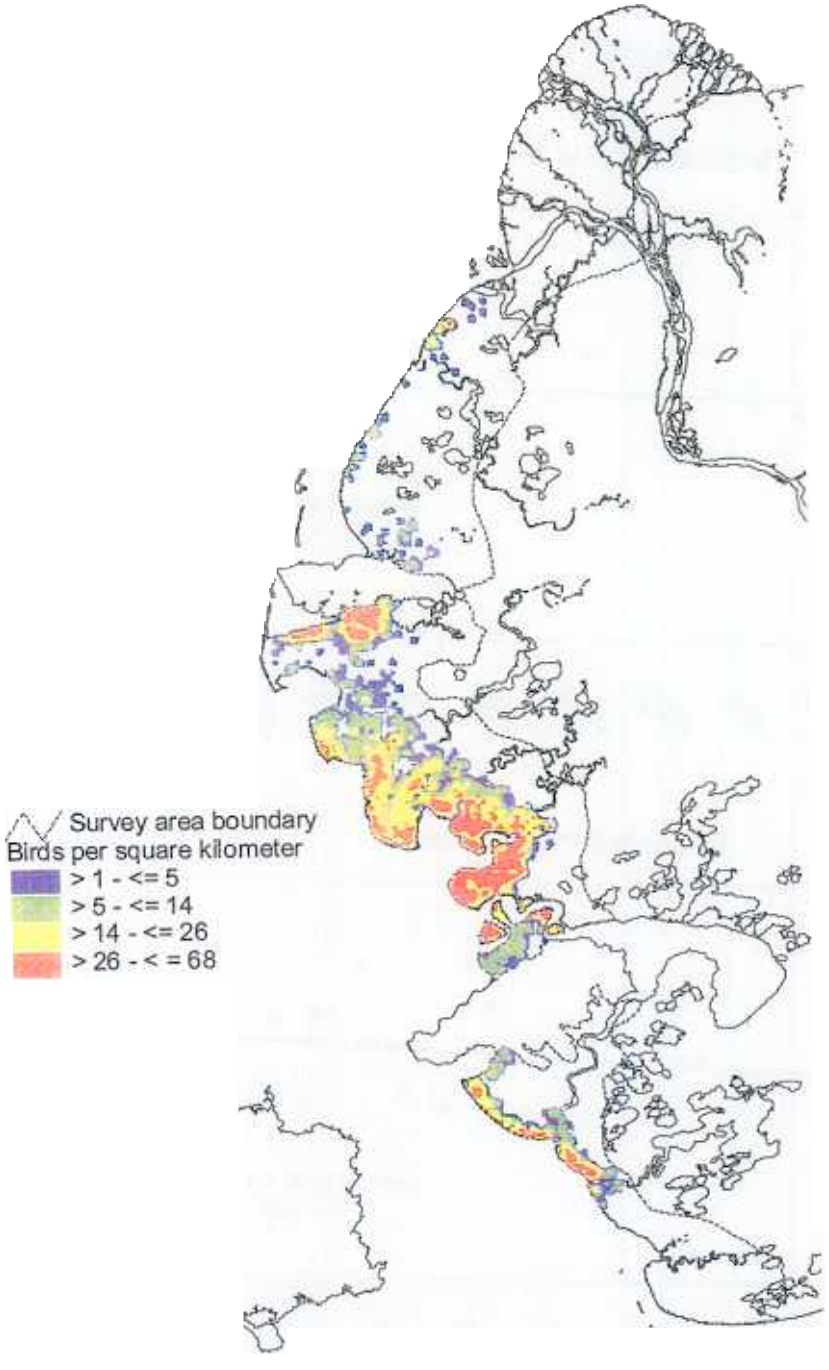


Fig. 9. Density contours of indicated pairs (2 x (singles + pairs)) of cackling Canada geese based on combined observations from 1998 - 2001, on the Yukon Delta coastal zone.

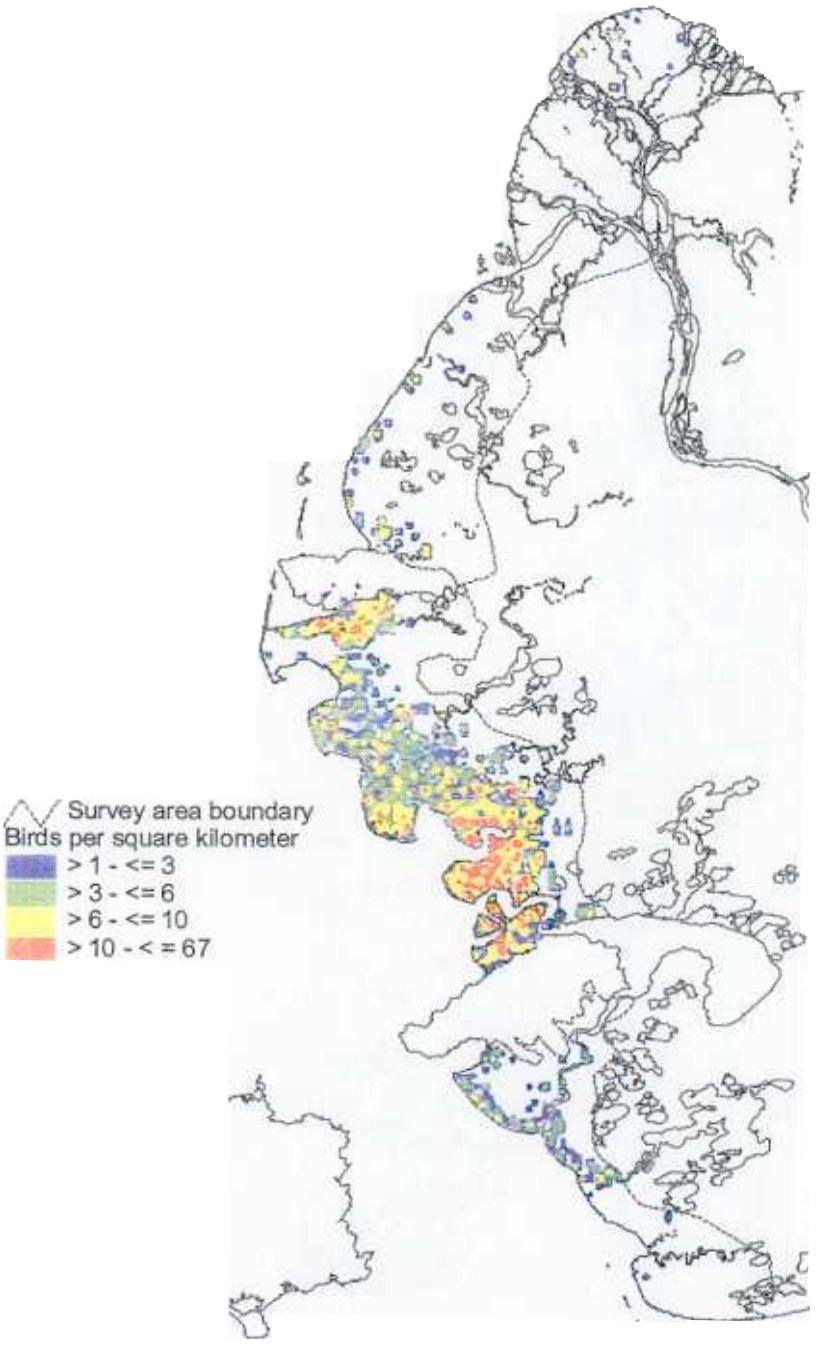


Fig. 10. Density contours of indicated pairs (2 x (singles + pairs)) of emperor geese based on combined observations from 1998 - 2001, on the Yukon Delta coastal zone.

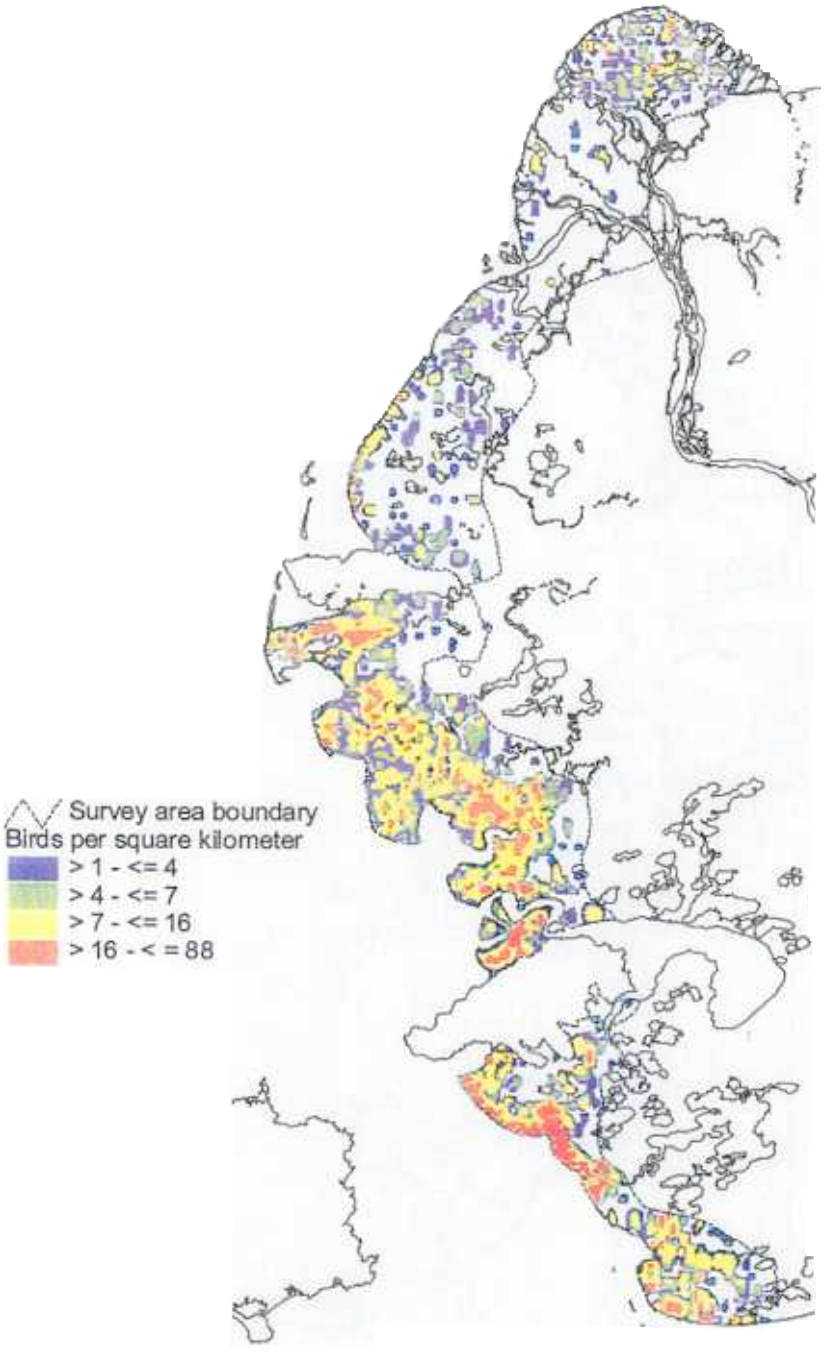


Fig. 11. Density contours of indicated pairs (2 x (singles + pairs)) of white-fronted geese based on combined observations from 1998 - 2001, on the Yukon Delta coastal zone.

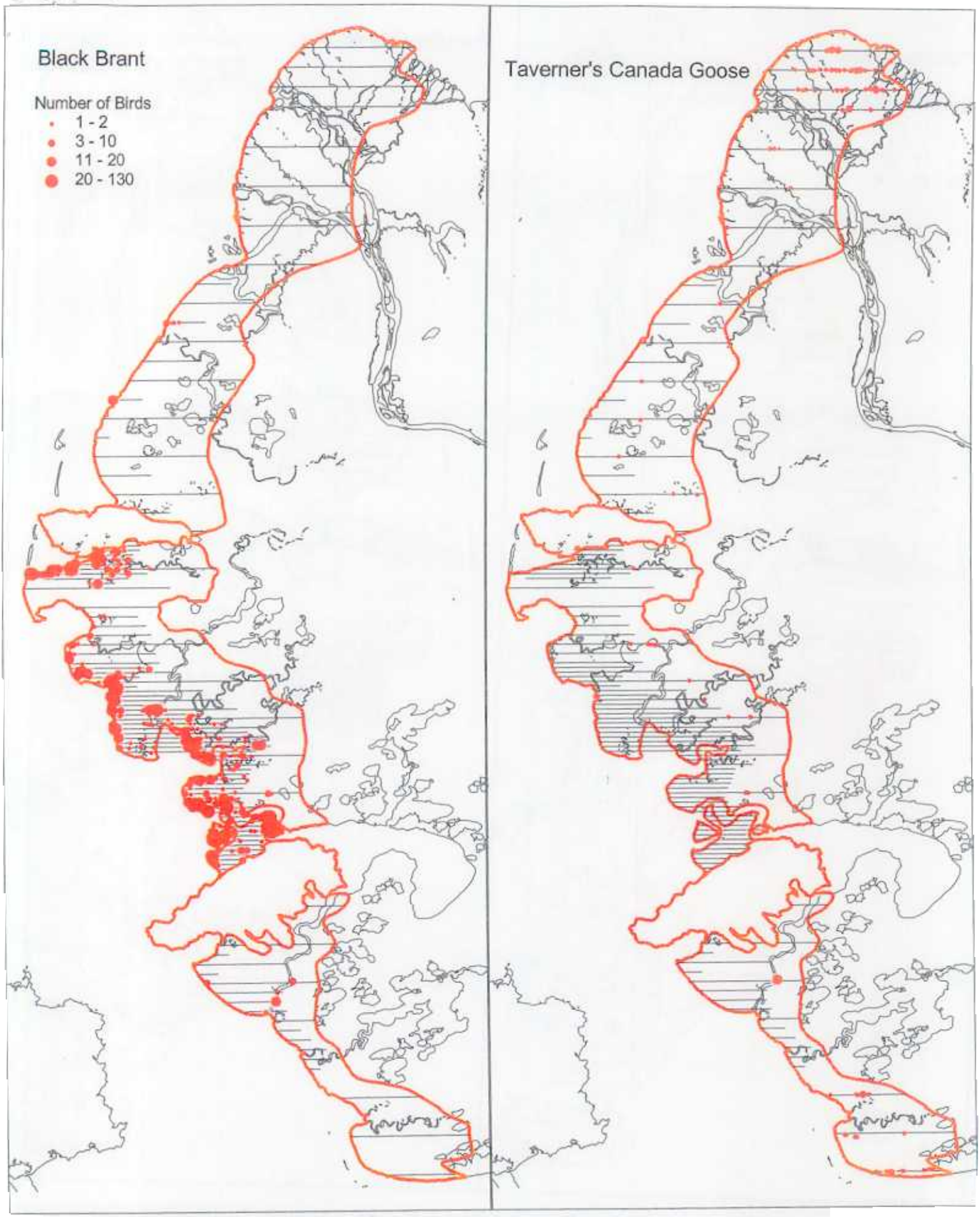


Fig. 12. Black Brant and Taverner's Canada goose locations from 2002 aerial survey, Yukon Delta coastal zone, Alaska.

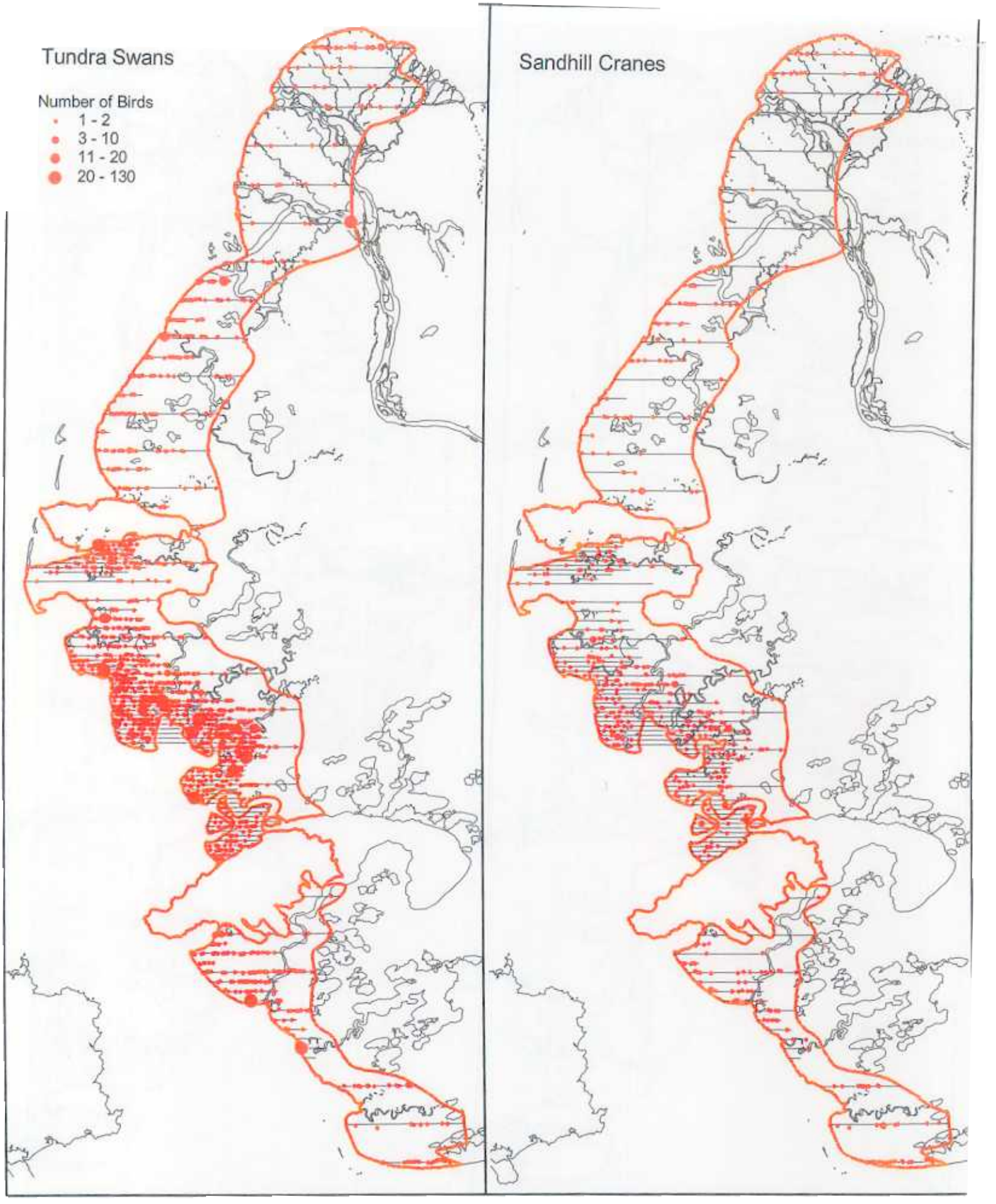


Fig. 13. Tundra swan and sandhill crane locations from 2002 aerial survey, Yukon Delta coastal zone, Alaska.

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