Mid-continent Greater White-fronted Goose Breeding Pair Survey in Northwest Alaska, 2007

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Introduction

The mid-continent population of greater white-fronted geese (*Anser albifrons frontalis*; hereafter white-fronts) breeds in tundra habitats from the central Canadian Arctic to the North Slope of Alaska, and south into boreal and taiga habitats of the interior and northwest portions of the state. Throughout their range, white-fronts are an important resource for consumptive and non-consumptive users. In Alaska, white-fronts are particularly important to subsistence hunters. Population and habitat management for white-fronts and waterfowl species in general, are integral components of enactment legislation for several National Wildlife Refuges, including Selawik NWR.

Harvest management of mid-continent white-fronts is based largely on a fall staging survey that provides an index for the entire population (Warner et al. 2007). The fall staging survey, however, does not necessarily reflect abundance or trend of the Alaska breeding component because white-fronts from all segments of the breeding range mix together in the fall survey area. The Management Plan for mid-continent white-fronts states that special management options for identifiable and manageable segments or subunits within the population could be considered should they be recognized with new information (Sullivan 1998). Winter distribution and migration patterns of white-fronts that breed in interior and northwest Alaska distinguishes this group of geese as a unique segment or subunit of the mid-continent population (Ely and Schmutz 1999, Webb 2006), but managers do not have a tool to identify when special management options are warranted.

Development of reliable management tools on a regional scale in Alaska has been elusive. Aerial molting goose surveys are conducted in various locations in interior and northwest Alaska (Fischer 2007), but population trends from these surveys are equivocal and are likely dependent on parameters currently not monitored with precision. For example, the molt survey primarily monitors molt migrants; but molt migration in geese involves failed breeders and non-breeders (Salomonsen 1968, Hohman et al. 1992) with highest numbers expected at molt sites in years of poor breeding success (Reed et al. 2003) or following years of high juvenile recruitment. Thus, abundance estimates derived from molt surveys are biased by current and past year breeding conditions.

An alternative method of monitoring population trend is with breeding ground surveys. The value of such surveys has long been recognized by biologists and waterfowl managers when region- or population-specific indices of geese are needed (Kaminski 1979, Bishop and Williams 1990, Kraft and Funk 1990, Rusch et al. 1996, Abraham et al. 1999, Moser and Caswell 2003). Experimental breeding pair surveys for the Eastern Prairie Population of Canada Geese (*Branta canadensis*) showed that such surveys are a useful alternative to staging or winter surveys and produce reasonable population estimates with relatively narrow confidence intervals (Malecki et al. 1981, Rusch et al. 1996).

In 2005-2007 we conducted breeding pair surveys in late-May and early June to measure abundance and distribution of white-fronts in northwest Alaska. The goals of this effort were to determine whether breeding pair surveys could be a useful tool in identifying when special management options are needed for this group of birds and to document the size and trend of the breeding population in northwest Alaska. Survey efforts on 2005 and 2006 showed total population estimates were approximately 41% lower than similar efforts conducted in 1996-1997. In 2007 we incorporated aerial detection techniques and analysis of survey timing to investigate whether the apparent decline in total abundance could be attributed to survey methodology, or reflected an actual decline in numbers of geese in the Selawik region. Survey results from 2005 and 2006 were reported in Fischer et al. (2007a).

Methods

Study Area, Standard Operating Procedures

The 2005-2007 white-fronted goose breeding pair survey was modified slightly from the 1996-1997 expanded breeding pair survey design (Platte 1999). The expanded breeding pair surveys were conducted in early to mid June to collect detailed distribution data within waterfowl production areas that are sampled annually during the Continental Waterfowl Breeding Population and Habitat Survey (hereafter, “Continental Survey”). Transect design in 2005-2007 was nearly identical to the 1997 expanded breeding pair survey of Selawik National Wildlife Refuge (NWR) and the Noatak Lowlands (Platte 1999; Fig. 1). One exception was that the Baldwin Peninsula stratum was excluded in 2005 because no white-fronts were observed there in 1997. While the Baldwin Peninsula was sampled in 2006 and 2007, few geese were detected and the strata is not included in analyses presented in this report. The survey design resulted in over 1,900 km of transects comprising a sample of 761 km^2, 788 km^2, and 700 km^2 in 2005, 2006 and 2007, respectively; approximately 5% of the 14,848 km^2 study area.

The survey was timed to maximize the likelihood that peak numbers of birds were present on the breeding grounds, during peak nest initiation. A surveillance survey was conducted on two designed transects on May 18, 2007 to assess presence and distribution of white-front pairs and flocks, and availability of nesting habitat. The parallel transects ran from the Kobuk Delta to the eastern boundary of the Refuge. Snow cover varied from 10% to 90% with an average snow cover of 75%. The far eastern portion of the refuge had the least amount of snow. A total of 66 greater white-fronted geese, 181 Canada geese, 70 northern pintail, 33 swans, 33 sandhill cranes, and 65 unidentified ducks, were observed on the transects. Most were observed as flocks in flight or in ponds or lakes with open water. Conditions were similar to 2006, however, more birds were observed. Based on these observations, the operational survey was flown May 29-June 1, 2007. Survey timing in the 1990s was significantly later (1996: June 18-21; 1997: June 4-8), whereas recent survey timing was relatively consistent (2005: May 25-28; 2006: May 27-June 3).

The aircrew used the Selawik NWR Husky on wheels as a survey platform. Birds within 200 m of either side of the aircraft were recorded by Paul Anderson (Pilot/Biologist; left side observations), and Tina Moran (Wildlife Biologist; right side observations). They used USFWS - Migratory Bird Management customized aerial survey software to record all goose, scoter, swan, and loon observations. Numbers of geese were recorded and observations were categorized as singles, pairs, or flocks. For analysis, flocks were further subdivided into small (3-5), medium (6-30), and large flocks (31+). Standard headers were recorded at the onset of each transect including: observer name, date, transect number, wind speed, wind direction, sky condition (clear, scattered, broken, overcast), and snow cover (<10%, 11-50%, 51%- 90%, >90%).

Analysis methods followed ratio estimation procedures (Cochran 1977) outlined for expanded breeding pair surveys in northwest Alaska (Platte 1999). We assumed single birds were accompanied by a mate on a nest that was not visible to the observer. Thus, the number of indicated pairs was calculated by two times the number of singles plus the number of paired birds (Malecki et al. 1981). The number of total indicated birds was calculated as indicated paired birds plus birds in flocks.

Aerial Detection Rate

To calculate detection rate we used a mark-resight analysis procedure using double count data collected on "detection" transects where both observers recorded bird locations from the same side of the aircraft. We distributed detection transects systematically on every fourth or fifth transect of the survey. Thus, we collected double-count data on each survey day, during various lighting conditions, and throughout all geographic regions. Detection transects comprised 24% of the total of 417.3 km^2 observed by the rear-seat observer. While on detection transects, the pilot-observer hesitated a few seconds before voicing observations into the intercom headset. This delay provided adequate time for the rear-seat observer to make independent observations. The rear-seat observer then recorded whether the observation was "paired" for those sightings where both observers saw the bird(s). Analysis of the double-count data followed standard mark-resight formulas (Chapman 1951, Skalski et al. 2005 p.452). Due to the sample size limitations in many subgroups (species, survey day, observer) we selected group size as the single variable to apply to detection rates in correcting the population indices.

Timing of Spring Warming

We estimated the relative timing of spring warming in years 1973-2007 based on daily mean temperature recorded at Kotzebue (PAOT), Selawik (PASK), and Noatak (PAWN) weather stations. We used both National Climatic Data Center (NCDC) global summary of the day (GSOD) files and the METAR airport data downloaded from the WeatherUnderground website (http://www.wunderground.com/). The average daily mean temperature on each single date across all years was calculated for each station. The average temperature moved above 32F on day-of-year 136, 131, and 132 (16, 11, 12 May in non-leap years) for Kotzebue, Selawik, and Noatak, respectively. The average of these was day 133. This was 4 days later than coast of the Yukon-Kuskokwim Delta (YKD) that averaged >32F on day 129 for Hooper Bay, Cape Romanzof, Mekoryuk, and Emmonak stations.

We reasoned that the chronology of spring warming temperatures, the melting of snow and ice, the availability of nest sites, and clutch initiation dates for white-fronts in the Selawik area would follow the same pattern shown by cackling geese on the YKD. Clutch initiation dates (Fischer et al. 2007b) and certain measures of Hooper Bay daily mean temperature data from 1991-2007 are highly correlated (Stehn et al., in prep.). We calculated the same three temperature parameters for the Selawik area that showed highest correlations with cackler clutch initiation on the YKD. The first of these parameters was the average temperature for a 21-day period (AvgT_21) calculated on day 140 (20 May) including days 120-140 (Table 1). Day 140 was 7 days after day 133, the date when Selawik daily temperatures reached >32F, making the calculations parallel to the YKD coast where 21-day temperature on day 136, 7 days after day 129 when YKD coast temperatures were >32F, showed the highest correlation with nest initiation date. The second temperature parameter calculated was the day each year when thaw-degree-days (TDD) reached 33. TDD measure accumulates daily mean temperatures degrees above 32F. The third parameter was the day-of-year when the 5-day average temperature (AvgT_5) first reached 33F degrees.

The parameters were made comparable among the 3 stations by expressing each annual value as a deviation from the 1995-2007 average for that station. Correlations among the 3 stations were all very high, ranging between 0.88 and 0.99 for these parameters. Additionally, to make the clutch timing estimates comparable among the 3 parameters, the annual deviations were multiplied by the regression coefficients based on YKD parameters as related to average clutch initiation dates for cackling geese. The coefficients were -1.171 clutch initiation days per AvgT_21 degree F, 0.403 initiation days per day at TDD >33, and 0.296 initiation days per day at AvgT_5 >33F. The annual deviates at each station were first averaged across the 3 stations; then the average was rescaled for each parameter and combined by averaging across the 3 parameters to provide a regional annual estimate for relative timing. The annual regional deviate (Table 2, Fig. 2) showed the days early (negative) or late (positive) in the expected clutch initiation date compared to the average timing of spring warming for the years 1995-2007.

If the same relationship between warming temperature and clutch initiation holds for the Selawik area as for Yukon Delta coastal tundra region, then the expected average clutch initiation day in the Selawik area would be day-of-year 146.5, May 26, with a 90% confidence interval of ±8.1 days among years (Table 2). This is just a three days later than the average cackling goose clutch initiation on the YKD of 143.6 days for the same period of 1995-2007. We do not have data on actual clutch initiation dates for white-fronts or other waterfowl from the Selawik area to determine if the assumed influence of spring warming on nest initiation is correct.

Results

Population Indices, Growth Rates, Distribution

We calculated unadjusted and detection-adjusted indices for 2007. We applied the correction for detection of singles, pairs, and flocks to all years (Table 3, Fig. 3). Use of unadjusted vs. detection-corrected estimates had little effect on the proportion of singles, pairs, and small, medium and large flocks (Fig. 2). In 2007, estimates of indicated breeding white-front pairs were up from 2006, and very similar to 2005.

Estimates of indicated total white fronts varied less that 1% between 2005, 2006, and 2007, but are all approximately 40% lower than estimates derived in 1996-1997.

Annual growth rate of indicated breeding pairs is 2% from 1996-2007; whereas growth rate of total indicated birds is -5.3% (Table 3). Comparison of population estimates and growth rates from the 1996-1997 surveys vs. 2005-2007 must take into consideration differences in survey timing that likely affected the proportion of flocked birds (see Discussion). For example, the proportions of singles, pairs and flocks are very similar among surveys in 2005-2007 (Fig. 3), but were approximately twice that seen in the 1996-1997 surveys.

Distribution of white-fronts in 2007 was similar to other survey years (Fig. 4)

Population indices and growth rates are also presented for Canada geese, tundra swans, Pacific loons, and black scoters (Tables 3, 4; Fig. 2).

Aerial Detection Rate

Detection rates varied between observers, species, survey dates, and group size (Table 3), although inadequate sample size precluded anything but preliminary interpretation for much of these data. Combining all species, the front-seat observer averaged 70% (SE = 0.017) detection rate while the rear-seat averaged 90% (SE = 0.022). This result was expected as the requirements of safely flying the aircraft can cause a reduction in actual observation time for the pilot-observer. While detection rates varied among observers, there was an apparent interaction effect by species, where front- and rear-seat detection rates were the same (82% vs. 82%) for white-fronts and quite close for tundra swan (82% vs. 92%; Table 3). Among species, tundra swan sightings averaged the highest detection rate at 87% while white-front detection was 82%. Insufficient sample sizes for other species precluded even speculative interpretation with regards to detection rate. Using data from all species combined, the first two survey days had slightly higher average detection rates (85%, 87%) than the second two days (74%, 75%; Table 3). The group size of birds per sighting also influenced the detection rate (geese and swans combined) with single birds averaging 72% detection while sightings of pairs averaged 92% detection (Table 3). We subjectively selected 95% as a reasonable detection rate for flocks. Due to the sample size limitations in many subgroups (species, survey day, observer) we selected group size as the single variable to apply to detection rates in correcting the population indices. We applied the 2007 data for the detection probability of sighting a single, pair, or flock to all years of data. Thus, we combined across observers, days, years, and species (geese and swans).

Discussion

Effect of Survey Timing and Detection Rates on Population Estimates

Population estimates of total greater white-fronted geese derived from the 2005-2007 surveys are notably invariant. However, these estimates are on average, 41% lower than those generated in 1996-1997. This difference begs the question, did the population truly decline during the interim eight year period, or is the difference a product of survey methodology? Preliminary investigation of survey timing and group size-specific detection rates presented in this report suggests the latter.

The surveys flown in 1996 and 1997 were flown considerably later, about 25 and 14 days, respectively, after the expected clutch initiation day based on the timing spring warming (Table 2). In contrast, surveys in 2005-2007 were consistently timed to coincide with clutch initiation (Table 2). Specifically, the average observation date (the day-of-year averaged over all sightings of all species) of the three recent surveys were within 4 days relative to spring warming. For example, the calendar observation date was the same in 2006 and 2007 although the 2007 survey timing was actually 4 days earlier relative to date of spring warming (Table 4). Similarly, although the 2005 survey was flown almost 5 calendar days earlier than 2006, the timing the 2005 and 2006 surveys were within 0.5 days relative to the chronology of spring warming. To control for the effect of timing on survey results, maintaining a constant calendar date may not be as important as trying to match the relative timing based on the chronology of spring warming each year.

Given the difference in relative timing between the surveys in the 1990s vs. recent surveys, we sought to understand whether estimates differed as a result of detection rates or from geese moving into the area from other locations. Associated with the larger total numbers observed on the 1996 and 1997 surveys compared to the 2005-2007 surveys was that more of the geese were seen in flocks (Fig. 3). As geese flock together later in June, for instance after nest failures, they also become more detectable. Increased visibility likely contributes to the increase in total aerial index count; however adjustment for detection rate differences between singles, pairs, and flocks should counteract that particular bias. Even after our adjustments for detection, the large increase in total geese remained (Fig. 3, Table 3). Thus, higher detection rate of flocks does not appear to account for the difference in estimates from the 1996-1997 to 2005-2007 surveys.

An alternative explanation is that differences in survey timing between the 1990s and the recent surveys influenced the estimate of total geese. Surveys timed too late may overestimate local populations if failed or non-breeding molt migrants from other breeding sites enter the area during the survey (Malecki et al. 1981). On average, molting flocks caught during banding drives in Selawik NWR (2000-2005) are comprised of 97% adults (Fischer 2007), suggesting that the area attracts molt migrants from other breeding sites. Thus, estimates from breeding surveys could be inflated if the survey is not completed prior to influx of molt migrants from other breeding sites which begins in mid to late June (Spindler and Hans 2005).

One way to investigate the hypothesis that non-breeders or failed breeders arrived to the Selawik area from other Interior Alaska sites, is to conduct a second survey timed 3 weeks later than the first survey, or a series of surveys at weekly intervals on a portion of the total area. Influx of non-breeders or failed breeders into the Selawik area likely vary among years as breeding conditions differ in Interior Alaska (in years of poor breeding in Interior Alaska, more flocks would migrate to the Selawik); thus, efforts to compare early and late surveys would require multiple years of data collection that span years of high and low breeding conditions.

Aerial Detection Rate

Acquiring enough aerial survey data to estimate the detection rate for each individual species, group size, day, habitat, and observer is not feasible for this, or perhaps any, aerial survey for a sparsely distributed species. A different problem occurs for situations where sightings are numerous or clumped in their distribution because, although many sightings are possible, the method of matching of observations based on distinct times (locations) becomes untenable. Fortunately, it is not really necessary to identify every factor that can influence detection rates provided the data acquired are proportional to all the survey conditions encountered (i.e. obtained with an adequate systematic sample, as was the case in this survey). In this circumstance, the average detection rate is applicable to the average of sightings across all observations. This approach provides a reasonable correction for underestimation bias in the total population index.

Another year of front- and rear-seat double-count observations is necessary to determine repeatability of these data. Simultaneous double-count aerial transect methodology continues to be explored for various aircraft, habitats, and species. Other attempts include an Alaska black scoter survey (Stehn et. al., in prep), a Nunavut breeding pair survey (Conant et al. 2007), eider surveys on the YKD coast, and Dusky goose surveys on the Copper River Delta. Further investigations should replicate double-count survey observations in a single survey with both instantaneous (in the air) matching and later indirect (computer analysis based on time) matching.

Alternative Indices

Prior efforts to monitor white-fronts in interior and northwest Alaska have yielded variable measures of population abundance and trend. Concerns for the status of white-fronts in the interior and northwest portion of the state were raised in the 1990s following reported regional declines in abundance (Spindler et al. 1999). This decline occurred at a time when population indices on the North Slope of Alaska were stable (Larned et al. 2006, Mallek et al. 2006) and the continental population was increasing (Warner et al. 2007). Subsequent molting surveys in interior Alaska suggest the population has returned to levels observed in the mid-1990s.

Abundance and trend of waterfowl breeding populations is currently monitored in interior and northwest Alaska during the Continental Survey, but the method is not designed specifically to monitor geese. Instead, the Continental Survey is timed to correspond with nest initiation and early incubation of ducks (Smith 1995), later than the optimal time for geese. Sightability of white-fronts decreases significantly in boreal habitats after nest initiation (M. Spindler, pers. comm.). The Continental Survey samples the Kotzebue Sound stratum (northwest Alaska) in early June (unpubl. FWS data; mean June 7, 1964-2007), approximately four weeks after white-fronts have arrived in the region (Shepard 1956, Kessell 1989, Spindler and Hans 2005, unpubl. FWS satellite data). Although white-fronts are currently monitored in northwest Alaska through the Continental Survey, sampling effort is just 16% of the white-front breeding pair survey area, and thus not sensitive to local changes in abundance and distribution. The two surveys have somewhat divergent estimates of pairs and total geese (Figs. 5-6).

The white-front survey should be repeated in May, 2008 to determine whether the estimate of total geese is consistent, and to generate additional data needed to assess factors associated with detection rate. An additional year of data from the white-front breeding pair survey may also help determine whether the population in northwest Alaska can be adequately monitored with the Continental Survey alone.

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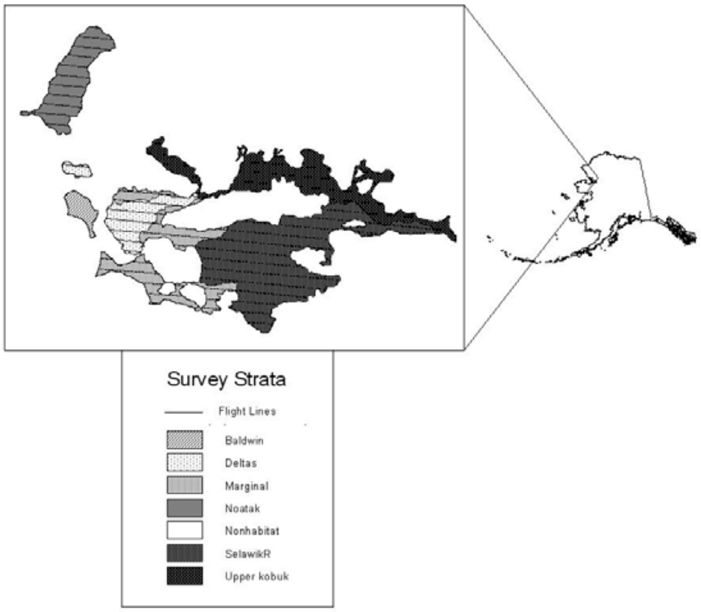

Figure 1. Location of the white-fronted goose breeding pair survey, northwest Alaska, 2005-2007.

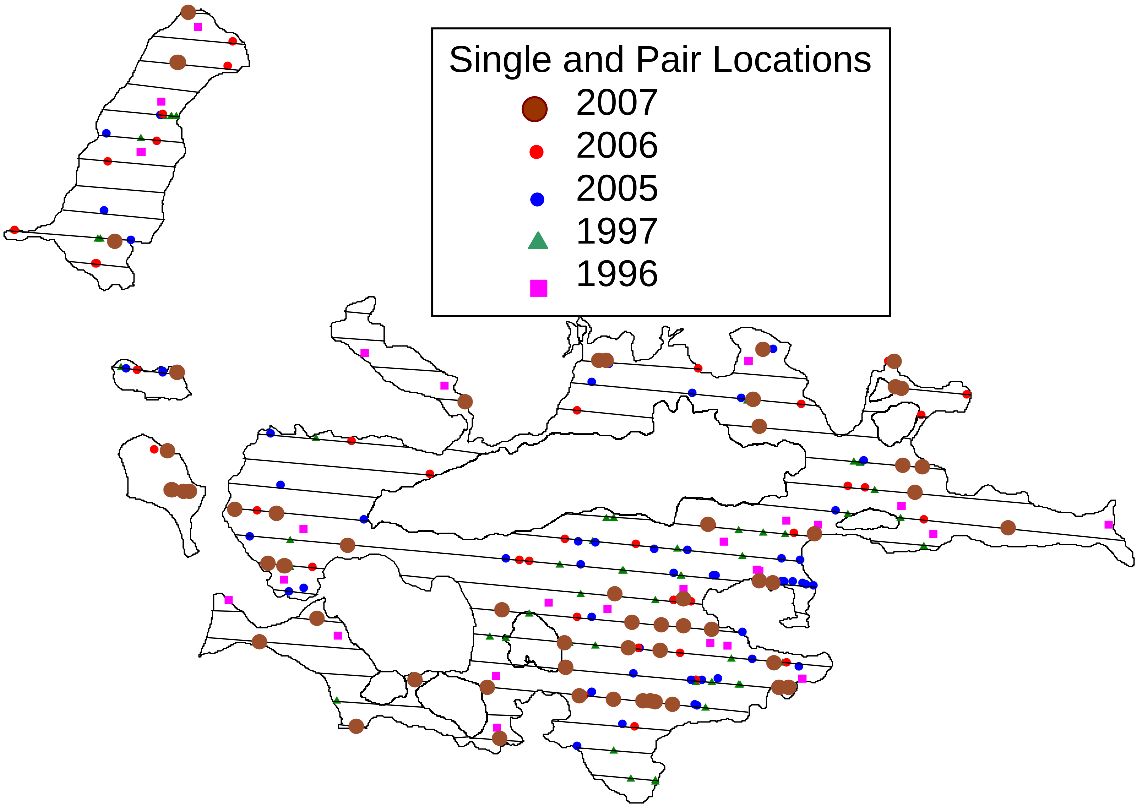

Figure 2. Locations of the 2006 survey transect lines, and indicated white-front pairs (singles and pairs), 1996-1997, and 2005-2007.

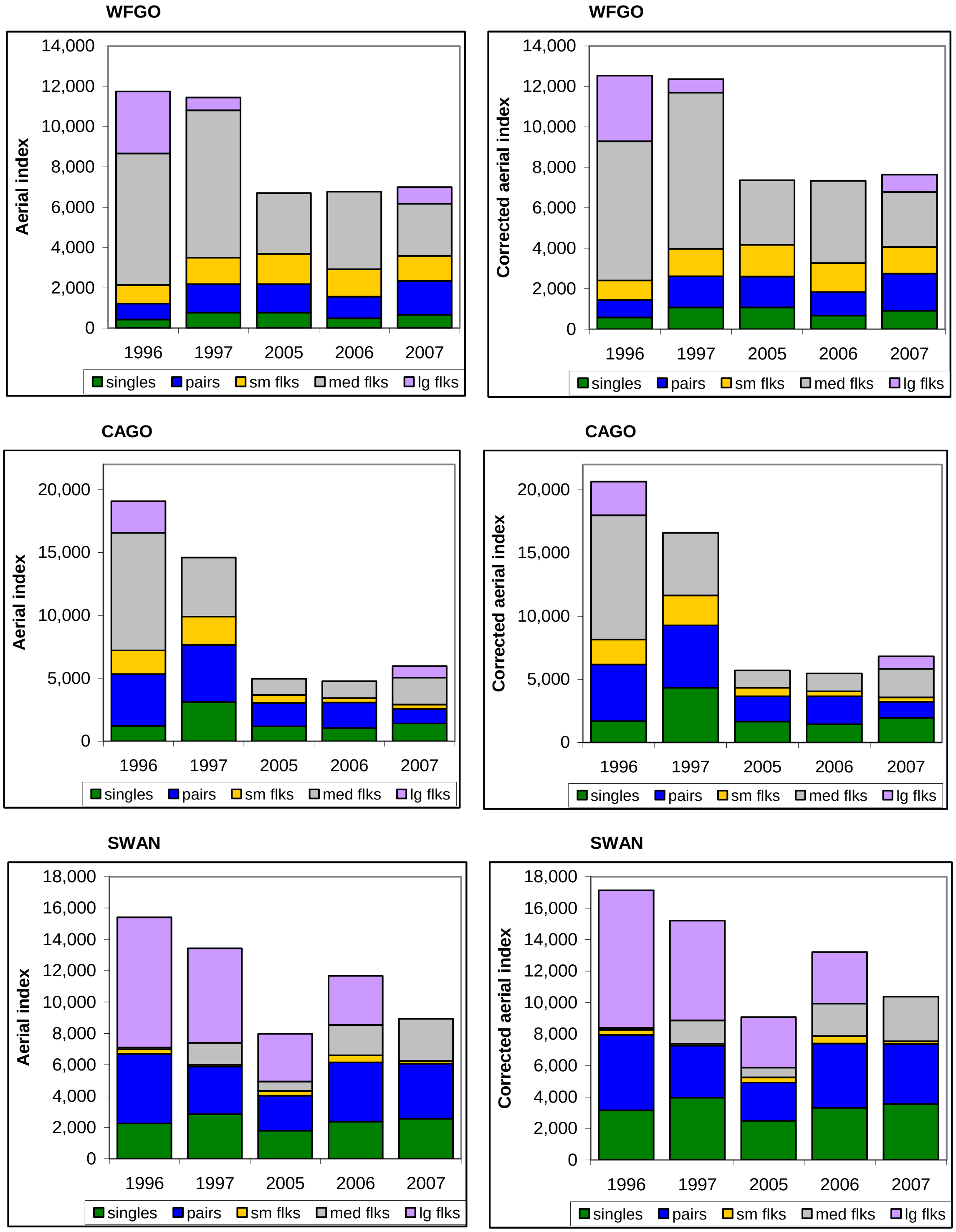

Figure 3. Contribution of various group sizes of singles, pairs, small flocks (3-5), medium flocks (6-30), and large flocks (31+) to the total aerial population indices for 3 main species for each survey year. The graphs on the left show unadjusted aerial indices, while the graphs of the right are corrected in all years by the 2007 detection rates estimated for sightings of singles, pairs, and flocks.

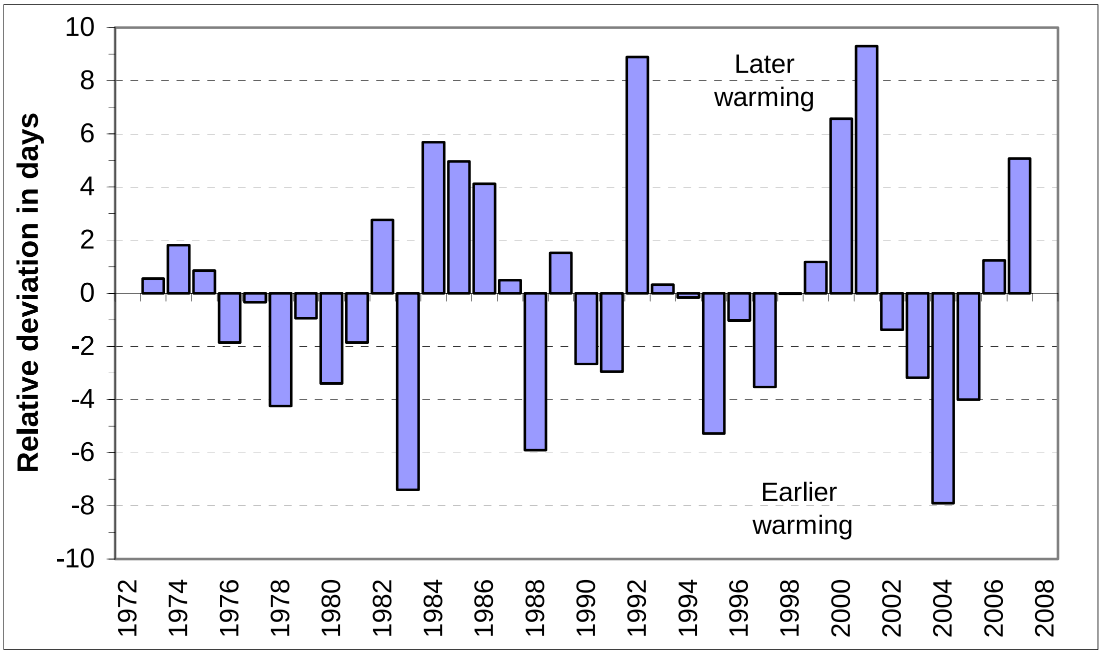

Figure 4. Relative timing of spring warming from 1973-2007 measured as regional average deviations using three spring-warming temperature parameters measured at Kotzebue (PAOT), Selawik (PASK), and Noatak (PAWN) weather stations. The annual deviates from average 1995-2007 conditions (see text) are rescaled to indicate predicted days early (negative) or late (positive) compared to the average clutch initiation date.

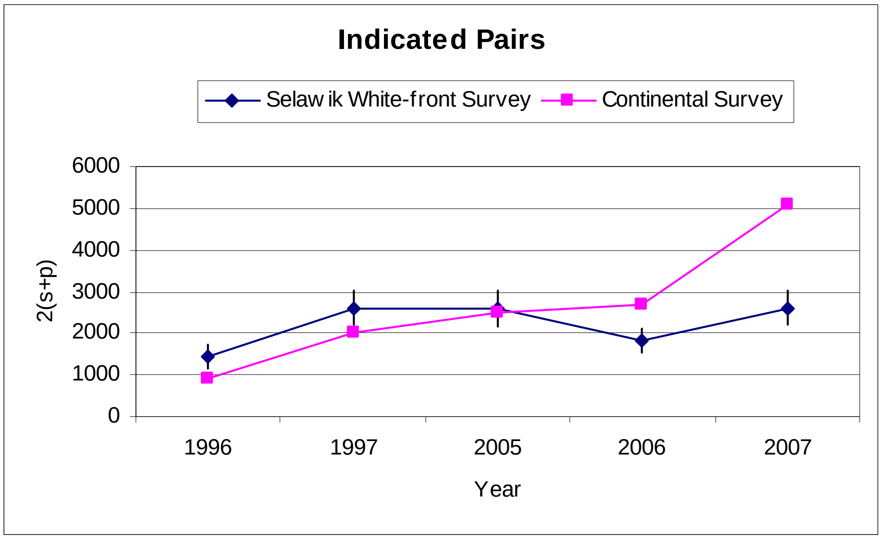

Figure 5. Comparison of indicated paired birds (±SE) estimated during the Selawik white-front surveys (1996-1997, and 2005-2007) and the Continental Survey.

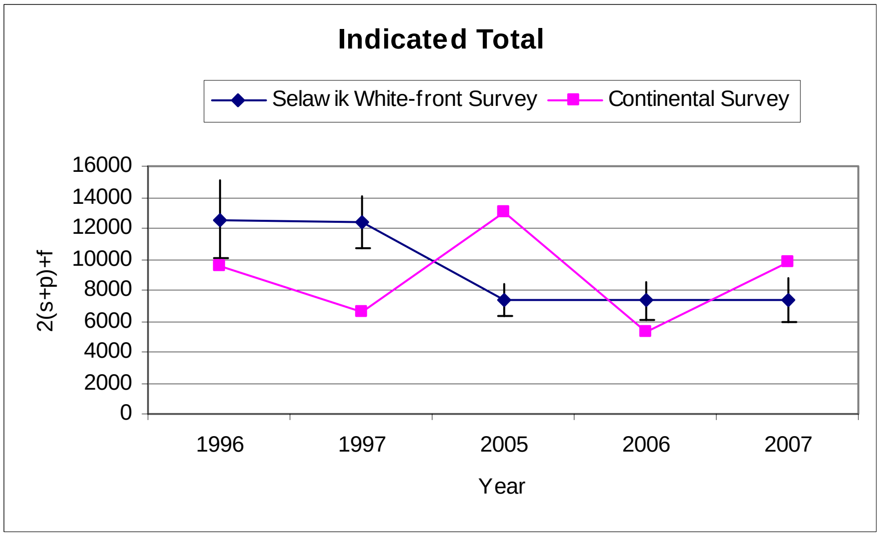

Figure 6. Comparison of total white-fronts (±SE) estimated during the Selawik white-front surveys (1996-1997, and 2005-2007) and the Continental Survey.

Table 1. Relative timing of spring warming 1973-2007 as measured at Kotzebue (PAOT), Selawik (PASK), and Noatak (PAWN) weather stations. The tabulated values are the same three spring-warming temperature parameters that showed the best correlation to Cackling goose clutch initiation dates based on 1991-2007 Hooper Bay daily mean temperatures data. The regional average of the rescaled annual deviates (see text) is expected to indicate days early (negative) or late (positive) compared to the average clutch initiation date.

Year	AvgT_21 on Day 141			Day when TDD >33			Day when AvgT_5 >33F			Regional average deviate
	Kotzebue	Selawik	Noatak	Kotzebue	Selawik	Noatak	Kotzebue	Selawik	Noatak	
1973	28.9			137			135			0.56
1974	29.2			150			131			1.81
1975	26.7			135			132			0.86
1976	32.1			137			123			-1.86
1977	30.6			139			130			-0.33
1978	33.2			129			114			-4.24
1979	32			140			128			-0.94
1980	35.2			131			128			-3.40
1981	33.3			139			125			-1.86
1982	25.8			148			130			2.76
1983	37.6			119			113			-7.40
1984	22.2			155			136			5.69
1985	22.8			146			143			4.97
1986	28.2			151			149			4.12
1987	30.3			139			137			0.49
1988	34.6			123			111			-5.91
1989	26.9			147			123			1.52
1990	34.3			133			129			-2.66
1991	33			130			125			-2.95
1992	17.6			161			142			8.89
1993	29.8			137			136			0.33
1994	31.5			140			134			-0.16
1995	35	38.8		129	128		116	116		-5.28
1996	30.6	32.2	31.1	133	132	134	128	128	130	-1.02
1997	35.9	35.9		130	131		126	128		-3.53
1998	29.1	31.7	30.8	138	134	136	132	131	132	-0.02
1999	27.2	28.4	31.1	140	140	137	134	133	133	1.18
2000	23	21.9	25.3	156	154	152	149	148	140	6.56
2001	19.2	19	18.9	162	158	152	154	153	148	9.30
2002	33.2	35.5	33.7	140	137	139	138	119	129	-1.37
2003	32.9	33.7	33.9	129	129	129	123	117	123	-3.18
2004	37.5	39	39.3	124	125	121	101	101	101	-7.91
2005	32.3	34.1	37.8	131	131	121	119	121	118	-3.99
2006	29.7	28.2	31.4	142	140	138	136	136	136	1.24
2007	24.4	20.6	28.8	153	152	138	145	150	137	5.08
Avg 1995-2007	30.0	30.7	31.1	139.0	137.8	136.1	130.8	129.3	129.7	-0.2

Table 2. Relative timing of spring-warming temperatures 1995-2007, estimated clutch initiation days assuming close similarity YKD relationships and species, and the day of the average aerial survey observation.

Year	Relative deviation in timing of warming	Estimated clutch initiation day	Average aerial observation day	Average interval following clutch initiation to survey day
1995	-5.3	141.2		
1996	-1.0	145.5	171.0	25.5
1997	-3.5	143.0	157.1	14.1
1998	0.0	146.5		
1999	1.2	147.7		
2000	6.6	153.1		
2001	9.3	155.8		
2002	-1.4	145.1		
2003	-3.2	143.3		
2004	-7.9	138.6		
2005	-4.0	142.5	145.9	3.4
2006	1.2	147.7	150.6	2.9
2007	5.1	151.6	150.6	-1.0

Table 3. Aerial population indices of indicated breeding birds, 2*(n singles + n pairs), and indicated total birds (including birds in flocks) observed for Greater White-fronted geese in the Selawik region. Adjusted indices were calculated based on 2007 detection rates for singles, pairs, and flocks applied to all years of surveys. The 2007 data does not include the left-rear observations made on double-count transects.

Year	Transect km2 observed	Breeding bird index	SE breeding bird index	Adj. breeding birds pop	SE breeding birds	Total bird index	SE total bird index	Adj. total pop	SE adj. total pop
Noatak R - 1,896 km^2									
1996	100.3	151	71	187	89	1286	414	1381	439
1997	103.3	294	159	353	180	2111	673	2266	712
2005	101.4	150	66	197	87	729	215	807	232
2006	101.8	298	95	335	108	633	290	688	308
2007	93.5	162	96	201	116	750	274	819	294
Deltas - 1,413 km^2									
1996	74.3	76	55	94	68	152	92	174	104
1997	71.7	118	64	140	78	296	145	327	157
2005	74	267	145	314	173	401	170	455	197
2006	67.2	168	78	209	100	505	282	563	302
2007	55.6	305	141	378	182	407	174	485	212
Marginal - 2,207 km^2									
1996	112	79	55	98	70	985	525	1052	554
1997	123.4	72	47	100	65	72	47	100	65
2005	117.6	75	53	93	65	695	407	745	429
2006	122.5	72	50	89	63	1568	696	1664	734
2007	113.2	273	88	308	102	721	324	780	343
Upper Kobuk - 3,255 km^2									
1996	176.7	258	139	303	157	2303	966	2456	1019
1997	143.4	182	142	211	159	1317	680	1406	718
2005	143.9	317	149	386	182	883	387	981	418
2006	156.7	208	77	238	92	1309	575	1397	607
2007	143.1	546	142	621	165	728	231	812	253
Selawik R - 6,076 km^2									
1996	315.9	654	178	769	212	7021	2086	7471	2199
1997	335.3	1522	261	1809	318	7648	1274	8256	1352
2005	323.8	1351	275	1593	325	3977	670	4358	721
2006	339.6	787	192	943	233	2737	577	2995	618
2007	294.8	948	244	1105	290	4143	1227	4469	1299
Baldwin Peninsula – 386 km^2									
1996									
1997	35.4	0	0	0	0	0	0	0	0
2005									
2006	39.8	19	20	21	21	19	20	21	21
2007	35.7	108	53	131	66	249	126	279	137
Total (without Baldwin) - 14,848 km^2									
1996	779.2	1218	249	**1451**	295	11747	2396	**12534**	2527
1997	777.1	2187	346	**2613**	411	11443	1601	**12355**	1697
2005	760.7	2160	355	**2583**	424	6685	916	**7346**	985
2006	787.8	1533	246	**1814**	298	6752	1145	**7307**	1214
2007	700.2	2234	342	**2614**	410	6749	1331	**7366**	1415

Table 4. Aerial population indices of breeding birds and indicated total birds observed for Greater White-fronted geese (GWFG), Canada geese (CAGO, and Tundra swans (TUSW), Pacific loons (PALO), and Black Scoter (BLSC) in the Selawik region, excluding the Baldwin Peninsula. For the two goose species and scoters, singles are doubled to indicate the undetected mate. Adjusted indices were calculated based on 2007 detection rates for singles, pairs, and flocks of combined geese and swans applied to all years and all species. Annual growth rates (GR) were calculated by loglinear regression for each aerial index measures.

Year	Transect area km^2	Breeding bird index	SE breeding bird index	Adj. breeding bird pop	SE breeding bird pop	Total bird index	SE total bird index	Adj. total pop	SE adj. total pop
GWFG									
1996	779.2	1218	249	1451	295	11747	2396	12534	2527
1997	777.1	2187	346	2613	411	11443	1601	12355	1697
2005	760.7	2160	355	2583	424	6685	916	7346	985
2006	787.8	1533	246	1814	298	6752	1145	7307	1214
2007	700.2	2234	342	2614	410	6749	1331	7366	1415
Growth R=		1.021		1.020		0.946		0.947	
SE GR=		0.028		0.028		0.005		0.004	
CAGO									
1996	779.2	5173	561	5958	650	18915	2889	20423	3054
1997	777.1	7481	655	9046	822	14425	1420	16354	1560
2005	760.7	2959	338	3571	423	4836	825	5547	898
2006	787.8	3000	384	3571	476	4647	653	5305	731
2007	700.2	2557	369	3207	492	5417	1268	6217	1369
Growth R=		0.923		0.926		0.883		0.887	
SE GR=		0.017		0.018		0.014		0.013	
TUSW									
1996	779.2	6349	590	7516	687	15065	4844	16691	5107
1997	777.1	5556	466	6835	587	13088	4817	14764	5081
2005	760.7	3684	402	4534	495	7602	2723	8658	2878
2006	787.8	5804	652	7016	764	11296	2764	12797	2929
2007	700.2	5899	668	7178	804	8759	1621	10188	1750
Growth R=		0.986		0.987		0.957		0.960	
SE GR=		0.022		0.021		0.017		0.016	
PALO									
1996	779.2	3200	339	3787	393	3259	344	3849	398
1997	777.1	2390	262	2999	325	2390	262	2999	325
2005	760.7	1792	253	2114	291	1848	258	2174	296
2006	787.8	1925	270	2264	316	2141	302	2491	346
2007	700.2	2453	395	2804	445	2596	409	2954	458
Growth R=		0.971		0.966		0.976		0.971	
SE GR=		0.018		0.015		0.018		0.016	
BLSC									
1996	779.2	8202	868	9779	1037	8548	901	10144	1069
1997	777.1	9549	948	11278	1118	11617	1269	13455	1428
2005	760.7	5198	803	6100	954	6361	1001	7324	1142
2006	787.8	4077	1128	4492	1229	7082	1709	7656	1827
2007	700.2	1808	661	2029	725	2224	723	2467	788
Growth R=		0.897		0.893		0.917		0.912	