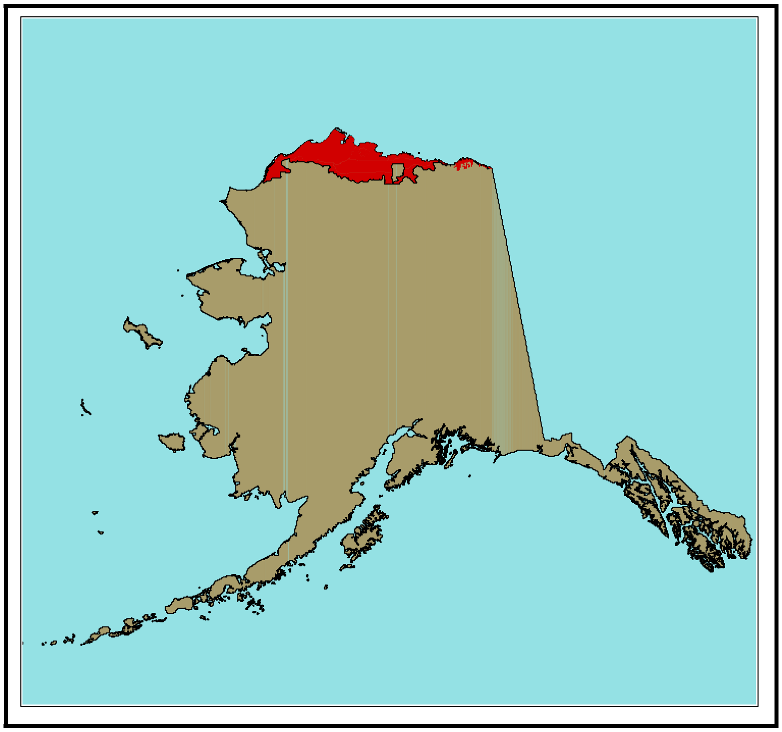
# WATERFOWL BREEDING POPULATION SURVEY
# ARCTIC COASTAL PLAIN, ALASKA
# 2009



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April 7, 2010

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# Arctic Coastal Plain, Alaska 2009

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**ABSTRACT.** Prior to 2007 two distinct waterfowl breeding population aerial surveys were conducted annually to monitor distribution and abundance of waterbirds in wet and moist tundra habitats on the Alaskan Arctic Coastal Plain (ACP). The two surveys differed in their timing and spatial coverage. The North Slope Eider Survey, conducted 1992-2006, was flown in early to mid-June and limited to low wet tundra habitats, primarily to assess and monitor populations of spectacled, king and Steller's eider populations, whose males typically depart for molt migration soon after nest initiation in mid-June. The traditional Arctic Coastal Plain Waterfowl Breeding Population Survey, conducted in late June through early July, 1986-2006, included the eider area plus upland riparian habitats further inland, and was designed to assess and track populations of waterbirds other than eiders, for management purposes including sport and subsistence harvest, and various extractive resource permitting requirements. Comparison of historic data from both surveys led us in 2007 to combine objectives in a single survey that sampled all important ACP habitats during the early to mid-June period. The 57,336 km$^2$ survey area was divided into 20 geographic strata reflecting differences in waterfowl habitat, historic breeding densities and location of oil and gas leasing tracts. Survey methods were unchanged from previous surveys except that we assigned each stratum 1 of 4 levels of sampling intensity instead of the previous uniform intensity throughout. Survey data were analyzed separately for two geographic units. Data from all 20 strata were analyzed to index current year waterbird populations and distribution for the entire ACP, using Alaska tundra visibility correction factors, while a 10-statum subset (eider strata) corresponding to the 1992-2006 eider survey area was used to estimate recent and long-term population trends of all species including eiders. The latter data subset was selected for trend calculation because of its homogeneity in survey timing. We tested for population growth rates significantly greater or less than 1.0 (with significance probability <0.10) for all survey years (1992-2009) and for the most recent 10 years (2000-2009). Of these, the 1992-2009 growth rates for Red-throated loon and spectacled eider were <1.0, while those for yellow-billed loon, scaup, king eider, greater white-fronted goose and tundra swan were >1.0. During the most recent 10 years, no priority species had growth rates <1.0, while growth rates of yellow-billed loon, scaup, king eider, white-fronted goose and tundra swan were >1.0. The 2009 spectacled eider index (5,525) was below the 17-year mean (6, 540). Yellow-billed loon and king eider indices (1,693, 19,989, respectively) were the highest on record for the eider strata, while the spectacled eider index (5,018 for eider strata) was the second lowest on record. Indices for greater white-fronted geese and tundra swans have been well above historic levels for three consecutive years.

**Key Words:** aerial survey, Alaska, arctic, breeding, distribution, eider, nesting, population, waterfowl

## INTRODUCTION

From 1992 to 2006, two aerial waterfowl breeding pair surveys were conducted on the Arctic Coastal Plain (ACP) during the month of June. The first was a comprehensive aerial waterfowl breeding population survey initiated in 1986, and continued annually to 2006. That survey (herein referred to as the "Standard ACP Survey"), was conducted from late June through early July. This timing was selected based both to target what was believed by the survey crew to be the optimal window to assess the abundance and breeding distribution of the majority of waterfowl species considered high priority at the time, and to avoid scheduling conflict with other spring surveys. It soon became evident that late June missed the optimal timing for eiders, the males of which typically begin to depart the breeding grounds for the post-nuptial molt soon after nest initiation, about 20 June ± one week, but there was relatively little management interest in those species. However, in response to a petition to list spectacled and Steller's eiders under the Endangered Species Act, the North Slope Eider Survey was initiated in 1992, timed in early to mid June to coincide with the peak presence of males on the breeding grounds, and designed to assess and monitor the abundance and distribution of eiders. The North Slope Eider Survey survey has consistently provided useful data for spectacled eiders, king eiders, and other water birds but has yielded imprecise Steller's eider estimates due to that species' very low breeding densities and clumped distribution.

Subsequent comparison of data sets from the two surveys (Larned et al. 2009) suggested that the earlier timing window of the North Slope Eider Survey may actually be optimal for most waterfowl species, possibly because it occurs prior to the main period of nest failure and subsequent local and regional redistribution of birds from breeding to molting areas. We therefore consolidated the two surveys into a single survey in 2007, with geographically stratified coverage roughly equivalent to that of the Standard ACP survey, but timed in early to mid June.

The new survey is titled the "Waterfowl Breeding Population Survey, Arctic Coastal Plain, Alaska", and referred to in this report as the "ACP Survey". This report describes the methods and results of the 2009 ACP survey. For the sake of continuity, long-term trends were calculated and presented using historical data from the North Slope Eider Survey and the current survey from the 10 survey strata matching the geographic extent of the North Slope Eider Survey (eider strata). This is appropriate since the timing of the current ACP Survey matches that of the North Slope Eider Survey. Long-term means from the Standard ACP Survey and 2008 and 2009 indices from all strata in the current ACP survey are also provided for total ACP context.

## OBJECTIVES

Objectives for the 2009 ACP Survey relate to the Spectacled Eider Recovery Plan (U. S. Fish and Wildlife Service 1996), evaluation of the potential impacts of extractive resource development to migratory birds, and USDOI obligations for annual assessment of harvested waterfowl populations under the Migratory Bird Treaty Act of 1918, as follows:

### Spectacled Eider Recovery Plan

*B1.4. Monitor trends and generate breeding pair abundance estimates for the [North Slope] spectacled eider breeding population.*

This task relates to the decision criteria for future de-listing or reclassifying from Threatened to Endangered. These criteria are based on population growth rate and the minimum abundance estimate, which is defined as the greater of the lower end of the 95% confidence interval from the best available estimates, or the actual number of birds counted.

Specific objectives:

1. Determine the population trend for spectacled eiders in light of recovery and reclassification criteria, including power analysis.

2. Estimate the abundance of spectacled eiders observable from the air.

### Evaluation of potential impacts of oil and gas development on water bird resources

Describe the distribution of observed spectacled eiders and other water birds within 500 meters of actual location, covering all known important waterfowl habitat on a rotational basis each 4 years using a systematic grid sampling frame. Use data to produce point location and density polygon maps describing location of observed water birds and areas with specified ranges of multi-year mean peak breeding density.

### Migratory Bird Treaty Act obligations

Estimate the annual breeding population of harvested waterfowl species using the protocol specified in the "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America" (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987), including extrapolation using standard Alaskan tundra detection ratios.

## STUDY AREA AND METHODS

**Aerial crew for 2009**:

**William Larned**, *Migratory Bird Management, Soldotna, Alaska*

**Robert MacDonald,** *Migratory Bird Management, Juneau, Alaska*

### Study area, survey design, navigation, and observation

The 2009 ACP Survey area (Fig. 1) has been consistent subsequent to survey redesign in 2007, and consists of a 57,336 km$^2$ portion of the 61,645 km$^2$ historic Standard ACP Survey area. Small areas (total 4,309 km$^2$) of relatively unproductive upland habitat were deleted from the standard ACP survey in 2007 to increase operational efficiency. Procedures followed the standard protocol described in the "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America" (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1987). A series of transects, oriented in an east-west direction (Fig. 1), were flown in a Cessna model 206 amphibious aircraft, at 38 m altitude and 176±19km/hr ground speed. Both the pilot and the starboard observer recorded all water birds, avian predators and shorebirds observed within 200m either side of the flight path. Observers used tape markers placed on the aircraft lift struts to aid in determining the outer transect boundaries. Viewing angle was determined trigonometrically, and a clinometer was used to position the tape for each observer.

Transects consisted of computer-generated great-circle segments, for compatibility with Global Positioning System (GPS) navigation. Transects were spaced systematically in each of 20 geographic strata from a randomly-selected starting point. Spacing varied by stratum, in 4 categories of sampling intensity: Low (9.5 km), Medium (4.75 km), High (2.375 km) and Super High (1.1875 km). Stratification and spacing assignments were based on a combination of physiographic (mostly hydrographic) characteristics, historic waterfowl breeding density data, and in the Teshekpuk Lake region, boundaries of planning areas for current and proposed oil and gas leases. In each stratum every fourth transect is flown in a given year; the sampling frame shifted incrementally the following year. Four years are required for coverage of all transects, after which the cycle will be repeated; thus transects flown in 2009 will be flown again in 2013. Annual sampling intensity varies by stratum from about 1-9% (Table 1). Stratification slightly decreased variance of estimates of some species, and facilitates comparisons among geographic areas. Transects flown in 2009 are depicted in Fig. 1.

Flight time required to complete the 2009 ACP Survey was 43.3hours, not including ferry time to and from the survey area.

### Data recording and transcription

Each observer had a notebook computer, into which bird observations were entered vocally via a remote microphone. Each computer received position data concurrently from a GPS receiver mounted in the aircraft instrument panel, and was supplied with power via a DC to AC power inverter connected to the aircraft's electrical system. The vocal and GPS inputs resulted in a sound file (.wav format) with voice recording, and a linked position file containing location, date and time. After the flight, the observer played back the sound file on the computer and entered the species name and group size for each observation using a custom transcribing program. The transcription program produced an ASCII text file, each line of which contained a species code, group size, geographic coordinates, date, time, observer code, observer position in aircraft, stratum and transect identifier. The system also created a "track file" containing a list of geographic coordinates for the aircraft recorded every five seconds during flight. These data files were used to produce maps, tables and other products describing population trends and distribution of the various taxa surveyed. The custom software used for this system was developed by John I. Hodges, U.S. Fish and Wildlife Service, Migratory Bird Management, 3000 Vintage Blvd., Suite 240, Juneau, AK 99801-7100.

Waterfowl data were treated according to the protocol described for the Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). That is, for all ducks except scaup, the indicated total population index is calculated as twice the number of males observed as singles, in pairs, and in groups of males up to four, plus birds in flocks of 5 or more regardless of sex composition. Male scaup not visibly paired are not doubled according to protocol, as scaup are known to have sex ratios strongly skewed toward males (ibid.). The protocol prescribes indices of all other waterbird species to consist of total birds recorded, with single birds not doubled. However, we deviated from this protocol by doubling the less visible single dark geese and cranes (white-fronted geese, Canada geese, black brant, and sandhill cranes) to account for assumed undetected mates on nests, while the more visible snow geese and swans are not doubled. All indices were geographically extrapolated.

## Data Analysis

We provide an index to the number of individuals of each waterfowl species and other selected bird species present within the survey area. The term <u>index</u> as used here is defined as a number that represents an unknown proportion of the population of birds occupying the survey area during the nesting season and detected by the observers. While unknown, the proportion is assumed to be constant among years, and the index is used to help track population changes through time.

Variances of mean density within strata were calculated using a ratio estimator accounting for the unequal length transects within each stratum. Total survey area variance is the sum of the strata variances. The variance reflects the sampling error associated with geographic variation in density among transects and other differences such as variation in observation conditions during the day or days of observation within each stratum. Differences between strata, phenological timing, years, observer effects, and detection rates are not included in the measured variance.

Average annual growth rates of species estimates among years were calculated by log-linear regression (Table 5, Figs. 3-20). For calculation of power we used alpha = 0.10, beta = 0.20, and a coefficient of variation based on either regression residuals or averaged annual sampling error.

To be consistent with the standard waterfowl breeding population survey protocol, we provided columns of duck indices expanded using visibility correction factors (tables 3,4 and 6) derived during a three-year helicopter/fixed wing study conducted in tundra habitat on the Yukon-Kuskokwim Delta (Conant et al. 1991). This is designed to provide a more realistic estimate of true population by accounting for birds present but not detected by observers in fixed wing aircraft. Untested assumptions were: 1. the helicopter crew recorded all birds present, 2. observers are equal in performance, and 3. detection rates of ducks in the Yukon-Kuskokwim Delta are similar to those in the ACP. Eiders were not included in the YK delta study, so no VCF is applied for these species.

**Bias**

Indices are subject to biases typically associated with aerial survey data collection. Bias in this survey comes primarily from three sources: 1. *sampling error* due to variability among the transects within each sampling stratum, 2. *mistiming* of the survey relative to bird breeding phenology, or asynchronous bird phenology, and 3. variation in *detection rate* of birds. In this survey s*ampling error* was estimated by ratio estimate procedures described by Cochran (1977), and the calculated variance is used to produce 95% confidence intervals for the population estimates. Survey *timing* is designed to coincide with the peak presence of males in the case of ducks, and the presence of peak numbers of all surveyed species on breeding territories in intact pairs. Proper timing is especially important for eiders, the males of which are normally present on the breeding grounds only from arrival until shortly after nest initiation, when they move offshore for the postnuptial molt (Kistchinski and Flint 1974, Lamothe in Johnson and Herter 1989, for spectacled and king eider, respectively). Variations in timing of arrival and departure between individual spectacled eider males on a study area in the Prudhoe Bay vicinity suggest that there may be few, if any, days when all breeding males are present in the survey area at the same time, especially in years of early spring melt (Troy 1997). Median nest initiation dates for Spectacled eiders at Prudhoe Bay from 1993 to 1996 varied from 7 to 16 June (average 1982-96 = 15 June), and telemetry data suggest that male departure begins within about 3 days of that date, and is more synchronized in the years when it commences later (ibid.). Most spectacled eider males departed the tundra for offshore molting areas by 20 to 25 June in Troy's Prudhoe Bay study (ibid.).

Aerial observations from the North Slope Eider Survey strata since 1992 suggest timing of male departure is constant within approximately ±1 week among areas and years. Phenological synchrony seems logical for spectacled eiders, which winter together in a small area near St. Lawrence Island (Petersen et al. 1999). King eider phenology is similar, but the period of male presence is normally more protracted and less synchronous than that of spectacled eiders, perhaps because: 1. king eiders utilize a greater diversity of wetland types which thaw at different times, and 2. king eiders that breed on the ACP are widely distributed during the winter (A. Powell and S. Oppel, pers. comm.., Phillips 2005), and it is unlikely that timing of spring migration and other breeding events would be closely synchronous among dispersed wintering populations. Daily counts of male king eiders on a study area immediately southeast of Teshekpuk Lake in 2002 indicated a stable presence from June 8 to 16, with rapid departure of most males on 18 June (L. Phillips, pers. comm.). On 18 June a brief spike in the number of males present suggested a transient group of departing males moving through the study area. An earlier study in Canada found males departing from Bathurst Island, N.W.T. rather abruptly and synchronously from one week to 10 days after clutch initiation (Lamothe 1973). For the North Slope Eider Survey and current ACP

Survey we assumed that proper timing for spectacled eiders is adequate for king eiders.

Our procedure for determining optimal survey timing consisted of the following: 1. We monitored weather, ice and snow cover data, planning to arrive in the survey area when fresh water and nesting cover were just becoming available to waterfowl over most of the arctic slope; 2. We contacted biologists in Prudhoe Bay and Barrow for their observations on waterfowl phenology; 3. Upon arrival, we flew a reconnaissance survey for a final check to make sure waterfowl, spectacled eiders in particular, appeared to be occupying breeding territories as pairs, rather than in mixed-sex/species flocks.

To evaluate retrospectively the appropriateness of the timing of our survey for comparison of data quality among years for spectacled and king eiders, and long-tailed ducks and northern pintails, we used a ratio of lone drakes (males unaccompanied by females) to total males (with and without females), averaged over the entire survey. This ratio, called the lone-drake index (LDI), was used for many years in the northern prairies of Canada and the U. S. (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). The assumption inherent in this index is that the proportion of lone or grouped males in the surveyed population will increase as the season progresses because males remain visible on breeding ponds, while females spend more time with nesting activities. This index is easy to interpret for dabbling ducks that normally remain on the breeding grounds after nest initiation to molt in local wetlands, whereas male eiders and other sea ducks depart the breeding grounds for distant, mostly marine molting habitats immediately after nest initiation, making them unavailable for observation. Hence, it is expected that the ratio will reach a peak at or slightly beyond the peak of nest initiation, followed by an abrupt drop as post-breeding males depart the survey area, while birds still visible may be mostly unsuccessful inexperienced pairs that stay on the breeding grounds beyond peak departure of successful males. This pattern has been observed in the Prudhoe Bay area (Warnock and Troy 1992). We consider the average lone drake ratio for the survey period and a plot of daily totals of this ratio helpful when considered in combination with other indicators of phenology, especially for the beginning of the survey window.

Detection bias is unaccounted for in the current survey analysis. The survey is assumed to track the populations of birds that visit the ACP during the breeding season. Of this total, some birds will not be represented in the sample because: 1. They have not yet arrived in the survey area; 2. They have left the survey area; 3. They have flushed from the sample transect before detection due to disturbance by the survey aircraft; 4. They are not visible from the aircraft (hidden by vegetation, terrain, aircraft fuselage etc.); 5. They are misidentified; 6. Observers fail to see them due to any of several variables including fatigue, experience level, visual acuity differences, distractions, sunlight conditions, presence or absence of snow and ice, cryptic bird behavior, and work load (density of other birds or objects competing for the observer's attention). As previously mentioned, we have attempted to minimize the effects of numbers 1 and 2 by proper survey timing. Aerial survey crews working in other areas have attempted to compensate for the net effect of all the other variables by ground-truthing a representative sub-sample using ground or helicopter crews (US Fish and Wildlife Service and Canadian Wildlife Service 1987), and using those data to calculate visibility ratios to adjust operational survey data. During the 2001 Eider Survey we conducted a fixed-wing/helicopter detection study covering a 270 $km^2$ subset of our operational transects. The results of this study were unsatisfactory in that our fixed-wing count often exceeded the helicopter count, suggesting a flaw in design or implementation.

Therefore we use an unadjusted annual index to abundance, for which we strive to minimize effects of observer bias by using the same methods and observers among years, to the extent possible. This year we analyzed data from individual observers as well as that from combined observers to examine the relative contribution of observer effect to variation of results among species.

## RESULTS

### Habitat conditions, survey schedule

Imagery from the NASA Modis Rapid Response website (http://rapidfire.sci.gsfc.nasa.gov/) indicated most snow cover was gone from the tundra by late May, though most ponds remained at least partially frozen until the second week of June. Also, the satellite images showed extensive continuous shore fast sea ice persisting along the Beaufort coast from Barrow to east of Prudhoe Bay until past mid-June, and few extensive leads in the Chukchi until about 17 June as well.

A reconnaissance flight on 6 June revealed eiders and other species well dispersed on ponds, so we began the survey on 7 June. Weather during the survey was typical of mid-June, with fog and low ceilings delaying daily survey departures most days until noon or later, and often persisting along the Chukchi coast through most of the day. Wind was generally moderate, exceeding 20 knots for portions of only 2 days. We lost one complete day due to fog and low ceilings (14 June) while staying in Atqasuk, and completed the survey on 15 June.

The overall ratio of lone males to total males during the survey (LDI), a rough measure of survey timing in relation to nest initiation, was average for spectacled eiders, slightly above average for long-tailed duck and pintail, and slightly below average for king eider, suggesting average timing overall for the 2009 survey (Table 2). The daily trend in LDI through the survey period in 2009 showed a slight upward slope for spectacled eider, long-tailed duck and pintail, and a steep slope for king eider (Fig. 2). This is consistent with most other recent years, suggesting comparable survey timing in relation to post-nest-initiation departure of males (Figure 4).

In summary, we feel satellite imagery, observations during the survey, and LDI interpretation all suggest a survey well timed for describing the breeding abundance and distribution of waterbirds on the ACP in 2009.

### Population indices for selected species

Totals for 2009 sample data (singles, pairs and flocked birds in the sample), as well as indices calculated from these data, are presented in Table 3 for the eider strata (strata 3-6, 9, 11, 15, 18-20), and Table 4 for all strata. Table 5 presents long-term population trend slopes, growth rates, and the power of the survey to detect trends (expressed as the minimum number of years required to detect a growth rate equivalent to a population growth or decline of 50 percent in 20 years), using data from the eider strata only. Table 6 provides a comparison of indices from all surveyed strata (2009) with 2008 indices and 1986-2006 means from the historic Standard ACP Survey (Mallek et al. 2007). Figures 3-20 include stacked bar graphs and tables describing the size and composition of the 2009 and historic population indices for selected species for the 10 eider strata. Column divisions separate the sample into singles, assumed mates of singles, and birds in pairs, small flocks (≤5 birds) medium flocks (6-30 birds), and large flocks (>30 birds). We used only data from Eider strata (and North Slope Eider Survey 1992-2006) for trend because of the similarity of timing and geographic coverage. Population growth rates are given both for the full 18 years of data (17 for eiders, see figs. 14 & 15) and for the most recent 10 years. In addition to composite indices (black lines), bar graphs include depictions of indices derived from data from individual observers: the blue lines represent indices from observer Larned, who observed on all North Slope Eider Surveys 1992-2006, and ACP surveys 2007-2009 mostly from the left front (pilot's) seat, while the red lines trace indices from various other observers who usually occupied the right front seat. The CONCLUSIONS section contains some general observations about apparent observer effects suggested by these graphics.

Spatial breeding distribution for the more abundant species has been well described at a scale commensurate with the 4-year sampling intensity (~8 percent for the historic Standard ACP Survey and 16 percent for the North Slope Eider Survey) in past annual reports from both historic surveys. Since the data set from the current design contains only three years of data, we will not generate equivalent figures showing species density isopleths until year 2010, when we have accumulated a complete 4-year data set. However, we have included maps depicting distribution of observations of 10 selected species from 2008 and 2009 surveys (Figs. 21-30). Maps showing locations of other species may be generated on request (william_larned@fws.gov, or call 907-260-0124).

Following are results and comments by species. Indices and trends refer to data from the eider strata and North Slope Eider Survey only, unless otherwise noted.

Loons

The 2009 yellow-billed loon index (1,693) is the highest index in the 18 years of the survey, 47% above the long-term mean, and the population growth rate indicates a significant positive trend over both the long term and most recent 10 year reference periods (Tables 3-5, Figure 3). Distribution was similar to that of 2008 and other years: highest density in the area between Teshekpuk Lake and the Topogoruk River (Fig. 21). The Pacific loon index (27,276) is the second highest for the survey, and 28% above the long-term average (Tables 3-5, Fig. 4). Neither the 18-year nor the 10-year growth rate differs significantly from 1.0 (Table 5). Pacific loons are abundant throughout most of the ACP where there are high pond densities. The 2009 red-throated loon index (2,585) increased by 30% from that of 2008, and is approximately equal to the 18-year mean (Table 3, Fig. 5). Long term data from the eider survey area shows a significant negative trend for this species, but is level over the most recent 10 years (Fig. 5). Distribution of survey observations of red-throated loon observations is predominately coastal, with the exception of the central arctic between Atqasuk and Nuiqsut, where they occur further inland, chiefly associated with river flood plains (Fig. 22). Our observations on habitat selection are consistent with those of Bergman and Derksen (1977); that is, red-throated loons on the ACP tend to select wetlands smaller and shallower than other loon species. This apparent partitioning of wetlands by size among loon species may result from interspecific competition for breeding territories. While red-throated loons may be driven from larger lakes by territorial Pacific loons, unlike the latter, their very short takeoff distance requirements (15-40m, Norberg and Norberg 1971), and their propensity for flying to marine or riverine habitats to forage for themselves and their young enables them to use small wetlands devoid of fish for nesting and brood-rearing. In the absence of competition from other loons, red-throated loons have been observed to select breeding territories independently of wetland size (Douglas and Reimchen 1988).

Jaegers

Jaeger species are combined for this survey to help avoid diversion of observer focus from eiders and other high priority species. The jaeger index fluctuates widely following prey abundance (primarily North American brown lemming, *Lemmus trimucronatus*). The jaeger index spiked across much of the arctic coastal plain in 2006, but since has returned to a number close to the long-term mean (Fig. 6). Our 2009 jaeger index (3,666) is 12% below the 1992-2009 mean of 4,155 (Tables 3-5, Fig. 6). The extremely variable annual index does not indicate a significant trend in either short or long term (Table 5, Fig. 6).

Gulls & terns

Discounting birds in flocks, a category whose annual value can vary widely if the year's transects happen to cross large breeding colonies or transient flocks, the glaucous gull index has remained essentially level and stable in both short and long terms (Tables 3-5, Fig. 7). The 2009 total index of 13,246 is 5% above the long-term mean. The 2009 Sabine's gull index (12,429) is the highest in the survey's history, and 26% above that of 2008 and 69% above the 18-year mean (Tables 3-5, Fig. 8). This species showed a significant positive growth rate over both long-term and most recent 10 years. The arctic tern index increased steadily through 2000, resulting in a significant positive long-term growth rate (Table 5). The trend has been erratic, but nearly level on average since 2000 (Table 5, Fig. 9). The 2009 index (13,593, Fig. 9) is 26% above the 18-year mean.

Ducks

Most duck indices in 2009 were consistent with trends established over the last several years of the North Slope Eider and ACP Survey (Figs. 10-16). The 2009 red-breasted merganser index (752) was 27% above that of 2008, 53% above the long-term mean, and the species has a significant positive growth rate over both 17 year and most recent 10-year time periods (Tables 3-6, Fig. 11). However, the 2008 and 2009 all-strata estimates were both below the long term average figure for the historic Standard ACP Survey (Table 6), suggesting a late migration pattern for this species, and possibly a recent trend toward earlier nesting related to climate change. Most red-breasted mergansers have been recorded along river corridors, well inland.

Mallard, American wigeon, green-winged teal and northern shoveler are recorded at such low numbers that we have little confidence in trends (Table 5). Observations of all four species in 2009 were widely scattered throughout the survey area.

The 2009 northern pintail index (40,451) is 32% lower than that of 2008, and 18% below the long-term average for the eider strata (Table 5, Fig. 11). Though an in-depth analysis has not been conducted, inspection suggests data sets from the North Slope Eider Survey and the standard ACP Survey both have high inter-annual variation, and the two indices are not strongly correlated among years (Mallek et al. 2007, Fig. 11 this report). Pintails are known to be mobile both within and among breeding seasons. Since the two surveys were conducted at substantially different times in June, the variability within and among these two annual surveys might be explained by movements of large numbers of birds within the ACP and/or between the ACP and other portions of the breeding range during June. These questions and the very strong male bias of the ACP spring pintail population provide fertile ground for further study, but so far the long-term trajectory does not warrant concern (Fig. 11).

The all-strata 2009 pintail index (171,023, expanded) is 32% below the 2008 index, and 22% below the long-term mean of 220,494 from the 1986-2006 ACP survey (Table 6). In 2009 the highest densities of pintails were recorded in the central portions of the survey area, within about 60 km of the coast (Fig. 23).

The 2009 scaup index (7,145) dropped 38% from last year's record high, but remains 49% above the l8-year mean (Fig. 12). The species continues to show a significant positive growth rate over both the long term and most recent 10 year period (Table 5, Fig. 13). With a 2009 expanded total ACP index of 34,147, scaup still rank as the third most abundant duck behind northern pintail and long-tailed duck (Table 6). Most ACP scaup are generally believed to be greater scaup, and our occasional close encounter with birds in flight appears consistent with that hypothesis based on wing color patterns, but species discrimination of scaup on aerial surveys is not considered reliable. Given the concerns about continental scaup populations, we believe this apparently expanding population warrants investigation into species composition and flyway affinities.

Based on our data, scaup appeared most abundant in the central Alaska arctic, in wetlands associated with major drainages (Fig. 24).

The 2009 long-tailed duck eider strata index (33,950) is 2% above that of 2008, and 11% above the 18-year mean (Fig. 13), however the all-strata expanded index (91,278) is 15% below the 1986-2006 ACP mean (Table 6). The population index growth rate for the eider strata is insignificantly <1.0 for both the 18-year (0.990) and most recent 10 year (0.986) periods (Table 5, Fig. 13).

Aerial observations of this species, with regard to discriminating males from females and groups of males from pairs, are difficult to accurately interpret due to color similarities between male and female breeding plumage. Perhaps this explains the large and variable discrepancies among observers (Fig. 13). This species is the second most abundant of ACP ducks, and is very uniformly dispersed throughout most of the Arctic Slope (Fig. 25).

The 2009 spectacled eider index (5,018) was 19% lower than that of 2008, and 23% below the 17-year mean (Table 3, Fig. 14). The negative growth rate is nearly identical over the long term and most recent 10 years (0.985, 0.977 respectively), but is significant only in the long term (95%CI=0.971-0.999, Fig. 14). Twelve of 272 indicated birds in the sample were recorded outside the 10 eider strata, which was similar to 2007 and 2008 (Tables 3, 4). The distribution of 2009 spectacled eider observations is grossly similar to that of 2008 and most other survey years (Fig. 27). It is difficult to visually compare population densities using Fig. 27 and other maps in this report due to differences in sampling intensity among strata. However, in comparing calculated densities of spectacled eiders among strata in the 10 eider strata, Stratum 19 (immediately north of Teshekpuk Lake, Fig. 1) is highest in 2009, at 0.37 bird/km$^2$. The average density of all eider strata is 0.17. There was a similar pattern in 2008, but prior to that the densities of spectacled eiders along the Chukchi coast were normally higher than those north of Teshekpuk Lake. If the 2008-9 pattern holds for 2010 we will look at it in more detail.

The 2009 king eider index (19,989) is 23% higher than that of 2008, 45% above the long-term mean, and the highest on record for the Eider Survey (Fig. 15). Our data show a consistent and significant increasing trend in both the long-term and recent 10-year reference periods (Table 5, Fig. 15). A map of survey observations clearly illustrates a continuing preference for the area immediately south and east of Teshekpuk Lake, to the western portion of the Coleville Delta (Fig. 18).

Though common eiders are recorded during this survey, they nest primarily on barrier islands and other coastal habitats, which are not sampled adequately by this survey. A specific coastal survey is conducted annually for this species, by C. Dau and others (Dau and Larned 2008).

There are so few Steller's eiders detected during this survey that resulting data are used primarily to document occurrence and long-term distribution rather than a meaningful trend. Intensive aerial surveys (50% coverage) conducted by ABR Inc. in the Barrow area annually since 1999 were conducted again in

2009. This year the ABR crew did not record a single Steller's eider observation during that effort (Obritschkewitsch pers. comm.). We observed one pair of Steller's eider during our survey in 2009, near Gaswell Road about 5 miles east of Barrow, which was extrapolated to a total ACP estimate of 47 birds (Table 4).

White-winged scoters have made up most of the scoter population observed during the eider survey since 1992. In 2009, only 4 indicated white-winged scoters were recorded in the eider strata (Table 3), compared to 38 in the ACP (all) strata. All were seen south of Teshekpuk Lake, primarily along the drainages of Fish Creek and the Ikpikpuk River, a distribution similar to other years of this survey. The 2009 white-winged scoter index (201) was 39% below the long-term mean, but 8% above the 2008 index (Fig. 16). The all-strata index (expanded) of 2,950 was 38% below that of 2008 (Table 6). Note that the data from the historic Standard ACP Survey contains a large component of scoters unidentified to species, hence the discrepancy between "all scoters" and the total of white-winged and black scoters (Table 6).

Geese and swans

This survey does not adequately sample snow geese, which occur mainly in isolated coastal breeding colonies. Our estimates fluctuate widely in response to transect placement relative to these colonies. Aerial snow goose colony surveys conducted by ABR Inc. indicate strong positive growth rates for most individual colonies and the overall ACP breeding population (Ritchie et al. 2002, 2007)

2009 was the 3rd consecutive year of unusually high estimates of white-fronted geese in the arctic coastal plain (Fig. 17). The 2009 index for the eider strata (159,188) exceeds the 17-year mean index by 81%, while the all-strata index (222,891, Tables 4, 6) is 6% greater than that of 2008, and exceeds the highest index from the standard ACP Survey (192,426 in 1999, Mallek et al. 2007). The trends are significantly positive in both the long and recent 10-year periods. We have no explanation for the sudden apparent jump in the Arctic Slope whitefront population, after a long gentle increase since 1992 (Fig. 17). The 2009 distribution of observations was very similar to that of 2008 (Fig. 29).

The 2009 Canada goose indices were 11,408 (eider strata, Table 3) and 21,289 (all strata, Table 4). The former index is 42% above the long-term mean (Tables 3, 5), while the latter is 16% above the 1986-2006 ACP survey mean (Table 6). The majority of Canada geese observed during this survey were flocked (Table 4). In past years Canada geese were most prevalent near the coast north of Teshekpuk Lake, but during the last few years we are beginning to record more scattered further inland throughout the central portions of the survey area.

Most black brant nest colonially on the Arctic Coastal Plain, so trends are difficult to detect with our systematic survey design. ABR Inc. conducts periodic aerial brant nesting and brood-rearing surveys between Barrow and the Coleville Delta, and found 32 colonies occupied in both 2001 (Ritchie et al. 2002) and 2006 (Ritchie et al. 2007), with active nest counts of 386 and 346, respectively, consistent with a level population (Ritchie et al. 2002, 2007). In contrast, results of our survey suggest a significant increase in the brant breeding population, or more precisely an abrupt increase between 2001 and 2004, with subsequent stability through 2009 at the higher level (Table 5, Fig. 18). Since the flocked proportion of the population has increased since 2002 it is possible that the recorded increase is largely an influx of early failed breeders from other breeding areas. However, we have also begun to record pairs and small flocks of brant in random locations farther from the coast during that same period. We will examine this phenomenon in more detail after completing the 4-year survey cycle in June 2010.

The 2009 tundra swan index (9,991) is the third of 3 consecutive highest indices in the history of the ACP survey (2009 index: 6% below 2008, 48% above the 18-year mean, Table 3, Fig. 19). The all-strata index (14,174) is 6% below that of 2008, but 42% above the ACP survey 1986-2006 mean (Tables 4, 6). Tundra swan indices indicate a significant positive growth rate for both long-term and most recent 10-year periods (Table 5, Fig. 19).

Raptors, Ravens, other birds

Despite concerns about raven populations expanding on the North Slope in response to increased anthropogenic nesting habitat (buildings and other artificial structures) and year-round food sources (garbage), we have detected neither a positive growth rate nor a geographic shift in our sample (Table 5). Our probability of detecting ravens among industrial and residential facilities is low, as they normally spend a large part of their time on or near such structures, which we intentionally avoid during our surveys due to regulatory and safety considerations. In addition, we believe detection of dark birds among oilfield structures would be poor.

Owl populations are extremely variable on the North Slope, with peaks typically associated with spikes in lemming populations. The 2009 eider strata short-eared owl index is the third highest at 170 (Table 3), while the all-strata index is 686, nearly 3 times the 2008 index of 246 (Table 6). The 2009 snowy owl index is 741 for the eider strata, 12% below the long-term average (Fig. 20), while the all-strata index is 1,188, which is a 6-fold increase over that of 2008, but similar to the 1,219 mean value for the ACP survey 1986-2006 period (Table 6). The highest densities of both short-eared and snowy owls in 2009 were recorded in the southwestern portion of the survey area, between Wainwright and Point Lay. Much of this area lies outside the eider strata.

We have recorded very few sandhill cranes during the ACP survey (2009 ACP Survey index from 10 eider strata = 413, eider strata 1992-2009 mean = 144, Tables 3, 5). We began recording shorebirds during the North Slope Eider Survey in 1997, largely as a measure of timing of their arrival on the breeding grounds, and large-scale distribution. We pooled shorebird species due to difficulty of species discrimination from the air and low priority on this survey. The shorebird index growth rate (0.989) is not significantly different from 1.0 (Table 5). There are several sources of bias associated with aerial detection of shorebirds, which confound evaluation of the shorebird index. Most of the shorebirds we record are in flight, as many flush readily and those on the ground are difficult to see. Flushing rates due to disturbance from our aircraft are unknown but probably vary a lot by species and phenology. Of those we see on the surface, the most common by far are phalaropes, which spend a large part of their time swimming in open water, and thus relatively visible; and black-bellied and golden plovers, which are large, conspicuously marked, and often display in sparsely vegetated areas.

## CONCLUSIONS

The species of greatest interest in terms of objectives for this survey are yellow-billed loon (species of international concern, proposed for ESA listing), red-throated loon (species of statewide concern, high proportion of Alaska population in ACP), Pacific loon (high proportion of Alaska population in ACP), northern pintail, greater scaup, king eider, long-tailed duck, white-fronted goose (harvested species of international concern, and ACP populations numerically significant in Alaska, North America), Tundra swan (ACP population comprises about 10% of the harvested eastern population, has management issues related to expanding population, causing habitat degradation and crop damage), and spectacled eider (listed as threatened under the ESA, ACP is one of three largest global breeding populations). All these populations are at some risk from detrimental effects of extractive resource development and other anthropogenic activities and changes. The other species recorded on this survey, while undeniably contributing to the biodiversity of the arctic coastal ecosystem, are either not addressed adequately by this survey design (e.g. Steller's eider, common eider, snow goose, common raven), and/or are present at such a small proportion of their range-wide population that even a large change in index would likely not elicit management action (e.g. mallard, American wigeon, northern shoveler).

2009 was the third year of the current design combining the Eider and the historic Standard ACP Survey, and apparently a year well-timed for most species, as was 2008. One more year will complete a full 4-year cycle covering all designed transects - a logical time to map density distribution by species and fully evaluate the design compared to its predecessors.

The trends for individual observers in the population trend graphs for the focal species for which we have adequate samples (Figs. 3-5, 11-15, 17, and 19) suggest that for most years and species, the constant observer/pilot had higher counts than the other observer. This is not surprising since the one constant observer has much more experience than the others both in general and specifically on this project. Regarding individual species, some show very close agreement among observers (e.g. Pintail, spectacled eider, king eider, white-fronted goose, Tundra swan), while others are very different (e.g. all loons, long-tailed duck). Estimates are consistent among observers for both spectacled and king eiders even despite small sample sizes. One reason for this strong agreement may be positive focal bias: observers are aware that these are high priority target species, so they may work with greater diligence to develop an appropriate search image and try extra hard not to miss birds. Observer differences for loons may be explained by their tendency to dive as the aircraft approaches, putting them out of sight as the aircraft passes. Thus the pilot, who typically and understandably spends much time looking ahead sees more loons than the observer, whose vision is more often trained perpendicular to the flight line. Long-tailed ducks are more difficult to detect compared to the other priority ACP species, due both to more cryptic coloration, and because they are often scattered about in very small wet depressions in vast upland areas where detection is difficult. Vigilance and focus may vary considerably among observers in these areas, adding variability to detection rates. Sex discrimination is also difficult for long-tailed ducks, potentially biasing pair vs. lone male data. Observer performance for white-fronted geese appears less variable (Fig. 21), probably because white-fronts are large and usually flush at the approach of the plane, making them easy for most observers to detect and identify. Tundra swans are well-distributed, large, white and rarely flush when surveyed, resulting in detection rates close to 1.0 (Conant et al. 1991) and populations monitored well by this survey. Hopefully this discussion provides helpful insights into reasons for variation in detection rates among species. A detection rate study for the Arctic Coastal Plain would be extremely useful, but challenging due to the relatively low densities of birds and expensive logistics.

## RECOMMENDATIONS

We recommend continuation of the survey annually, and welcome any comments or suggestions for improvement.

## ACKNOWLEDGMENTS

The authors would like to thank Rob MacDonald for the excellent job during his third consecutive season as observer on this survey. Special thanks to Debbie Nigro of the Bureau of Land Management for supporting the additional aerial coverage in the Teshekpuk Lake region.


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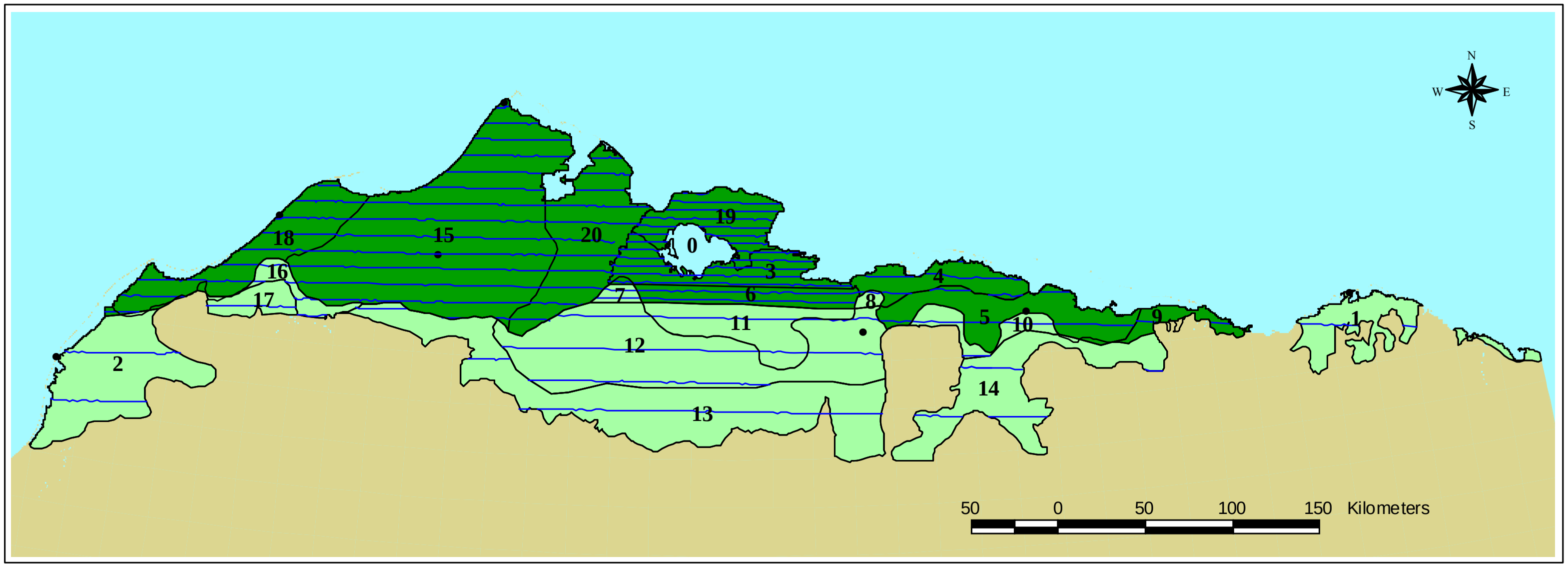



Figure 1. Spatial design of the aerial waterfowl breeding population survey, Arctic Coastal Plain, Alaska, June 2009. Eider strata are shown in dark green, strata outside the eider strata area are shown in light green. Blue lines show locations of the 2009 design transects. Numbered strata are described in Table 1 below.

Table 1. Sampling design by stratum, aerial waterfowl breeding population survey, Arctic Coastal Plain, Alaska, June 2009. ID numbers refer to Fig. 3 above.

| ID | Stratum Name | Stratum Area km$^2$ | Sample Area km2 | Sample % of Stratum Area | ID | Stratum Name | Stratum Area km$^2$ | Sample Area km2 | Sample % of Stratum Area |
|---|---|---|---|---|---|---|---|---|---|
| 0 | Non-habitat | | | | 14 | Sag Low | 3,571 | 40.5 | 1.1% |
| 1 | Arctic NWR Low | 1,812 | 15.4 | 0.8% | 15 | Barrow Hi | 11,358 | 481.5 | 4.2% |
| 2 | Pt Lay Low | 3,916 | 48.5 | 1.2% | 16 | S Kuk Hi | 582 | 22.9 | 3.9% |
| 3 | Teshekpuk SHi | 2,019 | 183.0 | 9.1% | 17 | S. Kuk Low | 748 | 20.6 | 2.8% |
| 4 | Colville Hi | 1,423 | 54.4 | 3.8% | 18 | Icy Wain Hi | 3,093 | 129.7 | 4.2% |
| 5 | Prudhoe Med | 2,581 | 51.1 | 2.0% | 19 | N Teshekpuk SHi | 2,044 | 157.6 | 7.7% |
| 6 | S Teshekpuk SHi | 1,362 | 100.0 | 7.3% | 20 | E Dease Hi | 3,768 | 155.1 | 4.1% |
| 7 | SW Teshekpuk SHi | 226 | 18.1 | 8.0% | | | | | |
| 8 | S Colville Hi | 128 | 3.5 | 2.7% | | All Low:1,2,9,13,14,17 | 18,276 | 235.5 | 1.3% |
| 9 | Canning Low | 577 | 9.7 | 1.7% | | All Med:5,10,11,12 | 13,058 | 298.3 | 2.3% |
| 10 | Sag Med | 784 | 30.1 | 3.8% | | All Hi: 4,8,15,16,18,20 | 20,351 | 847.1 | 4.2% |
| 11 | Central Med | 2,240 | 44.5 | 2.0% | | All SHi: 3,6,7,19 | 5,650 | 458.7 | 8.1% |
| 12 | S Eid Med | 7,453 | 172.6 | 2.3% | | Eider Strata:3-6,9,11,15,18-20 | 30,465 | 1,366.6 | 4.5% |
| 13 | S Central Low | 7,652 | 100.8 | 1.3% | | All Strata | 57,335 | 1,839.3 | 3.2% |

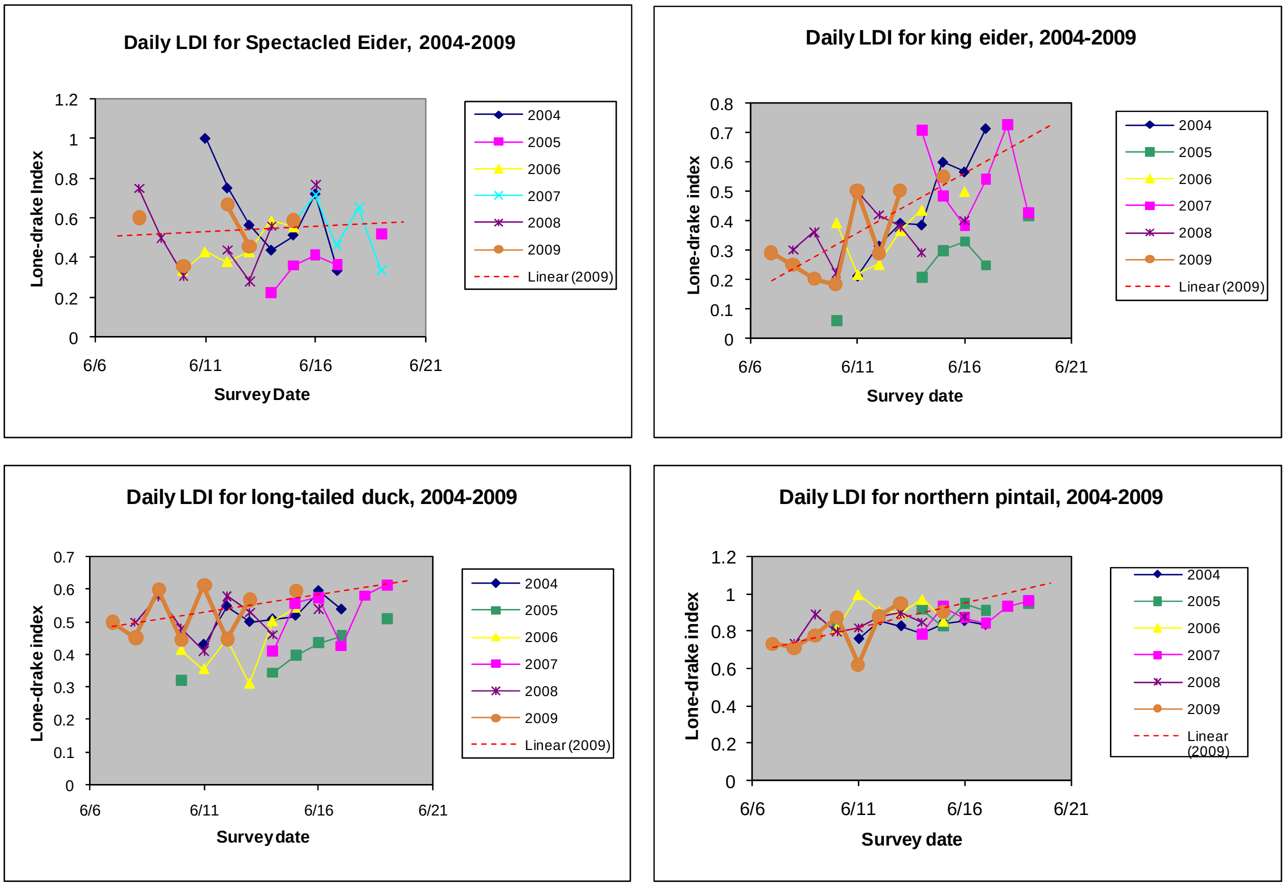



Figure 2. Daily ratio of lone males to total males (lone males plus males in pairs) of selected duck species observed during the Eider Survey (2004-2006) and the 2007-9 Standard waterfowl breeding population (ACP) survey, arctic coastal plain, Alaska.

Table 2. Average and range of ratios of lone males to total males (lone males plus males in pairs) of selected duck species observed during the Eider Survey (1992-2009) and the ACP 2007-9 survey, arctic coastal plain, Alaska.

| Species | LDI Avg. 1992-2009 | LDI SD | LDI range | LDI 2009 |
|---|---|---|---|---|
| Spectacled eider | 0.49 | 0.08 | 0.28-0.58 | 0.49 |
| King eider | 0.35 | 0.12 | 0.14-0.57 | 0.28 |
| Long-tailed duck | 0.49 | 0.04 | 0.39-0.58 | 0.52 |
| Northern pintail | 0.83 | 0.07 | 0.67-0.91 | 0.89 |

Table 3. Combined observations by starboard and port observers on aerial survey transects, arctic coastal plain, Alaska, June 2009, with observable population indices. Includes observations from previous eider survey strata only (Fig. 1). Expanded indices for selected ducks were calculated using visibility correction factors (VCF) developed on the Yukon Kuskokwim Delta for tundra habitats (Conant et al. 1991).

| Species | Single | Pair | Flocked Birds | Indicated Total | Density birds/km2 | Population Index | Population 95%CI | VCF | Expanded Pop. Index | %CV |
|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed loon | 27 | 26 | 0 | 79[1] | 0.056 | 1,693 | 1,188-2,198 | NA | | 15.2 |
| Pacific Loon | 249 | 477 | 33 | 1,236[1] | 0.895 | 27,276 | 23,873-30,679 | NA | | 6.4 |
| Red-throated loon | 27 | 46 | 0 | 119[1] | 0.085 | 2,585 | 1,915-3,255 | NA | | 13.2 |
| Jaeger spp.[3] | 127 | 15 | 0 | 157[1] | 0.120 | 3,666 | 3,008-4,323 | NA | | 9.2 |
| Glaucous gull | 326 | 76 | 111 | 589[1] | 0.435 | 13,246 | 10,385-16,107 | NA | | 11.0 |
| Sabine's gull | 199 | 107 | 214 | 627[1] | 0.408 | 12,429 | 9,228-15,630 | NA | | 13.1 |
| Arctic tern | 249 | 149 | 96 | 643[1] | 0.446 | 13,593 | 10,910-16,277 | NA | | 10.1 |
| Red-breasted merganser | 5 | 8 | 10 | 36[2] | 0.025 | 752 | 360-1,144 | 1.27 | 955 | 26.6 |
| Mallard | 0 | 0 | 0 | 0[2] | 0.000 | 0 | 0 | 4.01 | 0 | |
| Am. wigeon | 5 | 4 | 8 | 26[2] | 0.012 | 371 | 103-639 | 3.84 | 1,425 | 36.8 |
| Am. Green-winged teal | 1 | 2 | 0 | 6[2] | 0.003 | 94 | 4-216 | 8.36 | 786 | 65.7 |
| Northern pintail | 814 | 104 | 176 | 2012[2] | 1.328 | 40,451 | 29,629-51,273 | 3.05 | 123,376 | 13.6 |
| Northern shoveler | 0 | 1 | 0 | 2[2] | 0.001 | 27 | 2-74 | 3.79 | 102 | 87.9 |
| Greater scaup | 95 | 88 | 40 | 311[1] | 0.235 | 7,145 | 5,435-8,855 | 1.93 | 13,790 | 12.2 |
| Long-tailed duck | 362 | 331 | 81 | 1467[2] | 1.114 | 33,950 | 30,448-37,453 | 1.87 | 63,487 | 5.3 |
| Spectacled eider | 64 | 66 | 0 | 260[2] | 0.165 | 5,018 | 3,343-6,692 | NA | | 17.0 |
| Common eider | 1 | 2 | 0 | 6[2] | 0.005 | 143 | 6-348 | NA | | 73.0 |
| King eider | 131 | 336 | 18 | 952[2] | 0.656 | 19,989 | 17,156-22,823 | NA | | 7.2 |
| Steller's eider | 0 | 1 | 0 | 2[2] | 0.002 | 47 | 2-145 | NA | | 105.3 |
| Black scoter | 2 | 2 | 0 | 8[2] | 0.012 | 351 | 8-706 | 1.17 | 411 | 51.8 |
| White-winged scoter | 1 | 1 | 0 | 4[2] | 0.007 | 201 | 7-396 | 1.17 | 235 | 49.3 |
| Snow goose | 19 | 188 | 802 | 1197[1] | 0.917 | 27,926 | 1,197-61,482 | NA | | 61.3 |
| Gr. White-fronted goose | 516 | 1,943 | 2,640 | 7558[2] | 5.225 | 159,188 | 135,619-182,757 | NA | | 7.6 |
| Canada goose | 25 | 99 | 146 | 394[2] | 0.374 | 11,408 | 7,131-15,685 | NA | | 19.1 |
| Black brant | 53 | 73 | 313 | 565[2] | 0.335 | 10,221 | 6,209-14,232 | NA | | 20.0 |
| Tundra swan | 231 | 93 | 59 | 476[1] | 0.328 | 9,991 | 8,607-11,375 | NA | | 7.1 |
| Sandhill crane | 3 | 1 | 10 | 18[2] | 0.012 | 413 | 126-700 | NA | | 35.5 |
| Unid. Shorebird[4,5] | 289 | 190 | 417 | 1086[1] | 0.739 | 22,510 | 16,727-28,292 | NA | | 13.1 |
| Common raven | 1 | 0 | 0 | 1[1] | 0.002 | 51 | 8-93 | NA | | 43.4 |
| Short-eared owl | 6 | 0 | 0 | 6[1] | 0.006 | 170 | 35-304 | NA | | 40.4 |
| Snowy owl | 33 | 0 | 0 | 33[1] | 0.024 | 741 | 410-1,072 | NA | | 22.8 |
| Golden eagle | 2 | 0 | 0 | 2[1] | 0.001 | 27 | 2-73 | NA | | 84.6 |

1. singles+(2*pairs)+flocked 2. 2*(singles+pairs)+flocked 3. *Stercorarius longicaudus, S. parasiticus, S. pomarinus* 4. *Charadrius sp., Pluvialis spp., Calidris spp., Arenaria sp., Numenius sp., Limnodromus sp.* et al. 5. Data from left-side observer only.

Table 4. Combined observations by starboard and port observers on aerial survey transects, arctic coastal plain, Alaska, June 2009, with observable population indices. Includes observations from all strata (Fig. 1). Expanded indices for selected ducks were calculated using visibility correction factors (VCF) developed on the Yukon Kuskokwim Delta for tundra habitats (Conant et al. 1991).

| Species | Single | Pair | Flocked Birds | Indicated Total | Density birds/km2 | Population Index | Population 95%CI | VCF | Expanded Pop. Index | %CV |
|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed loon | 45 | 38 | 0 | 121[1] | 0.062 | 3569 | 2,944-4,194 | NA | | 8.9 |
| Pacific Loon | 291 | 566 | 36 | 1459[1] | 0.683 | 39188 | 34,045-44,331 | NA | | 6.7 |
| Red-throated loon | 29 | 52 | 0 | 133[1] | 0.054 | 3080 | 2,290-3,871 | NA | | 13.1 |
| Jaeger spp.[3] | 207 | 27 | 6 | 267[1] | 0.182 | 10,463 | 8,210-12,715 | NA | | 11.0 |
| Glaucous gull | 387 | 84 | 118 | 673[1] | 0.315 | 18,047 | 14,237-21,858 | NA | | 10.8 |
| Sabine's gull | 216 | 115 | 277 | 723[1] | 0.288 | 16,508 | 11,881-21,135 | NA | | 14.3 |
| Arctic tern | 339 | 197 | 107 | 840[1] | 0.402 | 23,045 | 19,504-26,585 | NA | | 7.8 |
| Red-breasted merganser | 9 | 12 | 10 | 52[2] | 0.026 | 1,487 | 753-2,220 | 1.27 | 1,888 | 25.2 |
| Mallard | 1 | 2 | 0 | 6[2] | 0.006 | 325 | 50-600 | 4.01 | 1,302 | 43.2 |
| Am. wigeon | 5 | 5 | 8 | 28[2] | 0.011 | 630 | 158-1,103 | 3.84 | 2,420 | 38.3 |
| Am. Green-winged teal | 2 | 1 | 0 | 6[2] | 0.004 | 246 | 94-398 | 8.36 | 2,059 | 31.5 |
| Northern pintail | 917 | 137 | 176 | 2284[2] | 0.978 | 56,073 | 43,472-68,674 | 3.05 | 171,023 | 11.5 |
| Northern shoveler | 4 | 4 | 0 | 16[2] | 0.015 | 848 | 16-1,793 | 3.79 | 3,214 | 56.8 |
| Greater scaup | 143 | 159 | 46 | 507[1] | 0.309 | 17,693 | 14,901-20,485 | 1.93 | 34,147 | 8.1 |
| Long-tailed duck | 441 | 408 | 81 | 1779[2] | 0.851 | 48,812 | 43,904-53,719 | 1.87 | 91,278 | 5.1 |
| Spectacled eider | 70 | 66 | 0 | 272[2] | 0.096 | 5,525 | 3,663-7,387 | NA | | 17.2 |
| Common eider | 1 | 2 | 0 | 6[2] | 0.002 | 143 | 6-348 | NA | | 73.0 |
| King eider | 146 | 350 | 18 | 1010[2] | 0.390 | 22,375 | 19,190-25,560 | NA | | 7.3 |
| Steller's eider | 0 | 1 | 0 | 2[2] | 0.001 | 47 | 2-145 | NA | | 105.3 |
| Black scoter | 2 | 2 | 0 | 8[2] | 0.006 | 351 | 8-706 | 1.17 | 410 | 51.8 |
| White-winged scoter | 7 | 9 | 6 | 38[2] | 0.044 | 2,521 | 1,160-3,882 | 1.17 | 2,950 | 27.5 |
| Snow goose | 19 | 188 | 802 | 1187[1] | 0.487 | 27926 | 0-61,482 | NA | | 61.3 |
| Gr. White-fronted goose | 611 | 2134 | 3160 | 8650[2] | 3.887 | 222,891 | 174,969-270,812 | NA | | 11.0 |
| Canada goose | 32 | 148 | 203 | 563[2] | 0.371 | 21,289 | 11,922-30,656 | NA | | 22.4 |
| Black brant | 53 | 73 | 313 | 565[2] | 0.178 | 10,221 | 6,209-14,232 | NA | | 20.0 |
| Tundra swan | 254 | 115 | 62 | 546[1] | 0.247 | 14,174 | 12,283-16,066 | NA | | 6.8 |
| Sandhill crane | 4 | 1 | 10 | 16[2] | 0.008 | 487 | 200-774 | NA | | 30.1 |
| Unid. Shorebird[4,5] | 334 | 230 | 512 | 1306[1] | 0.581 | 33,320 | 25,900-40,740 | NA | | 11.4 |
| Common raven | 5 | 1 | 0 | 7[1] | 0.009 | 493 | 5-981 | NA | | 50.5 |
| Short-eared owl | 14 | 0 | 0 | 14[1] | 0.012 | 686 | 119-1,254 | NA | | 42.2 |
| Snowy owl | 41 | 0 | 0 | 41[1] | 0.021 | 1,188 | 842-1,534 | NA | | 14.9 |
| Golden eagle | 5 | 0 | 0 | 5[1] | 0.003 | 192 | 88-296 | NA | | 27.6 |

1. singles+(2*pairs)+flocked 2. 2*(singles+pairs)+flocked 3. *Stercorarius longicaudus, S. parasiticus, S. pomarinus* 4. *Charadrius sp., Pluvialis spp., Calidris spp., Arenaria sp., Numenius sp., Limnodromus sp.* et al. 5. Data from left-side observer only.

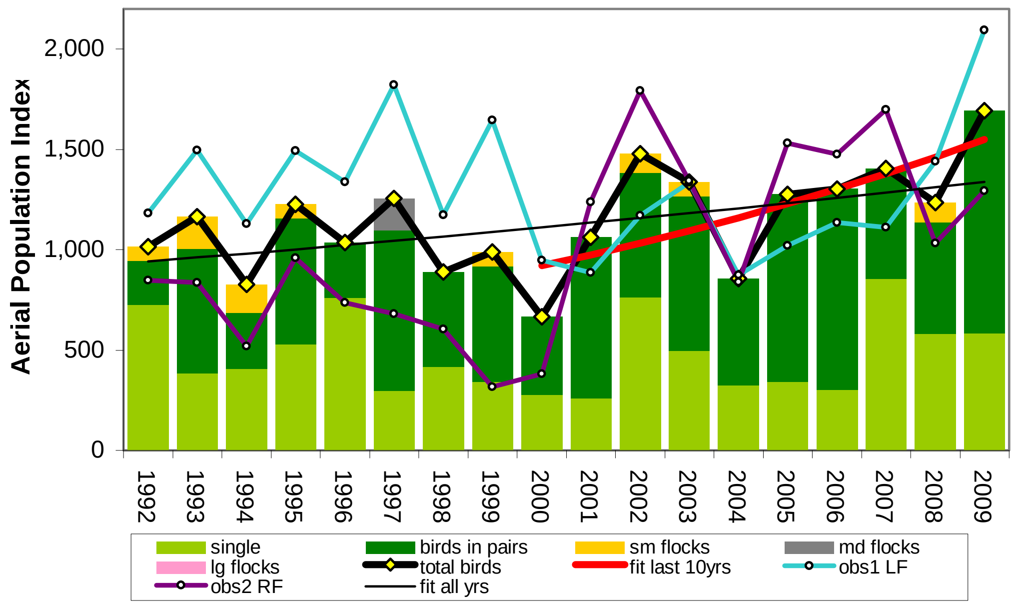
Table 5. Mean population indices, population growth rates, and years to detect a population trend equivalent to a 50 percent growth or decline in 20 years, for observations of selected bird species in early to mid-June 1992-2009 sampling Arctic Coastal Plain wetlands in Alaska. Variance estimates used were based on within-year sampling error among transects as stratified by 10 physiographic regions (Eider Strata). Significant growth rates are colored green for positive trend, red for negative.

| Species | Measure | Years | n years | Mean pop. Index | Log-linear slope | Mean pop. growth rate | Pop. Growth rate 90% CI | Avg. sampling error coef. of variation | Years to detect a slope of 0.0341 | Mean pop. growth rate last 10 years | Pop. GR last 10 years 90% CI |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Yellow-billed loon | S + 2*Pr + Fl | 1992-2009 | 18 | 1,151 | 0.021 | **1.021** | 1.005-1.037 | 0.217 | 14.4 | **1.059** | 1.017-1.104 |
| Pacific Loon | S + 2*Pr + Fl | 1992-2009 | 18 | 21,263 | 0.011 | 1.011 | 0.996-1.026 | 0.069 | 6.7 | 1.021 | 0.989-1.053 |
| Red-throated loon | S + 2*Pr + Fl | 1992-2009 | 18 | 2,578 | -0.030 | **0.961** | 0.935-0.988 | 0.153 | 11.4 | 0.995 | 0.950-1.043 |
| Jaeger spp. | S + 2*Pr + Fl | 1992-2009 | 18 | 4,155 | 0.011 | 1.011 | 0.978-1.046 | 0.117 | 9.5 | 1.030 | 0.946-1.121 |
| Glaucous gull | S + 2*Pr + Fl | 1992-2009 | 18 | 12,617 | 0.011 | 1.011 | 0.992-1.030 | 0.147 | 11.1 | 1.039 | 0.991-1.090 |
| Sabine's gull | S + 2*Pr + Fl | 1992-2009 | 18 | 7,349 | 0.028 | **1.028** | 1.003-1.054 | 0.132 | 10.3 | **1.074** | 1.028-1.122 |
| Arctic tern | S + 2*Pr + Fl | 1992-2009 | 18 | 10,777 | 0.036 | **1.037** | 1.026-1.048 | 0.111 | 9.2 | 1.002 | 0.975-1.030 |
| Red-breasted merganser | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 493 | 0.095 | **1.099** | 1.054-1.146 | 0.397 | 21.5 | **1.051** | 1.008-1.097 |
| Mallard | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 191 | -0.066 | 0.937 | 0.854-1.027 | 0.667 | 30.4 | 0.879 | 0.698-1.108 |
| Am. wigeon | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 389 | -0.005 | 0.995 | 0.915-1.083 | 0.644 | 29.7 | 0.943 | 0.753-1.180 |
| Am. Green-winged teal | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 282 | -0.011 | **0.900** | 0.828-0.978 | 0.511 | 25.5 | **1.186** | 1.020-1.379 |
| Northern pintail | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 49,052 | -0.012 | 0.989 | 0.959-1.019 | 0.101 | 8.6 | 0.965 | 0.908-1.027 |
| Northern shoveler | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 195 | 0.008 | 1.008 | 0.909-1.118 | 0.561 | 27.1 | 0.989 | 0.786-1.245 |
| Greater scaup | S + 2*Pr + Fl | 1992-2009 | 18 | 4,809 | 0.071 | **1.074** | 1.051-1.096 | 0.182 | 12.8 | **1.094** | 1.034-1.158 |
| Long-tailed duck | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 30,720 | -0.010 | 0.990 | 0.975-1.005 | 0.069 | 6.7 | 0.986 | 0.940-1.034 |
| Spectacled eider | 2 * (S + Pr) + Fl | 1993-2009 | 17 | 6,540 | -0.015 | **0.985** | 0.971-0.999 | 0.112 | 9.2 | 0.977 | 0.952-1.003 |
| Common eider | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 375 | -0.016 | 0.984 | 0.916-1.058 | 0.780 | 33.8 | 0.970 | 0.813-1.156 |
| King eider | 2 * (S + Pr) + Fl | 1993-2009 | 17 | 13,807 | 0.027 | **1.028** | 1.016-1.039 | 0.091 | 8.1 | **1.031** | 1.006-1.056 |
| Steller's eider | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 161 | 0.010 | 1.010 | 0.918-1.111 | 0.773 | 33.6 | 1.056 | 0.855-1.304 |
| Black scoter | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 126 | -0.026 | 0.974 | 0.889-1.068 | 0.711 | 31.7 | **1.234** | 1.069-1.425 |
| White-winged scoter | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 332 | 0.048 | 1.049 | 0.984-1.118 | 0.594 | 28.1 | 1.017 | 0.935-1.107 |
| Snow goose | S + 2*Pr + Fl | 1992-2009 | 18 | 7,961 | 0.200 | **1.222** | 1.111-1.343 | 0.568 | 27.3 | 1.290 | 0.984-1.692 |
| Gr. White-fronted goose | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 88,181 | 0.053 | **1.054** | 1.030-1.078 | 0.075 | 7.1 | **1.093** | 1.040-1.149 |
| Canada goose | 2 * (S + Pr) + Fl | 1993-2009 | 17 | 8,038 | -0.002 | 0.998 | 0.960-1.037 | 0.260 | 16.2 | 1.034 | 0.935-1.144 |
| Black brant | 2 * (S + Pr) + Fl | 1992-2009 | 18 | 7,056 | 0.102 | **1.108** | 1.081-1.135 | 0.247 | 15.7 | **1.098** | 1.090-1.202 |
| Tundra swan | S + 2*Pr + Fl | 1992-2009 | 18 | 6,749 | 0.036 | **1.036** | 1.020-1.052 | 0.110 | 9.1 | **1.058** | 1.029-1.088 |
| Sandhill crane | S + 2*Pr + Fl | 1992-2009 | 18 | 144 | 0.065 | **1.067** | 1.011-1.125 | 0.621 | 29 | 1.022 | 0.891-1.172 |
| Unid. Shorebird | S + 2*Pr + Fl | 1997-2009 | 13 | 44,046 | -0.011 | 0.989 | 0.961-1.018 | 0.094 | 8.3 | 0.990 | 0.944-1.037 |
| Common raven | S + 2*Pr + Fl | 1992-2009 | 18 | 59 | -0.002 | 0.998 | 0.943-1.057 | 0.675 | 30.7 | 0.964 | 0.840-1.106 |
| Short-eared owl | S + 2*Pr + Fl | 1992-2009 | 18 | 86 | 0.048 | 1.049 | 0.981-1.122 | 0.478 | 24.4 | 1.025 | 0.873-1.203 |
| Snowy owl | S + 2*Pr + Fl | 1992-2009 | 18 | 845 | -0.010 | 0.990 | 0.903-1.085 | 0.366 | 20.4 | 1.211 | 0.968-1.514 |
| Golden eagle | S + 2*Pr + Fl | 1992-2009 | 18 | 44 | 0.021 | 1.021 | 0.971-1.073 | 0.782 | 33.8 | 1.037 | 0.916-1.173 |

Table 6. Breeding population indices, standard Alaska ACP Survey, 1986-2006 means (Mallek et al. 2007) compared with indices from 2008 and 2009 surveys (all strata), which were flown earlier in June. Duck Indices were adjusted by multiplying by the standard tundra visibility correction factors from the Alaska-Yukon Breeding Population Survey (Conant et al. 1991).

| Species | VCF | ACP Survey mean 1986-2006 | All ACP strata 2008 (95%CI) | All ACP strata 2009 (95%CI) |
|---|---|---|---|---|
| Yellow-billed loon | 1.00 | 2,778 | 1,970 (1,513-2,426) | 3569(2,944-4,194) |
| Pacific Loon | 1.00 | 29,756 | 31,699 (28,215-35,183) | 39,188(34,045-44,331) |
| Red-throated loon | 1.00 | 3,240 | 2,425 (1,649-3,201) | 3,080(2,290-3,871) |
| Jaeger spp.3 | 1.00 | 7,197 | 8,850 (7,272-10,428) | 10,463(8,210-12,715) |
| Glaucous gull | 1.00 | 17,188 | 19,467 (16,829-22,104) | 18,047(14,237-21,858) |
| Sabine's gull | 1.00 | 11,810 | 10,937 (8,424-13,451) | 16,508(11,881-21,135) |
| Arctic tern | 1.00 | 23,544 | 22,120 (18,577-25,663) | 23,045(19,504-26,585) |
| Red-breasted merganser | 1.27 | 2,340 | 2,108 (1,266-2,950) | 1,888(956-2,819) |
| Mallard | 4.01 | 1,848 | 518 (0-1,175) | 1,302(201-2,406) |
| Am. wigeon | 3.84 | 4,123 | 3,459 (891-6,029) | 2,420(607-4,236) |
| Am. Green-winged teal | 8.36 | 3,210 | 5,850 (1,404-10,291) | 2,059(786-3,327) |
| Northern pintail | 3.05 | 220,494 | 249,749 (214,195-285,303) | 171,023(132,590-209,456) |
| Northern shoveler | 3.79 | 987 | 3,783 (819-6,746) | 3,214(61-6,795) |
| Greater scaup | 1.93 | 32,721 | 50,200 (34,651-65,749) | 34,147(28,759-39,536) |
| Long-tailed duck | 1.87 | 107,041 | 94,513 (83,362-105,664) | 91,278(82,100-100,455) |
| Spectacled eider | 1.00 | 619 | 6,497 (5,260-7,735) | 5,525(3,663-7,387) |
| Common eider | 1.00 | 441 | 340 (0-851) | 143(6-348) |
| King eider | 1.00 | 3,999 | 18,563 (15,705-21,422) | 22,375(19,190-25,560) |
| Steller's eider | 1.00 | 743 | 25 (0-70) | 47(2-145) |
| Black scoter | 1.17 | 43 | 289 (0-716) | 410(9-826) |
| White-winged scoter | 1.17 | 247 | 4,792 (2,555-7,031) | 2,950(1,357-4,542) |
| All scoters | 1.17 | 10,381 | 5,082 (2,555-7,747) | 3,360(1,366-5,368) |
| Snow goose | 1.00 | 3,025 | 8,476 (1,247-15,705) | 27,926(0-61,482) |
| Gr. White-fronted goose | 1.00 | 123,963 | 210,047 (185,773-234,320) | 222,891(174,969-270,812) |
| Canada goose | 1.00 | 18,309 | 5,284 (3,702-6,866) | 21,289(11,922-30,656) |
| Black brant | 1.00 | 9,792 | 12,247 (6,091-18,402) | 10,221(6,209-14,232) |
| Tundra swan | 1.00 | 9,971 | 15,079 (12,710-17,448) | 14,174(12,283-16,066) |
| Sandhill crane | 1.00 | | 271 (69-474) | 487(200-774) |
| Common raven | 1.00 | | 214 (0-468) | 493(5-981) |
| Short-eared owl | 1.00 | | 246 (0-501) | 686(119-1,254) |
| Snowy owl | 1.00 | 1,219 | 188 (0-427) | 1,188(842-1,534) |
| Golden eagle | 1.00 | 426 | 226 (136-316) | 192(88-296) |

YBLO Yellow-billed Loon North Slope early-June survey




*NSE 10 strata =30,465 km2*

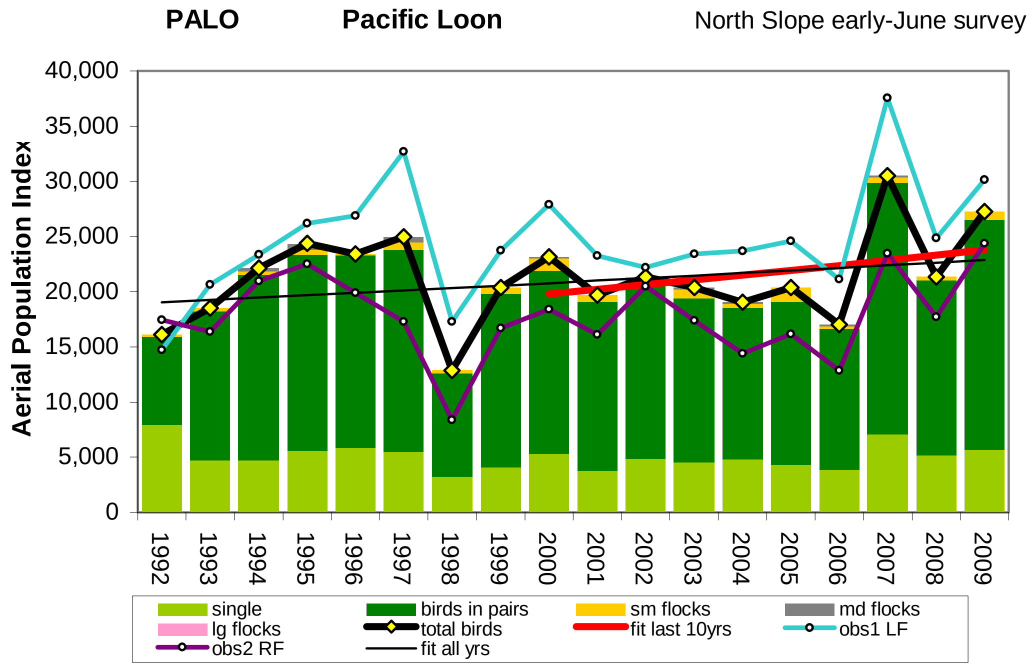
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 725 | 219 | 71 | 0 | 0 | **1015** | 179 |
| 1993 | 386 | 617 | 162 | 0 | 0 | **1165** | 267 |
| 1994 | 408 | 277 | 141 | 0 | 0 | **826** | 190 |
| 1995 | 527 | 628 | 70 | 0 | 0 | **1226** | 308 |
| 1996 | 761 | 275 | 0 | 0 | 0 | **1036** | 191 |
| 1997 | 297 | 801 | 0 | 157 | 0 | **1254** | 573 |
| 1998 | 416 | 474 | 0 | 0 | 0 | **890** | 200 |
| 1999 | 340 | 579 | 70 | 0 | 0 | **989** | 229 |
| 2000 | 277 | 388 | 0 | 0 | 0 | **665** | 165 |
| 2001 | 262 | 800 | 0 | 0 | 0 | **1062** | 196 |
| 2002 | 762 | 620 | 97 | 0 | 0 | **1479** | 231 |
| 2003 | 495 | 773 | 71 | 0 | 0 | **1339** | 236 |
| 2004 | 323 | 533 | 0 | 0 | 0 | **856** | 170 |
| 2005 | 344 | 932 | 0 | 0 | 0 | **1277** | 253 |
| 2006 | 302 | 1002 | 0 | 0 | 0 | **1304** | 337 |
| 2007 | 854 | 551 | 0 | 0 | 0 | **1405** | 251 |
| 2008 | 582 | 556 | 97 | 0 | 0 | **1235** | 216 |
| 2009 | 582 | 1111 | 0 | 0 | 0 | **1693** | 258 |

YBLO

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **1151** |
| std dev = | 257 |
| std error = | 61 |
| low 90%ci = | 1032 |
| high 90%ci = | 1270 |
| ln linear slope = | 0.021 |
| SE slope = | 0.0096 |
| Growth Rate = | **1.021** |
| low 90%ci GR = | 1.005 |
| high 90%ci GR = | 1.037 |
| regression resid CV = | 0.212 |
| avg sampling err CV = | 0.217 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 14.2 |
| w/ sample error CV = | 14.4 |
| most recent 10 years : | |
| Growth Rate = | **1.059** |
| low 90%ci GR = | 1.017 |
| high 90%ci GR = | 1.104 |

Figure 3. Population trend for Yellow-billed Loons (Gavia adamsii) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Calculation of power used alpha = 0.10, beta = 0.20, and a coefficient of variation based on either regression residuals or averaged annual sampling error. The power to detect trends can be compared across species using the estimated minimum years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

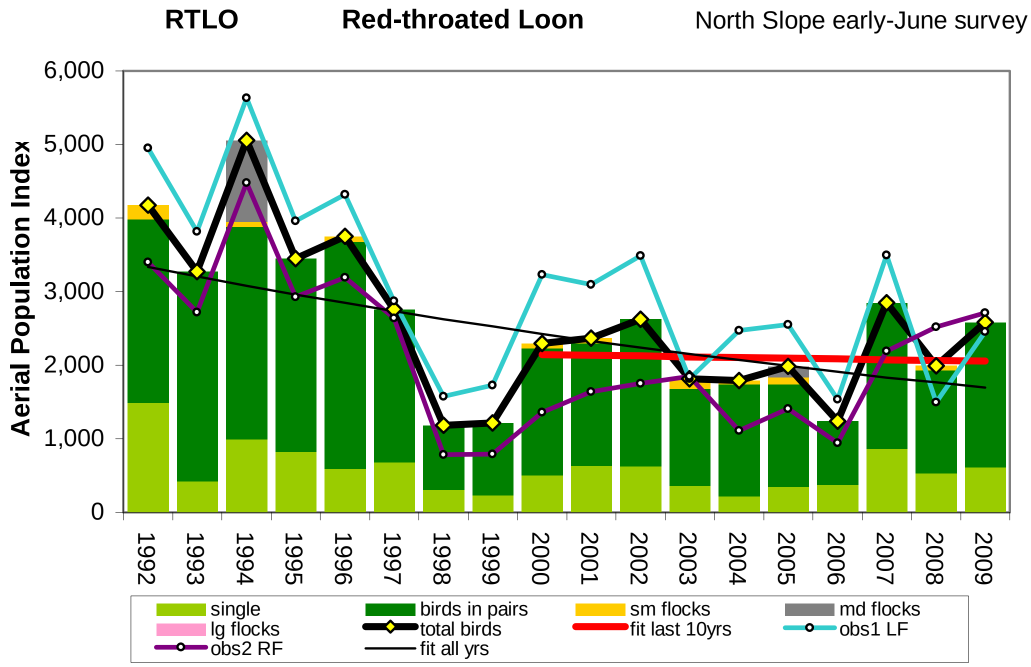
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 7931 | 7944 | 227 | 0 | 0 | **16103** | 1174 |
| 1993 | 4669 | 13592 | 251 | 0 | 0 | **18512** | 958 |
| 1994 | 4773 | 16753 | 354 | 266 | 0 | **22146** | 1329 |
| 1995 | 5592 | 17703 | 467 | 584 | 0 | **24347** | 1438 |
| 1996 | 5821 | 17495 | 71 | 0 | 0 | **23387** | 1193 |
| 1997 | 5497 | 18298 | 696 | 490 | 0 | **24981** | 1848 |
| 1998 | 3220 | 9392 | 222 | 0 | 0 | **12833** | 1370 |
| 1999 | 4070 | 15690 | 625 | 0 | 0 | **20385** | 1386 |
| 2000 | 5299 | 16556 | 1161 | 137 | 0 | **23152** | 1364 |
| 2001 | 3767 | 15326 | 581 | 0 | 0 | **19675** | 1330 |
| 2002 | 4880 | 16020 | 431 | 0 | 0 | **21330** | 1250 |
| 2003 | 4536 | 14842 | 842 | 177 | 0 | **20397** | 1701 |
| 2004 | 4802 | 13751 | 312 | 148 | 0 | **19014** | 1269 |
| 2005 | 4340 | 14728 | 1283 | 0 | 0 | **20351** | 1760 |
| 2006 | 3839 | 12783 | 250 | 147 | 0 | **17018** | 1532 |
| 2007 | 7051 | 22807 | 505 | 144 | 0 | **30507** | 1525 |
| 2008 | 5172 | 15853 | 290 | 0 | 0 | **21315** | 1647 |
| 2009 | 5647 | 20878 | 751 | 0 | 0 | **27276** | 1736 |

PALO

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **21263** |
| std dev = | 4109 |
| std error = | 968 |
| low 90%ci = | 19364 |
| high 90%ci = | 23161 |
| ln linear slope = | 0.011 |
| SE slope = | 0.0089 |
| Growth Rate = | **1.011** |
| low 90%ci GR = | 0.996 |
| high 90%ci GR = | 1.026 |
| regression resid CV = | 0.196 |
| avg sampling err CV = | 0.069 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 13.5 |
| w/ sample error CV = | 6.7 |
| most recent 10 years : | |
| Growth Rate = | **1.021** |
| low 90%ci GR = | 0.989 |
| high 90%ci GR = | 1.053 |

Figure 4. Population trend for Pacific Loons (Gavia pacifica) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Calculation of power used alpha = 0.10, beta = 0.20, and a coefficient of variation based on either regression residuals or averaged annual sampling error. The power to detect trends can be compared across species using the estimated minimum years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 1487 | 2495 | 196 | 0 | 0 | **4177** | 453 |
| 1993 | 421 | 2850 | 0 | 0 | 0 | **3271** | 434 |
| 1994 | 993 | 2888 | 75 | 1099 | 0 | **5054** | 990 |
| 1995 | 827 | 2617 | 0 | 0 | 0 | **3445** | 476 |
| 1996 | 596 | 3087 | 73 | 0 | 0 | **3756** | 390 |
| 1997 | 683 | 2075 | 0 | 0 | 0 | **2758** | 415 |
| 1998 | 306 | 879 | 0 | 0 | 0 | **1185** | 251 |
| 1999 | 234 | 983 | 0 | 0 | 0 | **1216** | 176 |
| 2000 | 502 | 1727 | 69 | 0 | 0 | **2298** | 330 |
| 2001 | 634 | 1663 | 71 | 0 | 0 | **2367** | 387 |
| 2002 | 627 | 1994 | 0 | 0 | 0 | **2621** | 335 |
| 2003 | 363 | 1315 | 140 | 0 | 0 | **1818** | 194 |
| 2004 | 217 | 1528 | 49 | 0 | 0 | **1793** | 294 |
| 2005 | 348 | 1398 | 94 | 141 | 0 | **1980** | 399 |
| 2006 | 374 | 862 | 0 | 0 | 0 | **1236** | 264 |
| 2007 | 860 | 1986 | 0 | 0 | 0 | **2846** | 388 |
| 2008 | 530 | 1395 | 70 | 0 | 0 | **1996** | 367 |
| 2009 | 605 | 1980 | 0 | 0 | 0 | **2585** | 342 |

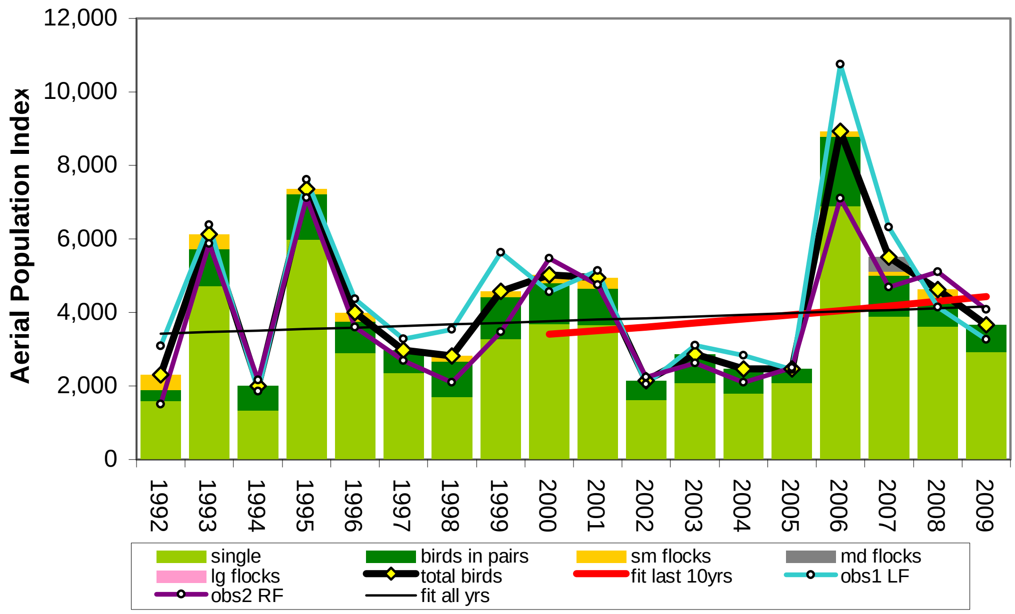
RTLO

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **2578** |
| std dev = | 1058 |
| std error = | 249 |
| low 90%ci = | 2089 |
| high 90%ci = | 3067 |
| ln linear slope = | -0.04 |
| SE slope = | 0.0169 |
| Growth Rate = | **0.961** |
| low 90%ci GR = | 0.935 |
| high 90%ci GR = | 0.988 |
| regression resid CV = | 0.372 |
| avg sampling err CV = | 0.153 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 20.6 |
| w/ sample error CV = | 11.4 |
| most recent 10 years : | |
| Growth Rate = | **0.995** |
| low 90%ci GR = | 0.950 |
| high 90%ci GR = | 1.043 |

Figure 5. Population trend for Red-throated Loons (Gavia stellata) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Calculations of power used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.

**JAEG** **Jaeger spp.** North Slope early-June survey



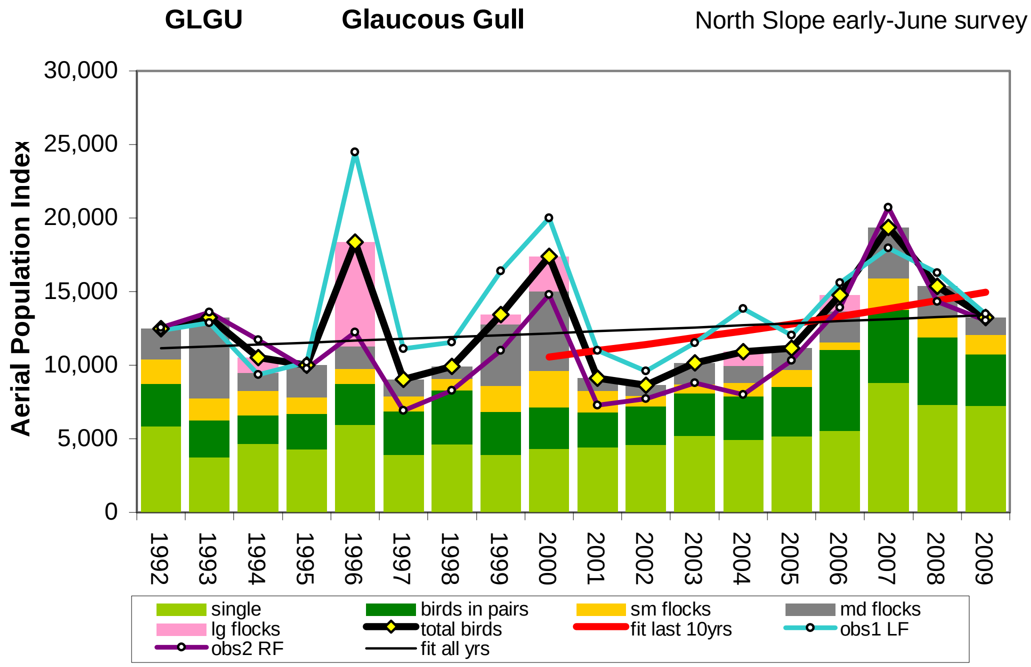

*NSE 10 strata =30,465 km2*

| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 1588 | 301 | 409 | 0 | 0 | **2298** | 297 |
| 1993 | 4713 | 1014 | 405 | 0 | 0 | **6131** | 706 |
| 1994 | 1335 | 671 | 0 | 0 | 0 | **2007** | 353 |
| 1995 | 5989 | 1232 | 144 | 0 | 0 | **7365** | 650 |
| 1996 | 2897 | 842 | 253 | 0 | 0 | **3992** | 485 |
| 1997 | 2346 | 638 | 0 | 0 | 0 | **2984** | 316 |
| 1998 | 1702 | 952 | 164 | 0 | 0 | **2817** | 384 |
| 1999 | 3276 | 1143 | 154 | 0 | 0 | **4572** | 477 |
| 2000 | 3673 | 1124 | 221 | 0 | 0 | **5018** | 526 |
| 2001 | 3655 | 1005 | 286 | 0 | 0 | **4946** | 604 |
| 2002 | 1622 | 525 | 0 | 0 | 0 | **2147** | 232 |
| 2003 | 2078 | 785 | 0 | 0 | 0 | **2863** | 300 |
| 2004 | 1793 | 666 | 0 | 0 | 0 | **2459** | 242 |
| 2005 | 2081 | 390 | 0 | 0 | 0 | **2471** | 278 |
| 2006 | 6893 | 1891 | 147 | 0 | 0 | **8930** | 589 |
| 2007 | 3886 | 1125 | 99 | 392 | 0 | **5502** | 909 |
| 2008 | 3618 | 620 | 392 | 0 | 0 | **4630** | 717 |
| 2009 | 2929 | 737 | 0 | 0 | 0 | **3666** | 335 |

JAEG

| Aerial index: Total birds | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **4155** |
| std dev = | 1933 |
| std error = | 456 |
| low 90%ci = | 3263 |
| high 90%ci = | 5048 |
| | |
| ln linear slope = | 0.011 |
| SE slope = | 0.0206 |
| Growth Rate = | **1.011** |
| low 90%ci GR = | 0.978 |
| high 90%ci GR = | 1.046 |
| regression resid CV = | 0.453 |
| avg sampling err CV = | 0.117 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 23.5 |
| w/ sample error CV = | 9.5 |
| most recent 10 years : | |
| Growth Rate = | **1.030** |
| low 90%ci GR = | 0.946 |
| high 90%ci GR = | 1.121 |

Figure 6. Population trend for jaeger species (Stercorarius parasiticus, S. pomarinus, S. longicaudus) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

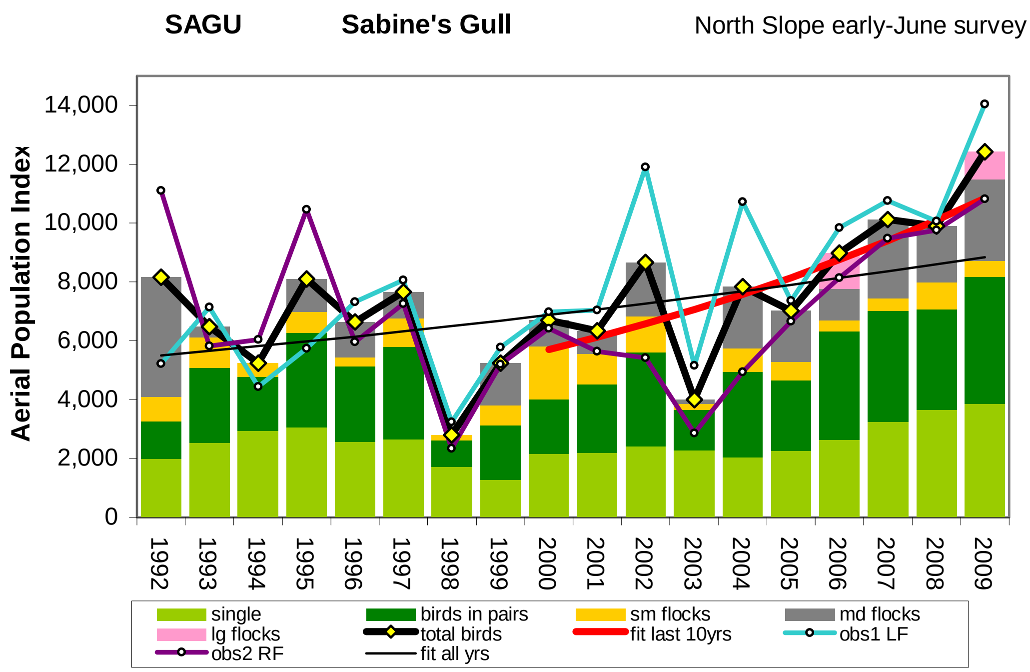
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 5840 | 2875 | 1704 | 2050 | 0 | **12469** | 1385 |
| 1993 | 3724 | 2536 | 1489 | 5490 | 0 | **13238** | 3151 |
| 1994 | 4648 | 1964 | 1640 | 1223 | 1057 | **10532** | 1794 |
| 1995 | 4300 | 2396 | 1119 | 2185 | 0 | **10000** | 1522 |
| 1996 | 5959 | 2772 | 1034 | 1501 | 7107 | **18372** | 7868 |
| 1997 | 3919 | 2979 | 973 | 1158 | 0 | **9028** | 1289 |
| 1998 | 4645 | 3636 | 786 | 859 | 0 | **9926** | 1097 |
| 1999 | 3932 | 2900 | 1780 | 4168 | 656 | **13435** | 1343 |
| 2000 | 4303 | 2832 | 2464 | 5454 | 2342 | **17394** | 3095 |
| 2001 | 4423 | 2391 | 1429 | 886 | 0 | **9130** | 1124 |
| 2002 | 4596 | 2615 | 706 | 732 | 0 | **8649** | 788 |
| 2003 | 5182 | 2878 | 645 | 1449 | 0 | **10153** | 1325 |
| 2004 | 4921 | 2971 | 898 | 1181 | 951 | **10921** | 1164 |
| 2005 | 5162 | 3376 | 1134 | 1503 | 0 | **11175** | 1255 |
| 2006 | 5573 | 5465 | 505 | 2098 | 1102 | **14743** | 1976 |
| 2007 | 8807 | 4945 | 2169 | 3424 | 0 | **19345** | 2390 |
| 2008 | 7304 | 4615 | 1326 | 2101 | 0 | **15346** | 1220 |
| 2009 | 7236 | 3494 | 1335 | 1181 | 0 | **13246** | 1460 |

GLGU

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **12617** |
| std dev = | 3298 |
| std error = | 777 |
| low 90%ci = | 11093 |
| high 90%ci = | 14140 |
| ln linear slope = | 0.011 |
| SE slope = | 0.0114 |
| Growth Rate = | **1.011** |
| low 90%ci GR = | 0.992 |
| high 90%ci GR = | 1.030 |
| regression resid CV = | 0.252 |
| avg sampling err CV = | 0.147 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 15.9 |
| w/ sample error CV = | 11.1 |
| most recent 10 years : | |
| Growth Rate = | **1.039** |
| low 90%ci GR = | 0.991 |
| high 90%ci GR = | 1.090 |

Figure 7. Population trend for Glaucous Gulls (Larus hyperboreus) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 1974 | 1276 | 833 | 4076 | 0 | **8158** | 1264 |
| 1993 | 2546 | 2525 | 1043 | 372 | 0 | **6487** | 737 |
| 1994 | 2935 | 1852 | 446 | 0 | 0 | **5234** | 624 |
| 1995 | 3059 | 3221 | 696 | 1122 | 0 | **8098** | 1482 |
| 1996 | 2567 | 2547 | 335 | 1184 | 0 | **6632** | 954 |
| 1997 | 2631 | 3160 | 966 | 898 | 0 | **7655** | 738 |
| 1998 | 1719 | 909 | 165 | 0 | 0 | **2793** | 409 |
| 1999 | 1280 | 1836 | 689 | 1443 | 0 | **5249** | 812 |
| 2000 | 2150 | 1841 | 1818 | 895 | 0 | **6705** | 844 |
| 2001 | 2198 | 2328 | 1028 | 788 | 0 | **6342** | 869 |
| 2002 | 2423 | 3179 | 1232 | 1816 | 0 | **8651** | 822 |
| 2003 | 2272 | 1389 | 196 | 146 | 0 | **4004** | 448 |
| 2004 | 2040 | 2909 | 784 | 2100 | 0 | **7833** | 1182 |
| 2005 | 2264 | 2388 | 625 | 1741 | 0 | **7018** | 866 |
| 2006 | 2640 | 3679 | 374 | 1072 | 1220 | **8984** | 1509 |
| 2007 | 3242 | 3781 | 414 | 2676 | 0 | **10113** | 1105 |
| 2008 | 3669 | 3410 | 893 | 1929 | 0 | **9901** | 1124 |
| 2009 | 3852 | 4317 | 543 | 2774 | 944 | **12429** | 1633 |

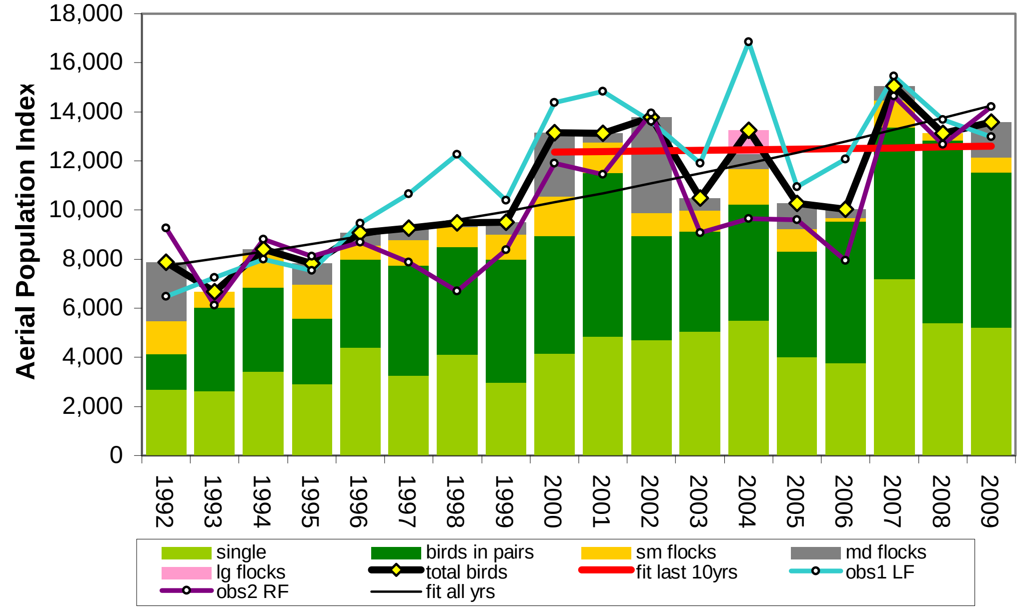
SAGU

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **7349** |
| std dev = | 2294 |
| std error = | 541 |
| low 90%ci = | 6289 |
| high 90%ci = | 8409 |
| ln linear slope = | 0.028 |
| SE slope = | 0.0149 |
| Growth Rate = | **1.028** |
| low 90%ci GR = | 1.003 |
| high 90%ci GR = | 1.054 |
| regression resid CV = | 0.328 |
| avg sampling err CV = | 0.132 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 19.0 |
| w/ sample error CV = | 10.3 |
| most recent 10 years : | |
| Growth Rate = | **1.074** |
| low 90%ci GR = | 1.028 |
| high 90%ci GR = | 1.122 |

**Figure** 8. Population trend for Sabine's Gulls (Xema sabini) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

**ARTE** **Arctic Tern** North Slope early-June survey




*NSE 10 strata =30,465 km2*

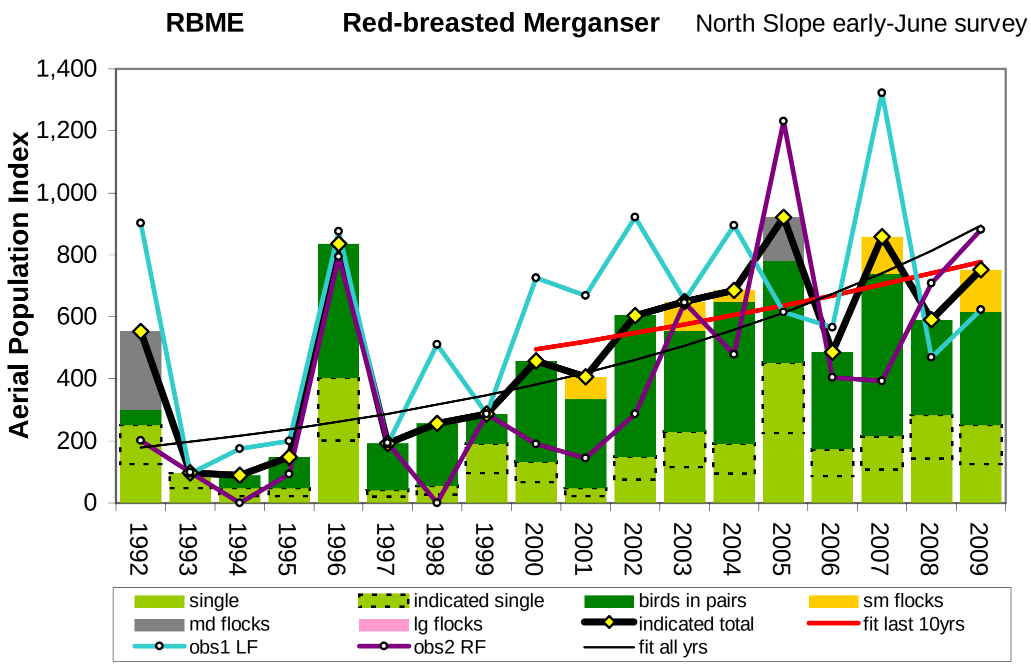
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 2691 | 1449 | 1327 | 2411 | 0 | **7877** | 1340 |
| 1993 | 2605 | 3425 | 652 | 0 | 0 | **6682** | 692 |
| 1994 | 3419 | 3417 | 1418 | 147 | 0 | **8400** | 933 |
| 1995 | 2905 | 2655 | 1393 | 879 | 0 | **7832** | 1186 |
| 1996 | 4398 | 3597 | 560 | 528 | 0 | **9083** | 906 |
| 1997 | 3252 | 4464 | 1069 | 488 | 0 | **9274** | 891 |
| 1998 | 4098 | 4409 | 806 | 179 | 0 | **9491** | 838 |
| 1999 | 2969 | 5016 | 1007 | 515 | 0 | **9508** | 1230 |
| 2000 | 4151 | 4783 | 1635 | 2571 | 0 | **13141** | 1361 |
| 2001 | 4844 | 6685 | 1217 | 389 | 0 | **13135** | 1236 |
| 2002 | 4698 | 4221 | 956 | 3905 | 0 | **13778** | 1800 |
| 2003 | 5033 | 4077 | 872 | 512 | 0 | **10493** | 1128 |
| 2004 | 5491 | 4735 | 1441 | 617 | 964 | **13248** | 1509 |
| 2005 | 3997 | 4301 | 917 | 1051 | 0 | **10266** | 1195 |
| 2006 | 3779 | 5752 | 147 | 348 | 0 | **10026** | 917 |
| 2007 | 7173 | 6186 | 1107 | 575 | 0 | **15040** | 1227 |
| 2008 | 5409 | 7435 | 275 | 0 | 0 | **13119** | 1475 |
| 2009 | 5199 | 6314 | 629 | 1451 | 0 | **13593** | 1369 |

ARTE

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **10777** |
| std dev = | 2505 |
| std error = | 590 |
| low 90%ci = | 9620 |
| high 90%ci = | 11934 |
| ln linear slope = | 0.036 |
| SE slope = | 0.0065 |
| Growth Rate = | **1.037** |
| low 90%ci GR = | 1.026 |
| high 90%ci GR = | 1.048 |
| regression resid CV = | 0.143 |
| avg sampling err CV = | 0.111 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 10.9 |
| w/ sample error CV = | 9.2 |
| most recent 10 years : | |
| Growth Rate = | **1.002** |
| low 90%ci GR = | 0.975 |
| high 90%ci GR = | 1.030 |

Figure 9. Population trend for Arctic Terns (Sterna paradisaea) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.



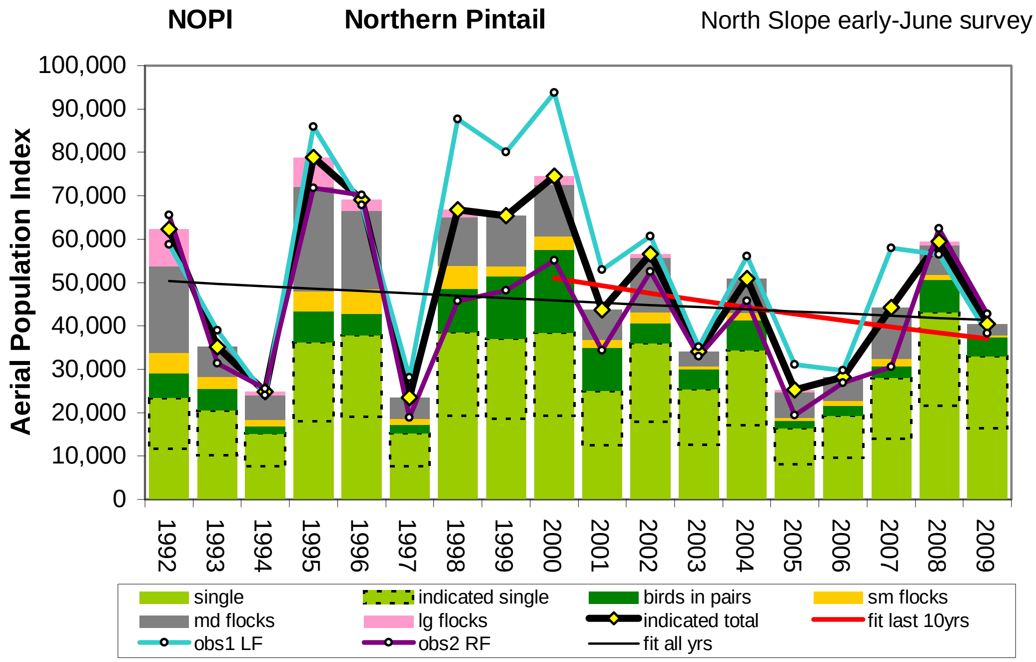

*NSE 10 strata =30,465 km2*

| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 250 | 50 | 0 | 252 | 0 | **552** | 252 |
| 1993 | 97 | 0 | 0 | 0 | 0 | **97** | 68 |
| 1994 | 47 | 41 | 0 | 0 | 0 | **88** | 63 |
| 1995 | 47 | 101 | 0 | 0 | 0 | **148** | 87 |
| 1996 | 403 | 433 | 0 | 0 | 0 | **836** | 220 |
| 1997 | 42 | 149 | 0 | 0 | 0 | **192** | 90 |
| 1998 | 55 | 202 | 0 | 0 | 0 | **256** | 99 |
| 1999 | 193 | 95 | 0 | 0 | 0 | **287** | 105 |
| 2000 | 132 | 326 | 0 | 0 | 0 | **458** | 153 |
| 2001 | 47 | 287 | 72 | 0 | 0 | **407** | 132 |
| 2002 | 150 | 454 | 0 | 0 | 0 | **604** | 155 |
| 2003 | 230 | 326 | 93 | 0 | 0 | **650** | 214 |
| 2004 | 191 | 459 | 37 | 0 | 0 | **686** | 179 |
| 2005 | 451 | 329 | 0 | 141 | 0 | **921** | 320 |
| 2006 | 174 | 312 | 0 | 0 | 0 | **485** | 158 |
| 2007 | 216 | 523 | 120 | 0 | 0 | **858** | 322 |
| 2008 | 283 | 308 | 0 | 0 | 0 | **591** | 228 |
| 2009 | 250 | 366 | 136 | 0 | 0 | **752** | 200 |

RBME

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **493** |
| std dev = | 269 |
| std error = | 63 |
| low 90%ci = | 369 |
| high 90%ci = | 617 |
| trend over all years : | |
| ln linear slope = | 0.094 |
| SE slope = | 0.0255 |
| Growth Rate = | **1.099** |
| low 90%ci GR = | 1.054 |
| high 90%ci GR = | 1.146 |
| regression resid CV = | 0.561 |
| avg sampling err CV = | 0.397 |
| trend of most recent 10 years : | |
| Growth Rate = | **1.051** |
| low 90%ci GR = | 1.008 |
| high 90%ci GR = | 1.097 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 27.1 |
| w/ sample error CV = | 21.5 |

Figure 10. Population trend for Red-breasted Meganser (Mergus serrator) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

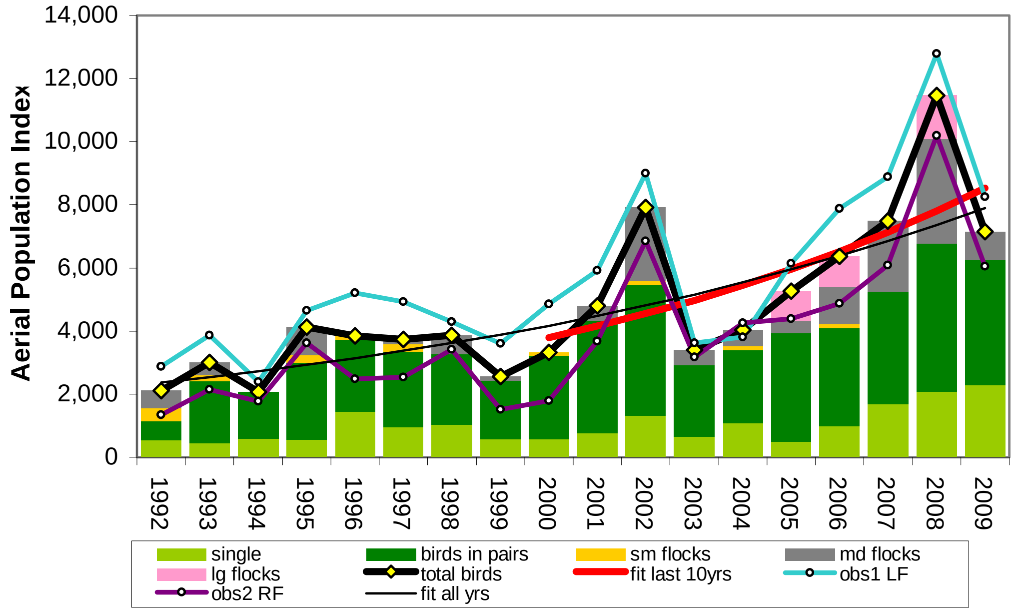
| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 23339 | 5630 | 4752 | 20018 | 8491 | **62230** | 6591 |
| 1993 | 20441 | 5126 | 2668 | 6905 | 0 | **35141** | 3261 |
| 1994 | 15254 | 1573 | 1550 | 5590 | 802 | **24768** | 2589 |
| 1995 | 36195 | 7281 | 4396 | 24109 | 6892 | **78872** | 8012 |
| 1996 | 37891 | 4794 | 5743 | 18034 | 2558 | **69020** | 9306 |
| 1997 | 15217 | 1984 | 1439 | 4812 | 0 | **23452** | 2624 |
| 1998 | 38469 | 10126 | 5255 | 11094 | 1832 | **66775** | 5576 |
| 1999 | 37076 | 14400 | 2264 | 11702 | 0 | **65443** | 3896 |
| 2000 | 38434 | 19056 | 3134 | 11843 | 1999 | **74466** | 6031 |
| 2001 | 24965 | 10029 | 1749 | 6882 | 0 | **43625** | 4392 |
| 2002 | 35915 | 4630 | 2602 | 12529 | 881 | **56557** | 6030 |
| 2003 | 25320 | 4725 | 643 | 3387 | 0 | **34075** | 3873 |
| 2004 | 34272 | 6991 | 1804 | 7817 | 0 | **50885** | 4796 |
| 2005 | 16381 | 1703 | 592 | 6047 | 481 | **25205** | 2544 |
| 2006 | 19280 | 2265 | 1118 | 5627 | 0 | **28290** | 2551 |
| 2007 | 28009 | 2669 | 1758 | 11796 | 0 | **44232** | 4828 |
| 2008 | 43134 | 7417 | 1202 | 6877 | 820 | **59450** | 5222 |
| 2009 | 32921 | 4351 | 528 | 2651 | 0 | **40451** | 5521 |

NOPI

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **49052** |
| std dev = | 18226 |
| std error = | 4296 |
| low 90%ci = | 40632 |
| high 90%ci = | 57472 |
| trend over all years : | |
| ln linear slope = | -0.012 |
| SE slope = | 0.0187 |
| Growth Rate = | **0.989** |
| low 90%ci GR = | 0.959 |
| high 90%ci GR = | 1.019 |
| regression resid CV = | 0.412 |
| avg sampling err CV = | 0.101 |
| trend of most recent 10 years : | |
| Growth Rate = | **0.965** |
| low 90%ci GR = | 0.908 |
| high 90%ci GR = | 1.027 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 22.1 |
| w/ sample error CV = | 8.6 |

Figure 11. Population trend for Northern Pintail (*Anas acuta*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.

**SCAU** **Scaup spp.** North Slope early-June survey




*NSE 10 strata =30,465 km2*

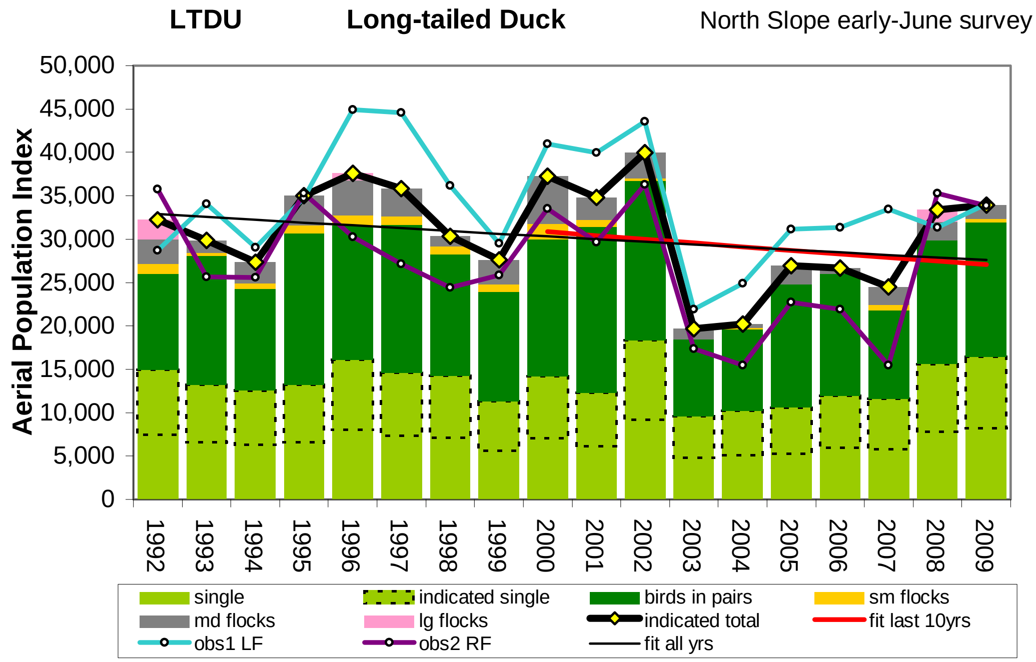
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 539 | 607 | 400 | 563 | 0 | **2109** | 572 |
| 1993 | 455 | 1946 | 192 | 411 | 0 | **3004** | 636 |
| 1994 | 594 | 1486 | 0 | 0 | 0 | **2080** | 366 |
| 1995 | 560 | 2453 | 209 | 912 | 0 | **4133** | 719 |
| 1996 | 1437 | 2292 | 120 | 0 | 0 | **3849** | 526 |
| 1997 | 948 | 2396 | 245 | 145 | 0 | **3735** | 661 |
| 1998 | 1035 | 2240 | 0 | 582 | 0 | **3857** | 470 |
| 1999 | 576 | 1847 | 0 | 143 | 0 | **2565** | 452 |
| 2000 | 579 | 2659 | 87 | 0 | 0 | **3325** | 556 |
| 2001 | 766 | 3556 | 0 | 480 | 0 | **4802** | 784 |
| 2002 | 1306 | 4147 | 120 | 2342 | 0 | **7915** | 982 |
| 2003 | 655 | 2266 | 0 | 483 | 0 | **3403** | 545 |
| 2004 | 1079 | 2319 | 119 | 524 | 0 | **4041** | 611 |
| 2005 | 507 | 3404 | 0 | 421 | 937 | **5269** | 1043 |
| 2006 | 988 | 3103 | 125 | 1177 | 976 | **6370** | 1550 |
| 2007 | 1685 | 3567 | 0 | 2237 | 0 | **7488** | 1514 |
| 2008 | 2072 | 4709 | 0 | 3290 | 1397 | **11468** | 3418 |
| 2009 | 2283 | 3966 | 0 | 895 | 0 | **7145** | 872 |

SCAU

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **4809** |
| std dev = | 2432 |
| std error = | 573 |
| low 90%ci = | 3685 |
| high 90%ci = | 5932 |
| ln linear slope = | 0.071 |
| SE slope = | 0.0128 |
| Growth Rate = | **1.074** |
| low 90%ci GR = | 1.051 |
| high 90%ci GR = | 1.096 |
| regression resid CV = | 0.282 |
| avg sampling err CV = | 0.182 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 17.1 |
| w/ sample error CV = | 12.8 |
| most recent 10 years : | |
| Growth Rate = | **1.094** |
| low 90%ci GR = | 1.034 |
| high 90%ci GR = | 1.158 |

Figure 12. Population trend for Scaup (*Aythya marila, A. affinis*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.



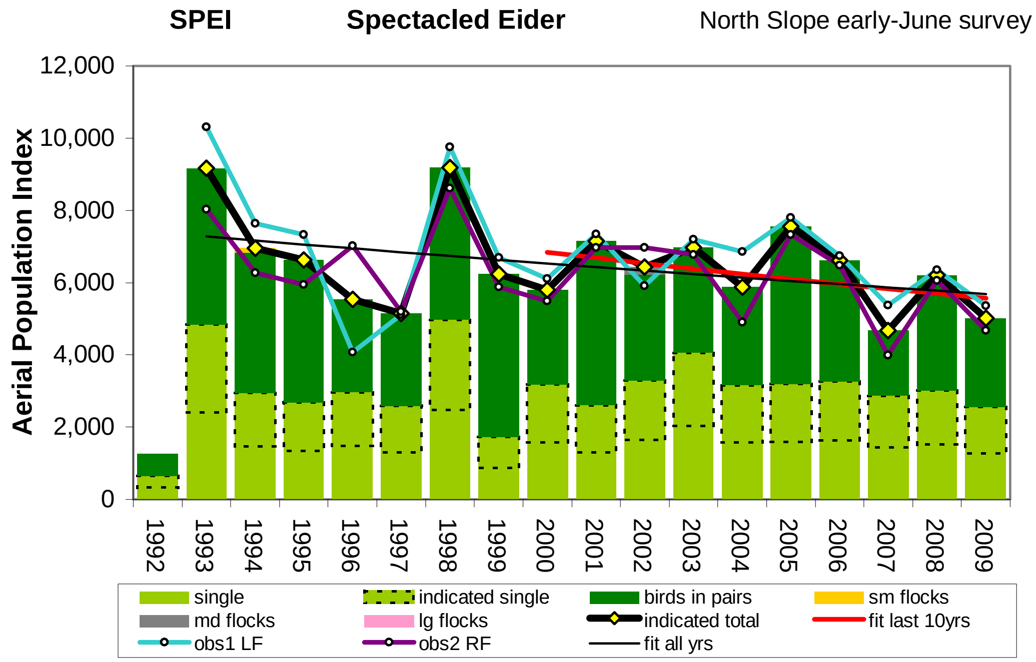

*NSE 10 strata =30,465 km2*

| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 14896 | 11116 | 1123 | 2818 | 2268 | **32221** | 3513 |
| 1993 | 13208 | 14871 | 346 | 1432 | 0 | **29858** | 1989 |
| 1994 | 12570 | 11684 | 623 | 2434 | 0 | **27312** | 2090 |
| 1995 | 13206 | 17440 | 913 | 3463 | 0 | **35021** | 2361 |
| 1996 | 16046 | 15597 | 1099 | 4023 | 849 | **37614** | 2419 |
| 1997 | 14607 | 17009 | 1021 | 3215 | 0 | **35853** | 2087 |
| 1998 | 14244 | 13963 | 942 | 1162 | 0 | **30310** | 1612 |
| 1999 | 11329 | 12640 | 872 | 2742 | 0 | **27584** | 1811 |
| 2000 | 14154 | 15833 | 1737 | 5529 | 0 | **37252** | 2773 |
| 2001 | 12270 | 19161 | 807 | 2572 | 0 | **34810** | 2016 |
| 2002 | 18317 | 18405 | 257 | 2953 | 0 | **39931** | 2097 |
| 2003 | 9579 | 8894 | 0 | 1168 | 0 | **19642** | 1227 |
| 2004 | 10230 | 9380 | 198 | 391 | 0 | **20199** | 1658 |
| 2005 | 10594 | 14197 | 0 | 2122 | 0 | **26912** | 1583 |
| 2006 | 11917 | 14036 | 0 | 716 | 0 | **26669** | 2150 |
| 2007 | 11597 | 10191 | 645 | 2046 | 0 | **24479** | 1857 |
| 2008 | 15579 | 14283 | 0 | 2078 | 1405 | **33345** | 2755 |
| 2009 | 16439 | 15526 | 425 | 1561 | 0 | **33950** | 1787 |

LTDU

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **30720** |
| std dev = | 5850 |
| std error = | 1379 |
| low 90%ci = | 28017 |
| high 90%ci = | 33423 |
| trend over all years : | |
| ln linear slope = | -0.01 |
| SE slope = | 0.0092 |
| Growth Rate = | **0.990** |
| low 90%ci GR = | 0.975 |
| high 90%ci GR = | 1.005 |
| regression resid CV = | 0.202 |
| avg sampling err CV = | 0.069 |
| trend of most recent 10 years : | |
| Growth Rate = | **0.986** |
| low 90%ci GR = | 0.940 |
| high 90%ci GR = | 1.034 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 13.8 |
| w/ sample error CV = | 6.7 |

Figure 13. Population trend for Long-tailed Duck (*Clangula hyemalis*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.



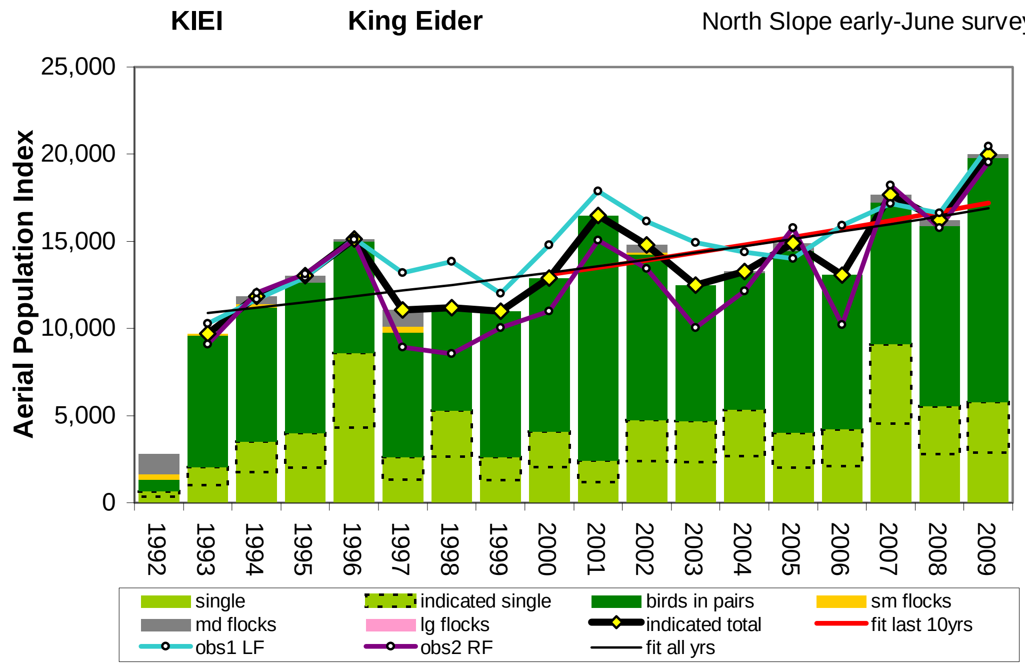

*NSE 10 strata =30,465 km2*

| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 657 | 602 | 0 | 0 | 0 | | |
| 1993 | 4828 | 4339 | 0 | 0 | 0 | **9167** | 900 |
| 1994 | 2945 | 3885 | 122 | 0 | 0 | **6951** | 733 |
| 1995 | 2679 | 3951 | 0 | 0 | 0 | **6630** | 677 |
| 1996 | 2964 | 2580 | 0 | 0 | 0 | **5544** | 680 |
| 1997 | 2594 | 2553 | 0 | 0 | 0 | **5148** | 515 |
| 1998 | 4963 | 4223 | 0 | 0 | 0 | **9186** | 1001 |
| 1999 | 1723 | 4517 | 0 | 0 | 0 | **6240** | 541 |
| 2000 | 3170 | 2628 | 0 | 0 | 0 | **5798** | 487 |
| 2001 | 2611 | 4537 | 0 | 0 | 0 | **7148** | 675 |
| 2002 | 3284 | 2938 | 0 | 216 | 0 | **6439** | 812 |
| 2003 | 4058 | 2918 | 0 | 0 | 0 | **6976** | 635 |
| 2004 | 3165 | 2716 | 0 | 0 | 0 | **5881** | 574 |
| 2005 | 3186 | 4374 | 0 | 0 | 0 | **7561** | 964 |
| 2006 | 3259 | 3356 | 0 | 0 | 0 | **6615** | 947 |
| 2007 | 2864 | 1813 | 0 | 0 | 0 | **4676** | 668 |
| 2008 | 3019 | 3188 | 0 | 0 | 0 | **6207** | 592 |
| 2009 | 2549 | 2468 | 0 | 0 | 0 | **5018** | 854 |

SPEI

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 17 |
| mean pop index = | **6540** |
| std dev = | 1265 |
| std error = | 307 |
| low 90%ci = | 5939 |
| high 90%ci = | 7142 |
| trend over all years : | |
| ln linear slope = | -0.015 |
| SE slope = | 0.0087 |
| Growth Rate = | **0.985** |
| low 90%ci GR = | 0.971 |
| high 90%ci GR = | 0.999 |
| regression resid CV = | 0.176 |
| avg sampling err CV = | 0.112 |
| trend of most recent 10 years : | |
| Growth Rate = | **0.977** |
| low 90%ci GR = | 0.952 |
| high 90%ci GR = | 1.003 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 12.5 |
| w/ sample error CV = | 9.2 |

Figure 14. Population trend for Spectacled Eider (Somateria fischeri) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years. A low index in 1992 was excluded from trend calculation because the survey was flown too late in June.




*NSE 10 strata =30,465 km2*

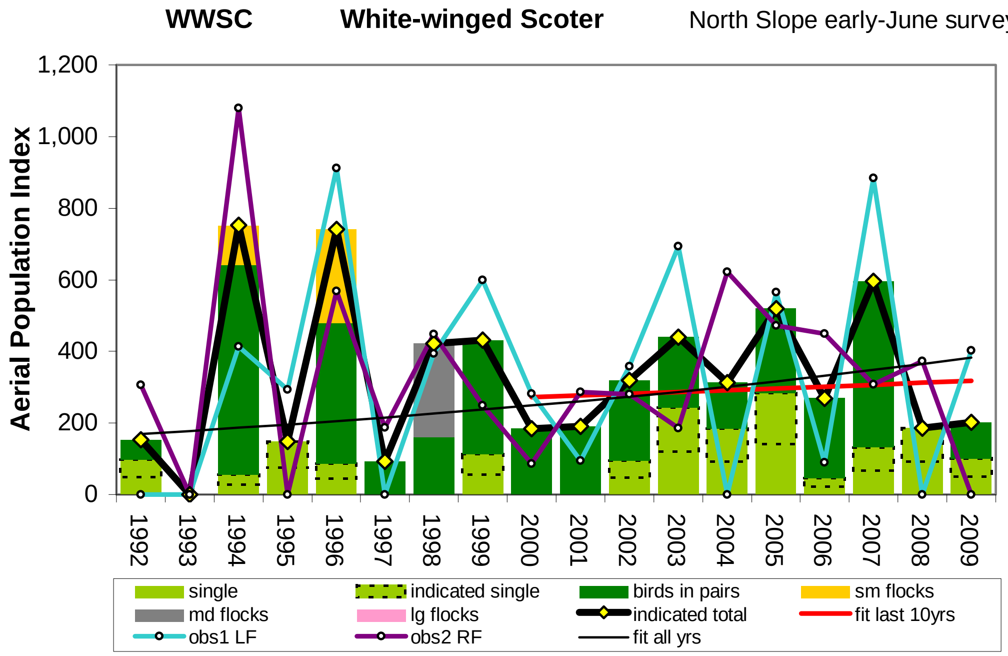
| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 661 | 677 | 290 | 1142 | 0 | | |
| 1993 | 2029 | 7587 | 75 | 0 | 0 | **9692** | 1046 |
| 1994 | 3495 | 7695 | 212 | 451 | 0 | **11853** | 1052 |
| 1995 | 4013 | 8650 | 0 | 373 | 0 | **13037** | 1197 |
| 1996 | 8598 | 6400 | 0 | 146 | 0 | **15143** | 1395 |
| 1997 | 2618 | 7163 | 333 | 958 | 0 | **11072** | 962 |
| 1998 | 5295 | 5746 | 169 | 0 | 0 | **11211** | 852 |
| 1999 | 2597 | 8389 | 0 | 0 | 0 | **10987** | 1143 |
| 2000 | 4079 | 8803 | 0 | 0 | 0 | **12882** | 1349 |
| 2001 | 2403 | 14066 | 0 | 0 | 0 | **16469** | 1236 |
| 2002 | 4746 | 9507 | 94 | 432 | 0 | **14780** | 1518 |
| 2003 | 4689 | 7796 | 0 | 0 | 0 | **12485** | 1252 |
| 2004 | 5336 | 7820 | 0 | 95 | 0 | **13251** | 1094 |
| 2005 | 3988 | 10458 | 0 | 445 | 0 | **14891** | 1348 |
| 2006 | 4206 | 8862 | 0 | 0 | 0 | **13068** | 1239 |
| 2007 | 9103 | 8132 | 0 | 450 | 0 | **17685** | 1789 |
| 2008 | 5543 | 10347 | 0 | 341 | 0 | **16230** | 1230 |
| 2009 | 5771 | 14019 | 0 | 199 | 0 | **19989** | 1446 |

KIEI

<u>Aerial index: Indicated total</u>

| | |
|---|---|
| n yrs = | 17 |
| mean pop index = | **13807** |
| std dev = | 2705 |
| std error = | 656 |
| low 90%ci = | 12521 |
| high 90%ci = | 15093 |
| <u>trend over all years :</u> | |
| ln linear slope = | 0.027 |
| SE slope = | 0.0068 |
| Growth Rate = | **1.028** |
| low 90%ci GR = | 1.016 |
| high 90%ci GR = | 1.039 |
| regression resid CV = | 0.137 |
| avg sampling err CV = | 0.091 |
| <u>trend of most recent 10 years :</u> | |
| Growth Rate = | **1.031** |
| low 90%ci GR = | 1.006 |
| high 90%ci GR = | 1.056 |
| <u>min yrs to detect -50%/20yr rate :</u> | |
| w/ regression resid CV = | 10.6 |
| w/ sample error CV = | 8.1 |

Figure 15. Population trend for King Eider (Somateria spectabilis) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. A low index in 1992 was excluded from trend calculation because the survey was flown too late in June.



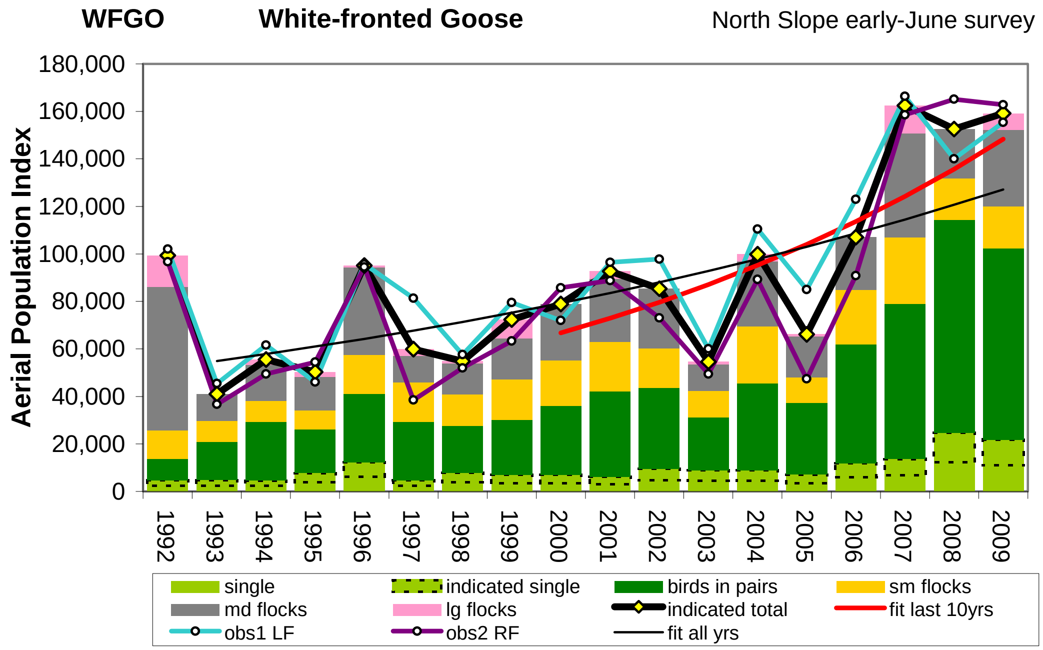

*NSE 10 strata =30,465 km2*

| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 98 | 55 | 0 | 0 | 0 | **153** | 85 |
| 1993 | 0 | 0 | 0 | 0 | 0 | **20** | 0 |
| 1994 | 55 | 588 | 109 | 0 | 0 | **752** | 585 |
| 1995 | 148 | 0 | 0 | 0 | 0 | **148** | 108 |
| 1996 | 87 | 392 | 261 | 0 | 0 | **740** | 344 |
| 1997 | 0 | 94 | 0 | 0 | 0 | **94** | 62 |
| 1998 | 0 | 160 | 0 | 261 | 0 | **421** | 227 |
| 1999 | 112 | 319 | 0 | 0 | 0 | **431** | 210 |
| 2000 | 0 | 184 | 0 | 0 | 0 | **184** | 86 |
| 2001 | 0 | 191 | 0 | 0 | 0 | **191** | 92 |
| 2002 | 94 | 225 | 0 | 0 | 0 | **319** | 232 |
| 2003 | 242 | 198 | 0 | 0 | 0 | **440** | 294 |
| 2004 | 185 | 128 | 0 | 0 | 0 | **313** | 212 |
| 2005 | 283 | 235 | 0 | 0 | 0 | **519** | 418 |
| 2006 | 45 | 225 | 0 | 0 | 0 | **269** | 201 |
| 2007 | 132 | 464 | 0 | 0 | 0 | **596** | 58 |
| 2008 | 186 | 0 | 0 | 0 | 0 | **186** | 131 |
| 2009 | 101 | 101 | 0 | 0 | 0 | **201** | 99 |

WWSC

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **332** |
| std dev = | 214 |
| std error = | 51 |
| low 90%ci = | 233 |
| high 90%ci = | 431 |
| trend over all years : | |
| ln linear slope = | 0.048 |
| SE slope = | 0.0389 |
| Growth Rate = | **1.049** |
| low 90%ci GR = | 0.984 |
| high 90%ci GR = | 1.118 |
| regression resid CV = | 0.857 |
| avg sampling err CV = | 0.594 |
| trend of most recent 10 years : | |
| Growth Rate = | **1.017** |
| low 90%ci GR = | 0.935 |
| high 90%ci GR = | 1.107 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 36.0 |
| w/ sample error CV = | 28.1 |

Figure 16. Population trend for White-winged Scoters (Melanitta fusca) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years. To calculate slope, an index value of 20 was substituted for years with no observations.




*NSE 10 strata =30,465 km2*

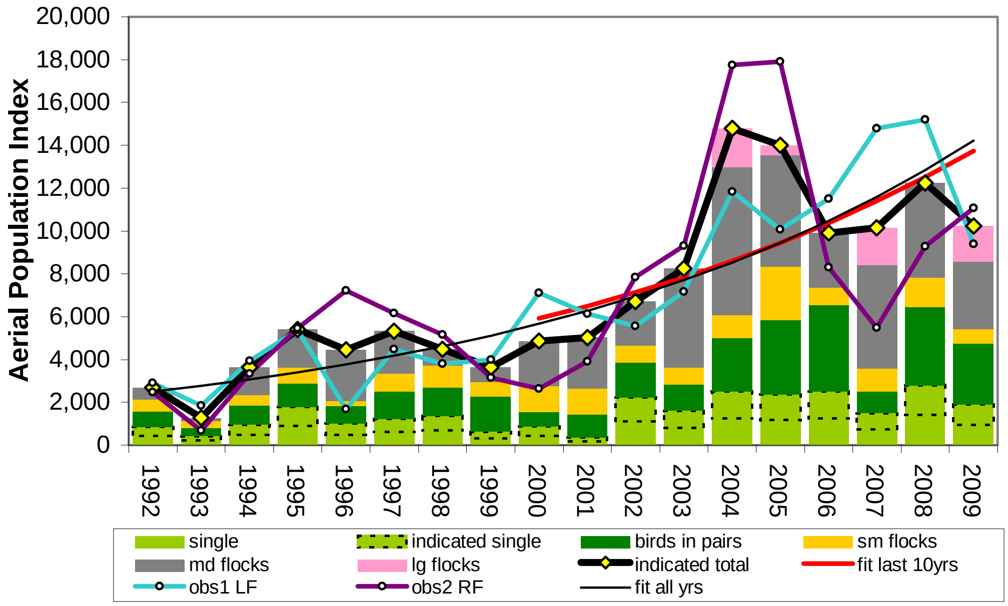
| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 4794 | 8915 | 12107 | 60359 | 13185 | **99361** | 9691 |
| 1993 | 4760 | 16232 | 8712 | 11378 | 0 | **41083** | 2856 |
| 1994 | 4538 | 24854 | 8764 | 15121 | 2240 | **55517** | 4494 |
| 1995 | 7702 | 18479 | 7962 | 14033 | 2096 | **50272** | 4464 |
| 1996 | 12280 | 28850 | 16325 | 36897 | 773 | **95125** | 5640 |
| 1997 | 4632 | 24567 | 16692 | 11212 | 2854 | **59956** | 4413 |
| 1998 | 7884 | 19632 | 13290 | 13178 | 855 | **54839** | 4175 |
| 1999 | 7092 | 22928 | 17152 | 17275 | 7835 | **72283** | 6579 |
| 2000 | 6898 | 29138 | 19078 | 23780 | 0 | **78895** | 5433 |
| 2001 | 6108 | 35961 | 20830 | 26652 | 3081 | **92632** | 4963 |
| 2002 | 9522 | 34232 | 16392 | 25217 | 0 | **85363** | 6814 |
| 2003 | 8911 | 22116 | 11314 | 11127 | 1141 | **54609** | 4023 |
| 2004 | 8928 | 36562 | 24046 | 27344 | 2979 | **99859** | 7212 |
| 2005 | 7071 | 30148 | 10886 | 17160 | 906 | **66171** | 5033 |
| 2006 | 11929 | 50076 | 22780 | 22240 | 0 | **107025** | 8692 |
| 2007 | 13673 | 65197 | 28140 | 43777 | 11654 | **162441** | 10921 |
| 2008 | 24665 | 89655 | 17445 | 20870 | 0 | **152634** | 10049 |
| 2009 | 21823 | 80567 | 17603 | 32274 | 6921 | **159188** | 12025 |

WFGO

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **88181** |
| std dev = | 37561 |
| std error = | 8853 |
| low 90%ci = | 70828 |
| high 90%ci = | 105533 |
| trend over all years : | |
| ln linear slope = | 0.0525 |
| SE slope = | 0.0139 |
| Growth Rate = | **1.054** |
| low 90%ci GR = | 1.030 |
| high 90%ci GR = | 1.078 |
| regression resid CV = | 0.306 |
| avg sampling err CV = | 0.075 |
| trend of most recent 10 years : | |
| Growth Rate = | **1.093** |
| low 90%ci GR = | 1.040 |
| high 90%ci GR = | 1.149 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 18.1 |
| w/ sample error CV = | 7.1 |

Figure 17. Population trend for Greater White-fronted Geese (*Anser albifrons frontalis*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.

**BLBR** **Black Brant** North Slope early-June survey



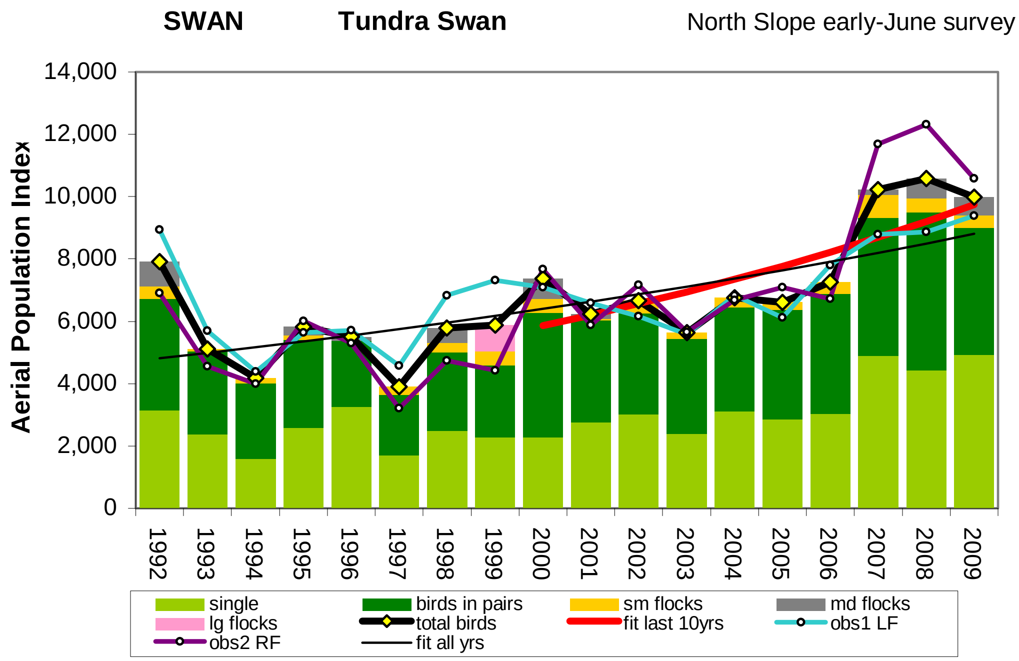

*NSE 10 strata =30,465 km2*

| year | 2*sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 844 | 737 | 566 | 549 | 0 | **2695** | 490 |
| 1993 | 413 | 376 | 331 | 141 | 0 | **1262** | 460 |
| 1994 | 960 | 893 | 479 | 1305 | 0 | **3636** | 888 |
| 1995 | 1780 | 1084 | 748 | 1795 | 0 | **5407** | 2452 |
| 1996 | 996 | 815 | 247 | 2387 | 0 | **4445** | 1439 |
| 1997 | 1224 | 1264 | 849 | 1983 | 0 | **5320** | 1758 |
| 1998 | 1357 | 1333 | 1015 | 768 | 0 | **4473** | 731 |
| 1999 | 633 | 1647 | 677 | 674 | 0 | **3630** | 698 |
| 2000 | 863 | 692 | 1217 | 2093 | 0 | **4864** | 821 |
| 2001 | 344 | 1097 | 1198 | 2391 | 0 | **5030** | 1494 |
| 2002 | 2235 | 1628 | 782 | 2065 | 0 | **6710** | 1251 |
| 2003 | 1609 | 1208 | 792 | 4655 | 0 | **8263** | 2844 |
| 2004 | 2505 | 2476 | 1102 | 6885 | 1816 | **14783** | 2650 |
| 2005 | 2354 | 3467 | 2499 | 5217 | 457 | **13994** | 2951 |
| 2006 | 2486 | 4041 | 820 | 2553 | 0 | **9900** | 1808 |
| 2007 | 1481 | 1022 | 1068 | 4841 | 1726 | **10138** | 1657 |
| 2008 | 2798 | 3673 | 1333 | 4443 | 0 | **12247** | 3140 |
| 2009 | 1912 | 2849 | 653 | 3150 | 1656 | **10221** | 2047 |

BLBR

| Aerial index: Indicated total | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **7056** |
| std dev = | 3971 |
| std error = | 936 |
| low 90%ci = | 5222 |
| high 90%ci = | 8891 |
| trend over all years : | |
| ln linear slope = | 0.102 |
| SE slope = | 0.0150 |
| Growth Rate = | **1.108** |
| low 90%ci GR = | 1.081 |
| high 90%ci GR = | 1.135 |
| regression resid CV = | 0.330 |
| avg sampling err CV = | 0.247 |
| trend of most recent 10 years : | |
| Growth Rate = | **1.098** |
| low 90%ci GR = | 1.043 |
| high 90%ci GR = | 1.157 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 19.0 |
| w/ sample error CV = | 15.7 |

Figure 18. Population trend for Pacific Black Brant (*Branta bernicla nigricans*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

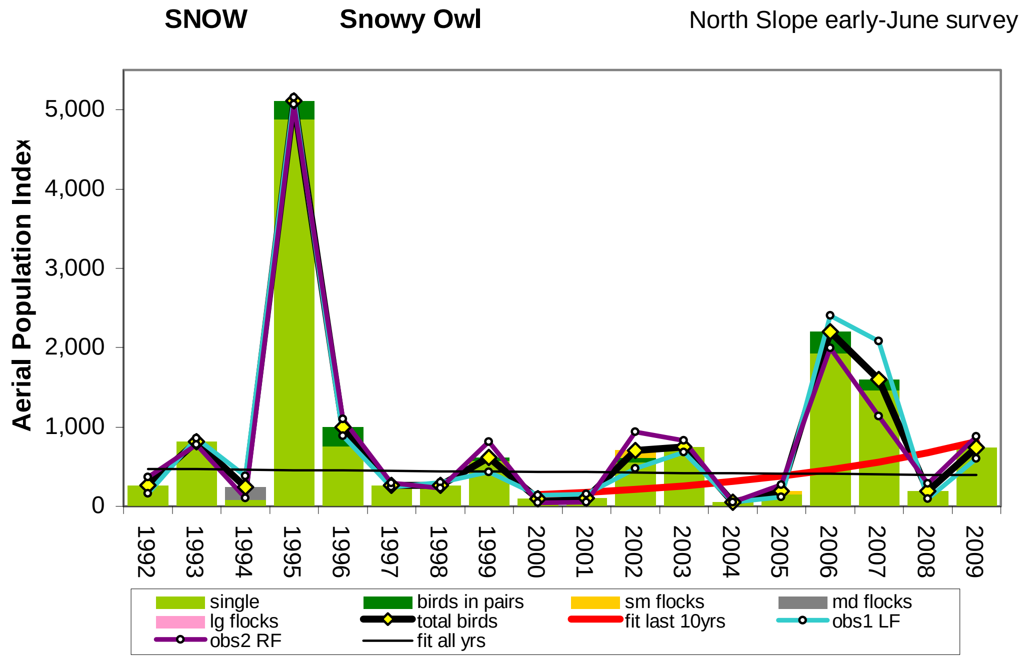
| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 3129 | 3591 | 394 | 809 | 0 | **7924** | 1219 |
| 1993 | 2366 | 2682 | 72 | 0 | 0 | **5120** | 534 |
| 1994 | 1582 | 2429 | 177 | 0 | 0 | **4188** | 444 |
| 1995 | 2581 | 2826 | 138 | 280 | 0 | **5824** | 690 |
| 1996 | 3246 | 2126 | 0 | 131 | 0 | **5503** | 583 |
| 1997 | 1697 | 1942 | 260 | 0 | 0 | **3898** | 504 |
| 1998 | 2476 | 2525 | 314 | 473 | 0 | **5788** | 656 |
| 1999 | 2282 | 2317 | 449 | 0 | 839 | **5887** | 1029 |
| 2000 | 2276 | 3989 | 461 | 655 | 0 | **7380** | 1037 |
| 2001 | 2758 | 3265 | 71 | 142 | 0 | **6237** | 645 |
| 2002 | 3025 | 3223 | 420 | 0 | 0 | **6668** | 758 |
| 2003 | 2381 | 3050 | 211 | 0 | 0 | **5641** | 629 |
| 2004 | 3112 | 3320 | 322 | 0 | 0 | **6754** | 529 |
| 2005 | 2862 | 3495 | 250 | 0 | 0 | **6607** | 566 |
| 2006 | 3024 | 3862 | 376 | 0 | 0 | **7262** | 667 |
| 2007 | 4894 | 4414 | 749 | 174 | 0 | **10231** | 672 |
| 2008 | 4428 | 5073 | 453 | 622 | 0 | **10575** | 1126 |
| 2009 | 4923 | 4071 | 413 | 584 | 0 | **9991** | 706 |

SWAN

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **6749** |
| std dev = | 1914 |
| std error = | 451 |
| low 90%ci = | 5865 |
| high 90%ci = | 7633 |
| | |
| ln linear slope = | 0.036 |
| SE slope = | 0.0094 |
| Growth Rate = | **1.036** |
| low 90%ci GR = | 1.020 |
| high 90%ci GR = | 1.052 |
| regression resid CV = | 0.207 |
| avg sampling err CV = | 0.110 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 13.9 |
| w/ sample error CV = | 9.1 |
| most recent 10 years : | |
| Growth Rate = | **1.058** |
| low 90%ci GR = | 1.029 |
| high 90%ci GR = | 1.088 |

Figure 19. Population trend for Tundra Swans (*Cygnus columbianus*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Calculations of power used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.




*NSE 10 strata =30,465 km2*

| year | sg | 2*npr | sm flk | md flk | lg flk | Index | StdErr |
|---|---|---|---|---|---|---|---|
| 1992 | 264 | 0 | 0 | 0 | 0 | **264** | 112 |
| 1993 | 817 | 0 | 0 | 0 | 0 | **817** | 180 |
| 1994 | 80 | 0 | 0 | 160 | 0 | **240** | 158 |
| 1995 | 4880 | 234 | 0 | 0 | 0 | **5113** | 780 |
| 1996 | 759 | 236 | 0 | 0 | 0 | **995** | 227 |
| 1997 | 265 | 0 | 0 | 0 | 0 | **265** | 94 |
| 1998 | 267 | 0 | 0 | 0 | 0 | **267** | 72 |
| 1999 | 570 | 48 | 0 | 0 | 0 | **618** | 155 |
| 2000 | 95 | 0 | 0 | 0 | 0 | **95** | 51 |
| 2001 | 101 | 0 | 0 | 0 | 0 | **101** | 60 |
| 2002 | 559 | 48 | 99 | 0 | 0 | **706** | 176 |
| 2003 | 751 | 0 | 0 | 0 | 0 | **751** | 154 |
| 2004 | 49 | 0 | 0 | 0 | 0 | **49** | 36 |
| 2005 | 157 | 0 | 36 | 0 | 0 | **194** | 74 |
| 2006 | 1927 | 277 | 0 | 0 | 0 | **2203** | 421 |
| 2007 | 1458 | 144 | 0 | 0 | 0 | **1602** | 412 |
| 2008 | 188 | 0 | 0 | 0 | 0 | **188** | 122 |
| 2009 | 741 | 0 | 0 | 0 | 0 | **741** | 169 |

SNOW

Aerial index: Total birds

| | |
|---|---|
| n yrs = | 18 |
| mean pop index = | **845** |
| std dev = | 1206 |
| std error = | 284 |
| low 90%ci = | 288 |
| high 90%ci = | 1402 |
| ln linear slope = | -0.01 |
| SE slope = | 0.0557 |
| Growth Rate = | **0.990** |
| low 90%ci GR = | 0.903 |
| high 90%ci GR = | 1.085 |
| regression resid CV = | 1.229 |
| avg sampling err CV = | 0.366 |
| Power (yrs to detect -50%/20yr rate) : | |
| w/ regression resid CV = | 45.7 |
| w/ sample error CV = | 20.4 |
| most recent 10 years : | |
| Growth Rate = | **1.211** |
| low 90%ci GR = | 0.968 |
| high 90%ci GR = | 1.514 |

Figure 20. Population trend for Snowy Owls (*Bubo scandiacus*) observed on aerial survey transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 10 physiographic regions. Average annual growth rate was calculated by log-linear regression. Power calculations used alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power of the survey to detect trends can be compared across species using the estimated minimum number of years necessary to detect a slope of -0.0341, a 50% decline in 20 years.

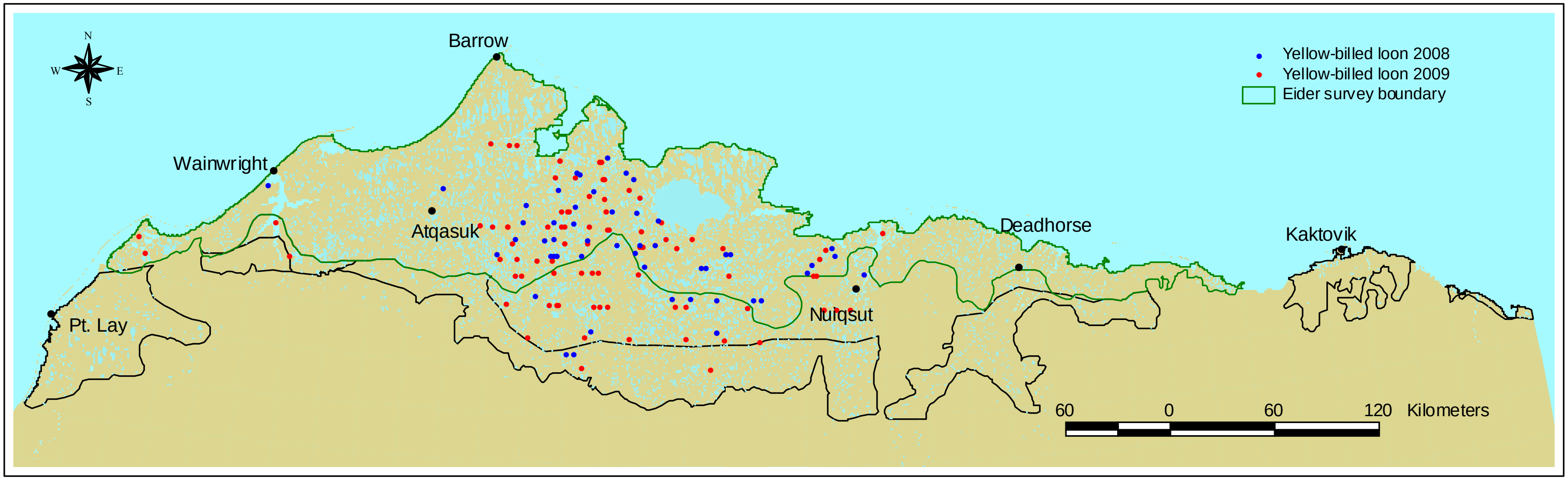



Figure 21. Location of yellow-billed loons observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

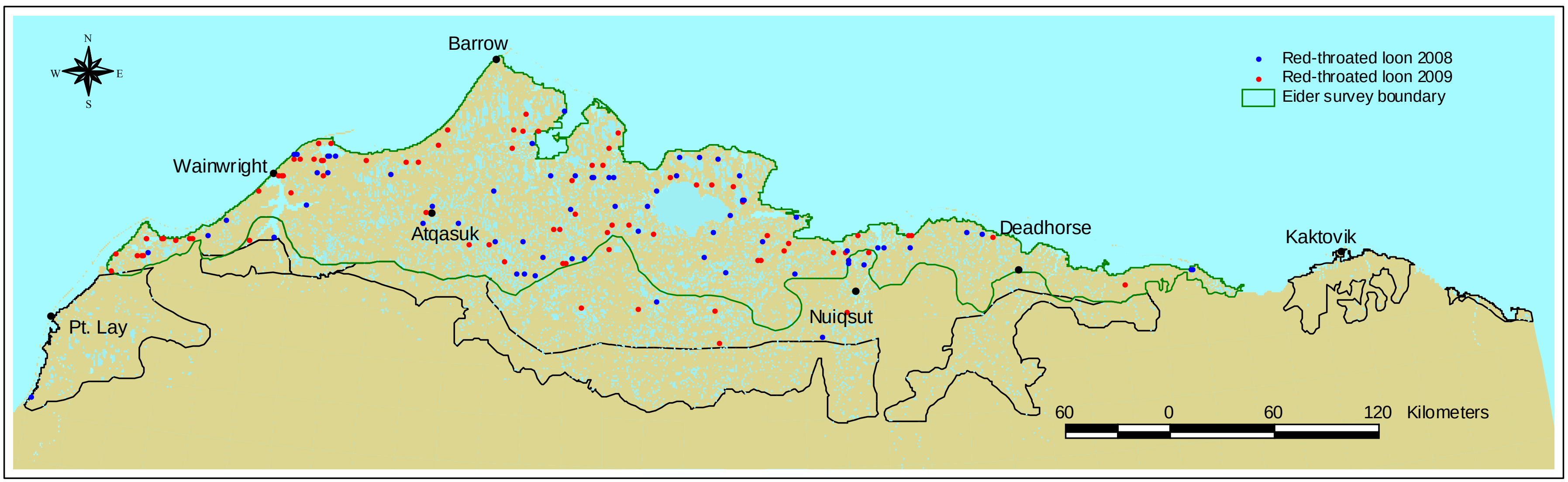



Figure 22. Location of red-throated loons observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

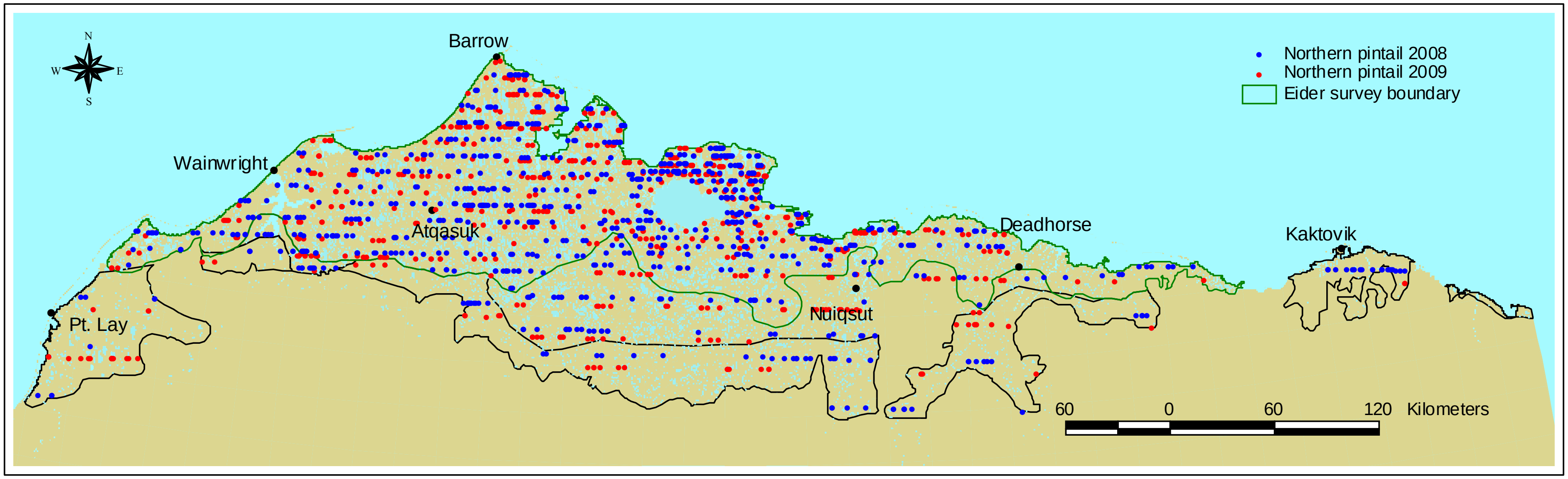



Figure 23. Location of northern pintails observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009

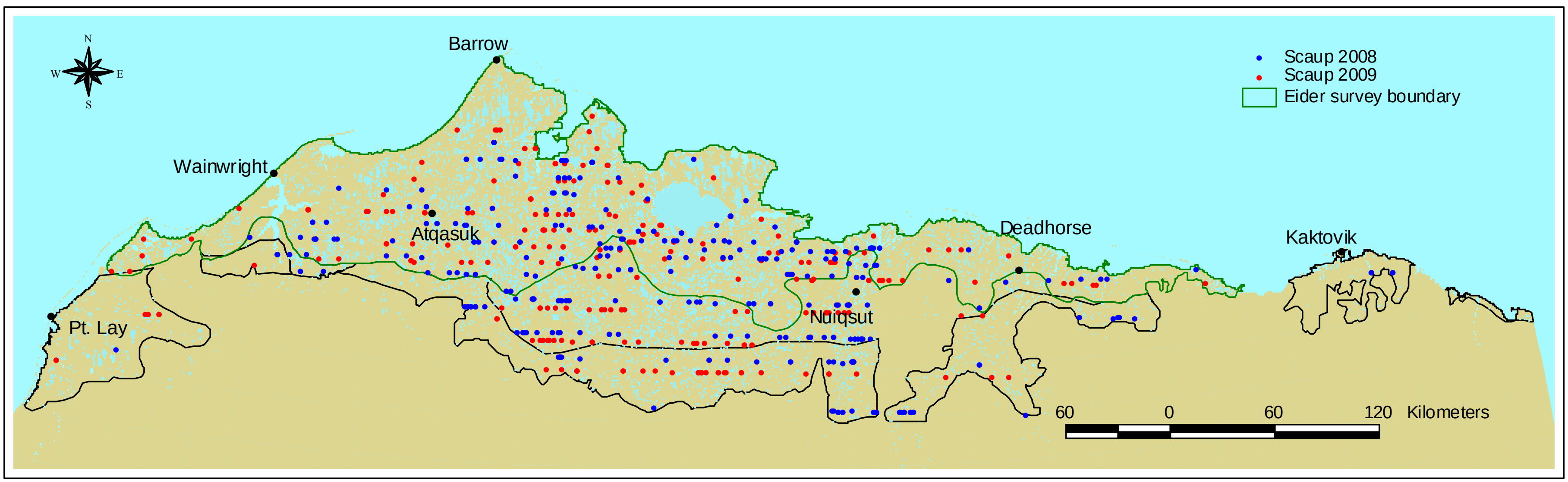



Figure 24. Location of scaups observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

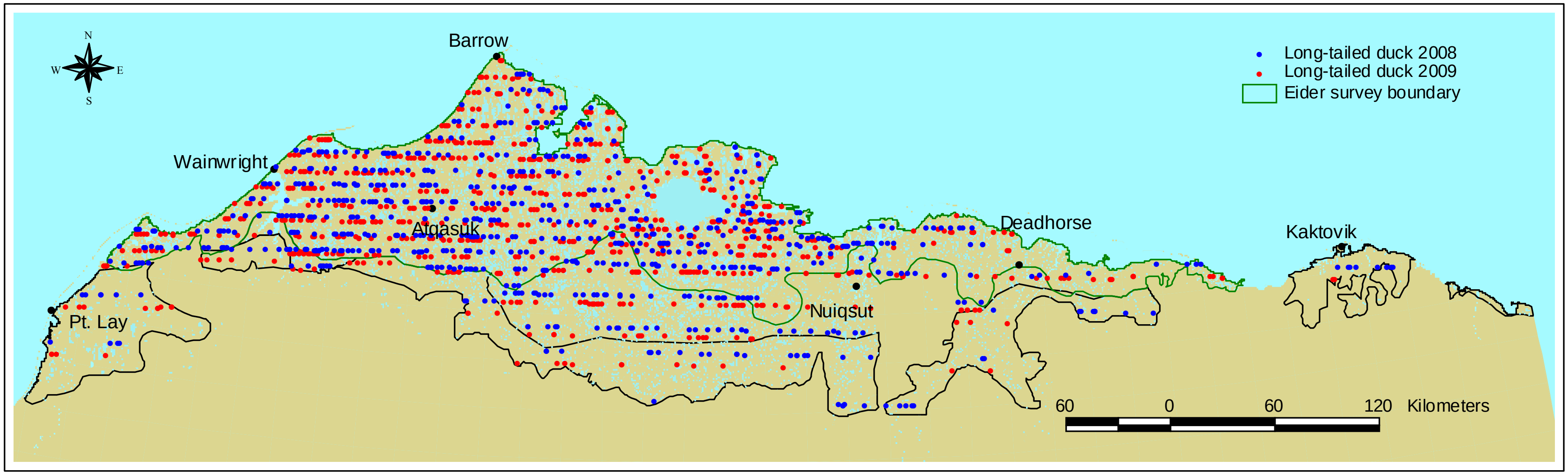



Figure 25. Location of long-tailed ducks observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

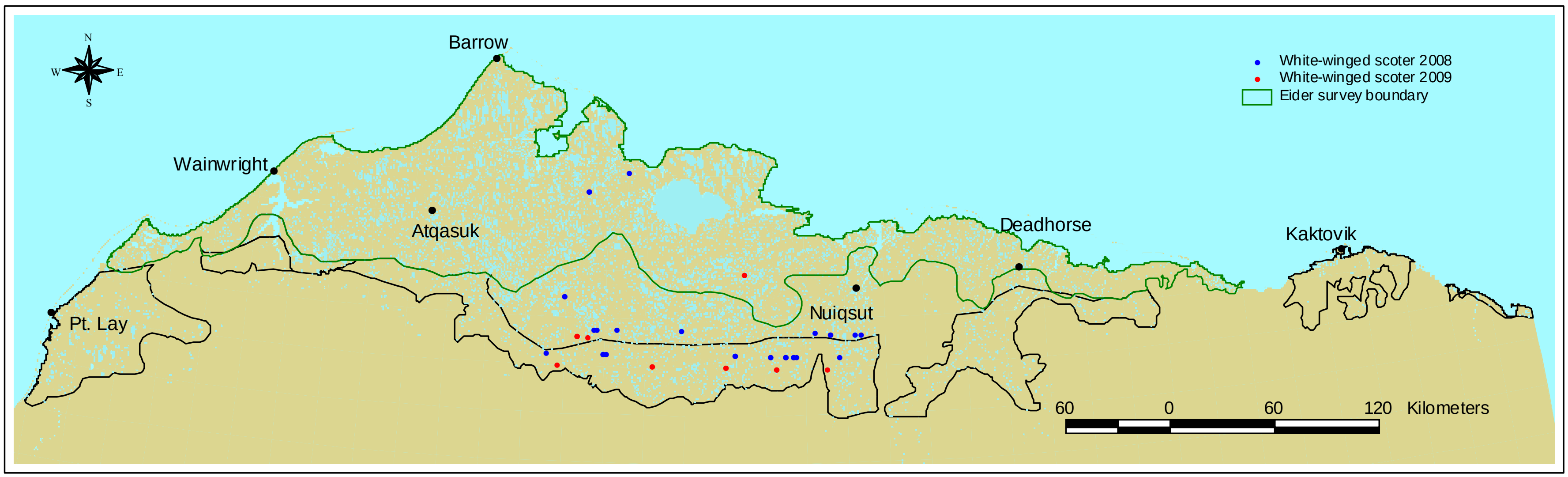



Figure 26. Location of white-winged scoters observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

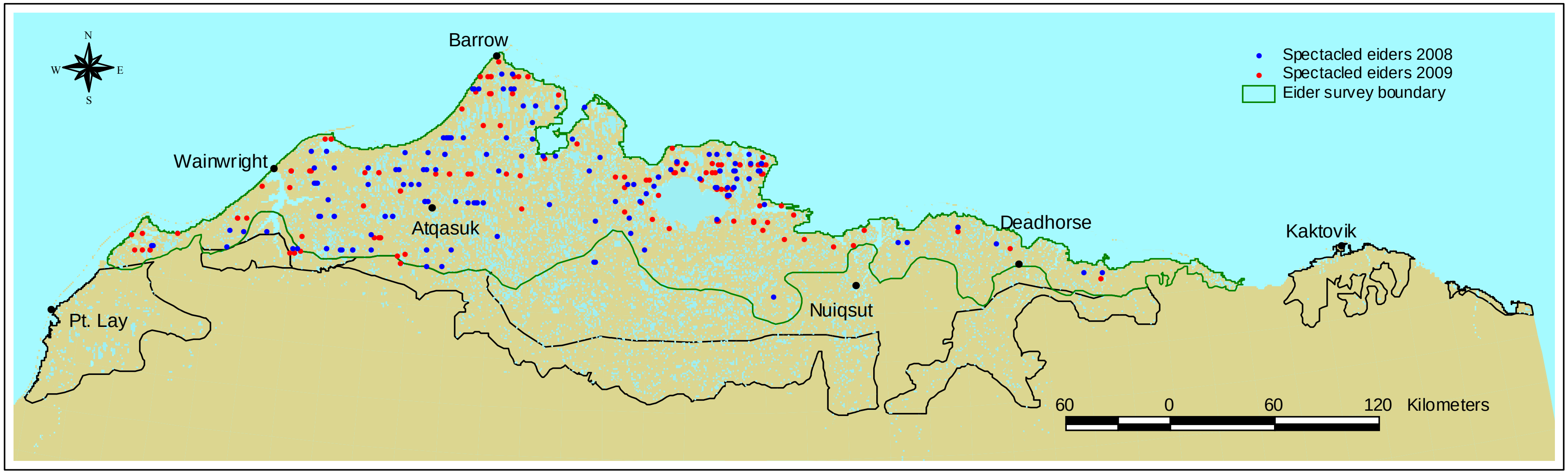



Figure 27. Location of spectacled eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

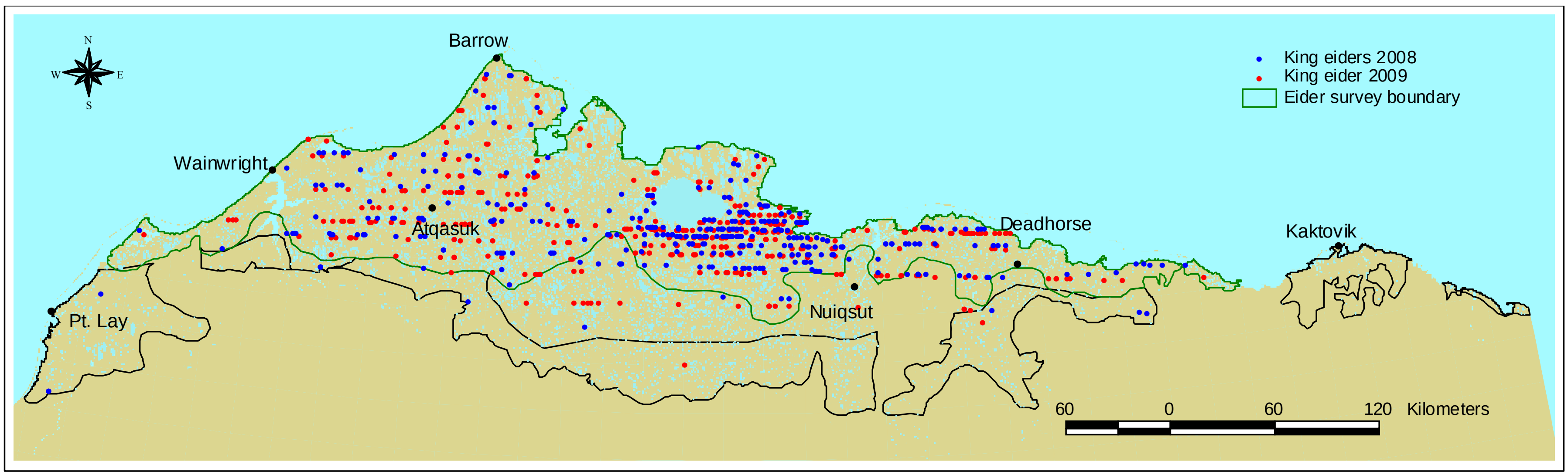



Figure 28. Location of king eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

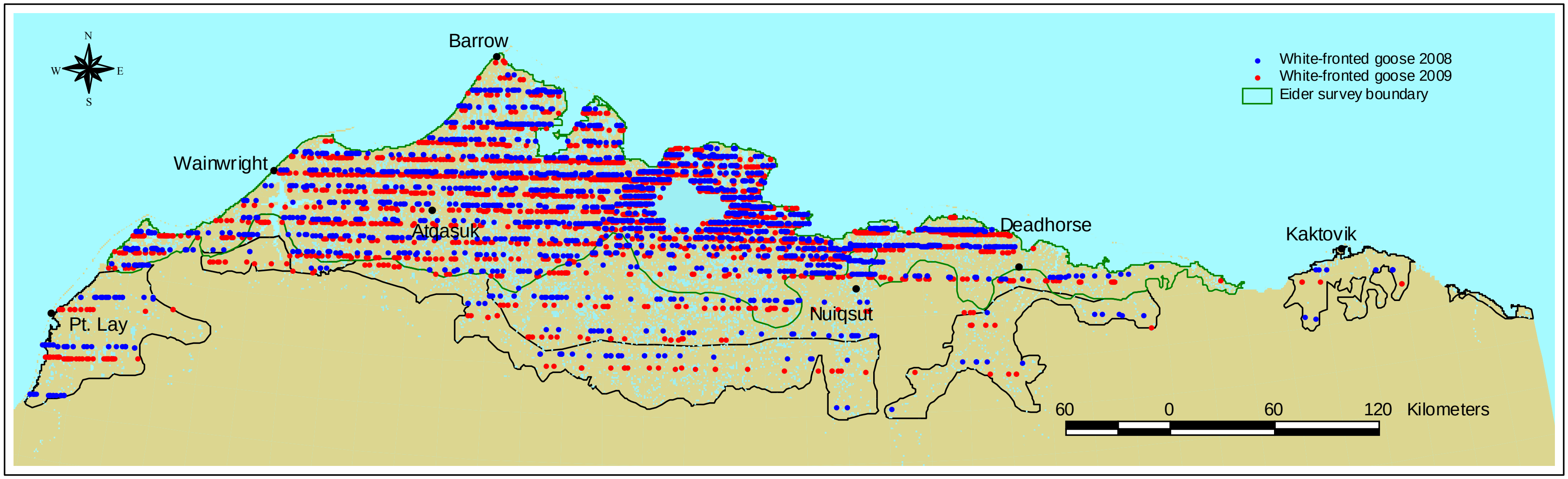



Figure 29. Location of white-fronted geese observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

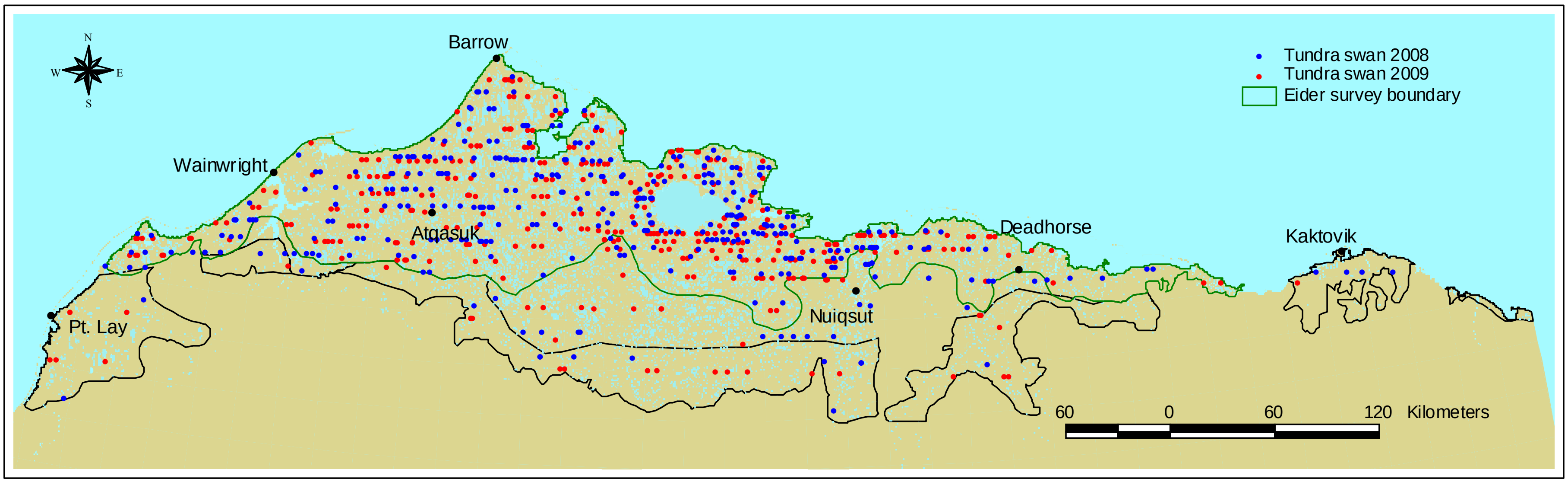



Figure 30. Location of tundra swans observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

APPENDIX 1. Common and scientific names of species mentioned in this report.

| **Common Name** | **Scientific Name** |
|---|---|
| Loons: (Family *Gaviidae*) | |
| Yellow-billed loon | *Gavia adamsii* |
| Pacific loon | *G. pacifica* |
| Red-throated loon | G. *stellata* |
| Gulls, terns, jaegers: (Family *Laridae*) | |
| Glaucous gull | *Larus glaucescens* |
| Sabine's gull | *Xema sabini* |
| Arctic tern | *Sterna paradisaea* |
| Long-tailed jaegers | *Stercorarius longicaudus* |
| Parasitic jaeger | *S. parasiticus* |
| Pomarine jaeger | *S. pomarinus* |
| Ducks, geese, swans: (Family *Anatidae*) | |
| Red-breasted merganser | *Mergus serrator* |
| Mallard | *Anas platyrhynchos* |
| American wigeon | *A. americana* |
| Am. Green-winged teal | *A. crecca* |
| Northern pintail | *A. acuta* |
| Northern shoveler | *A. clypeata* |
| Greater scaup | *Aythya marila,* |
| Lesser scaup | *A. affinis* |
| Long-tailed duck | *Clangula hyemalis* |
| Spectacled eider | *Somateria fischeri* |
| Common eider | *S. mollissima* |
| King eider | *S. spectabilis* |
| Steller's eider | *Polysticta stelleri* |
| Black scoter | *Melanitta nigra* |
| White-winged scoter | *M. fusca* |
| Snow goose | *Chen caerulescens* |
| Canada goose | *Branta canadensis* |
| Black brant | *B. bernicla* |
| Greater white-fronted goose | *Anser albifrons* |
| Tundra swan | *Cygnus columbianus* |
| Shorebirds: (Families *Scolopacidae*, *Charadriidae*) | |
| | *Charadrius spp., Pluvialis spp., Calidris spp., Arenaria spp., Numenius spp., Limnodromus sp* |
| Cranes: (Family *Gruidae*) | |
| Sandhill crane | *Grus canadensis* |
| Ravens: (Family *Corvidae*) | |
| Common raven | *Corvus corax* |
| Owls: (Family *Strigidae*) | |
| Short-eared owl | *Asio flammeus* |
| Snowy owl | *Bubo scandiacus* |
| Eagles: (Family *Accipitridae*) | |
| Golden eagle | *Haliaeetus leucocephalus* |