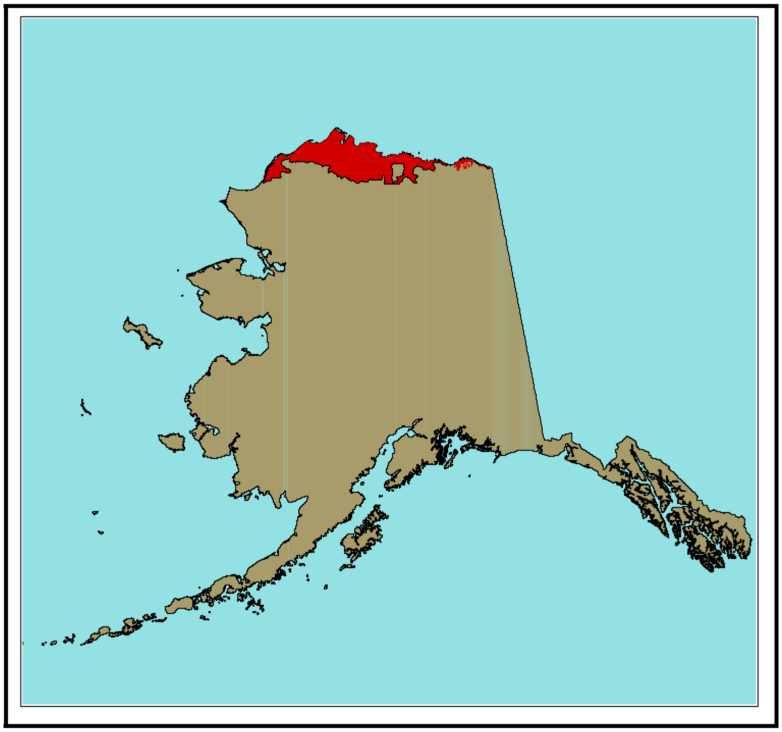
WATERFOWL BREEDING POPULATION SURVEY
ARCTIC COASTAL PLAIN, ALASKA
2009



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Waterfowl breeding population survey
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 index 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.

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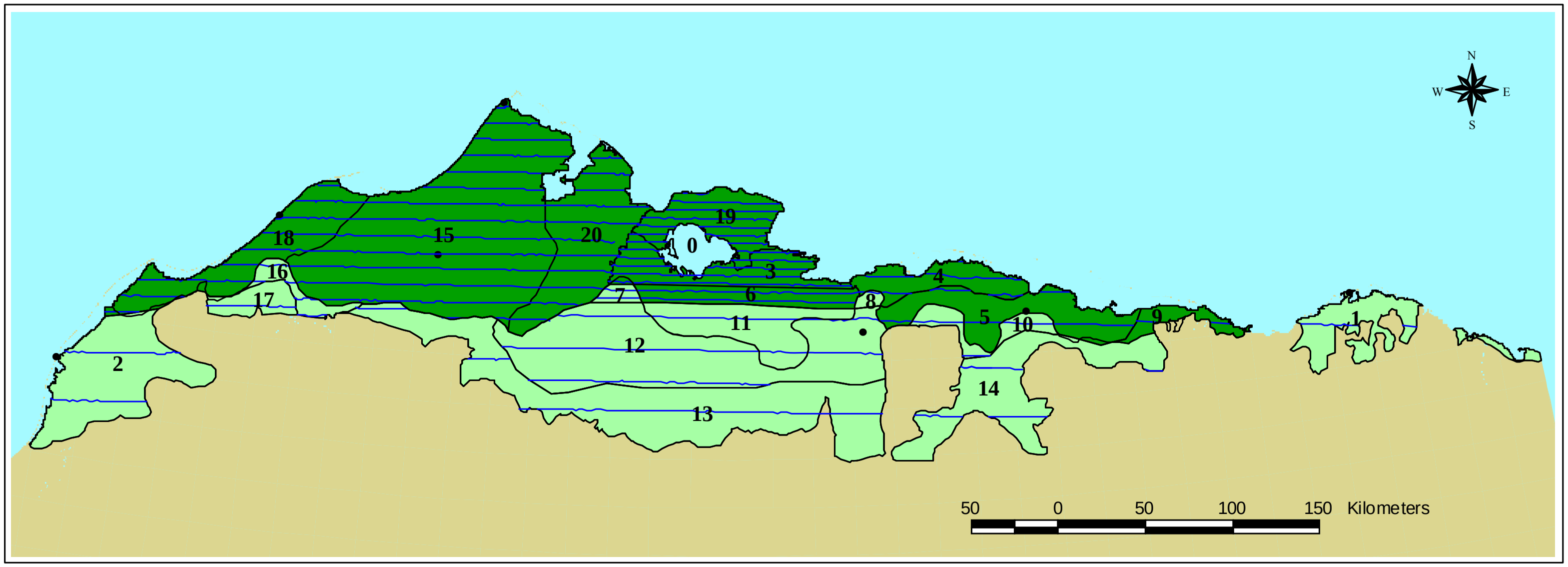


Figure 1. Spatial design of the aerial waterfowl breeding population survey, Arctic Coastal Plain, Alaska, June 2009. Eider strata are shown in dark green, strata outside the eider strata area are shown in light green. Blue lines show locations of the 2009 design transects. Numbered strata are described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

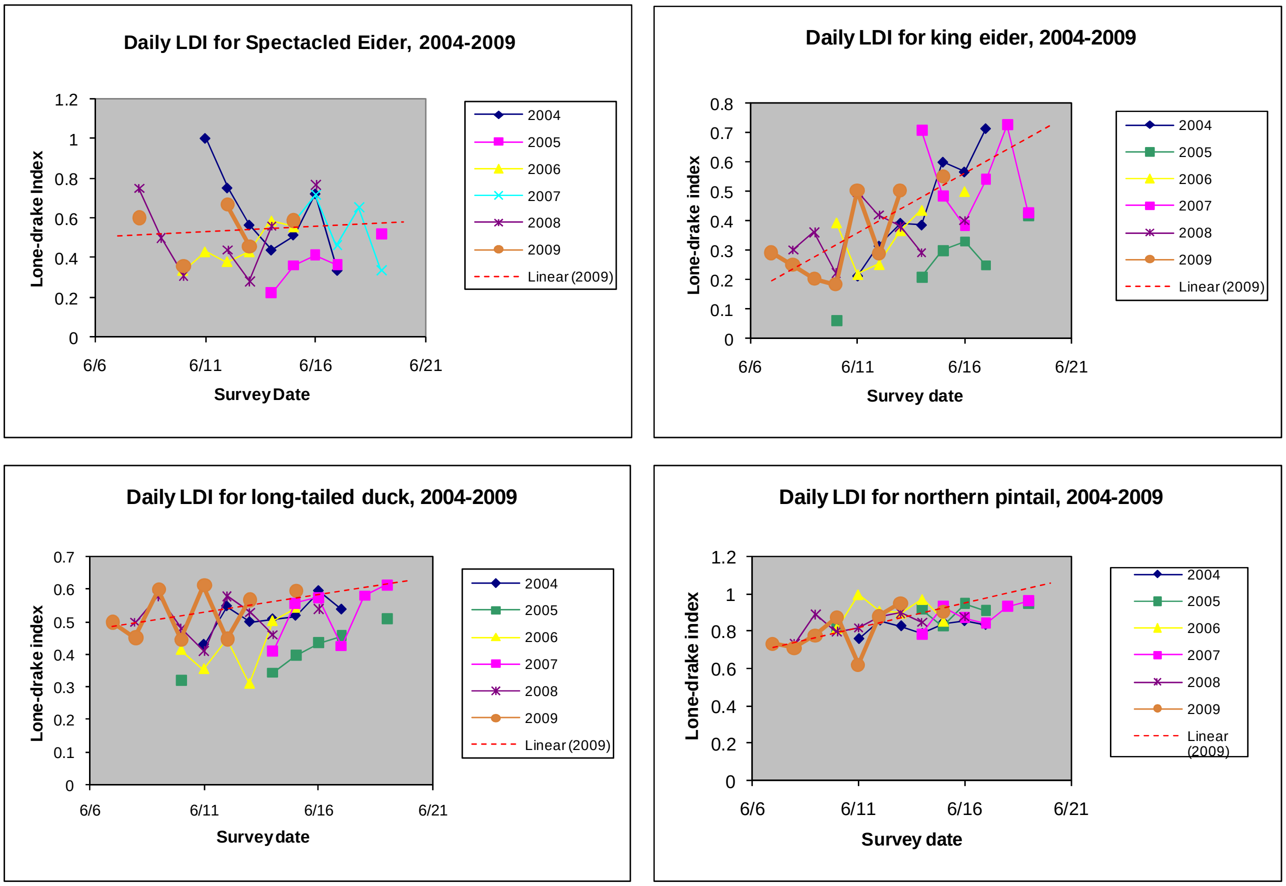


Figure 2. Daily ratio of lone males to total males (lone males plus males in pairs) of selected duck species observed during the Eider Survey (2004-2006) and the 2007-9 Standard waterfowl breeding population (ACP) survey, arctic coastal plain, Alaska.

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

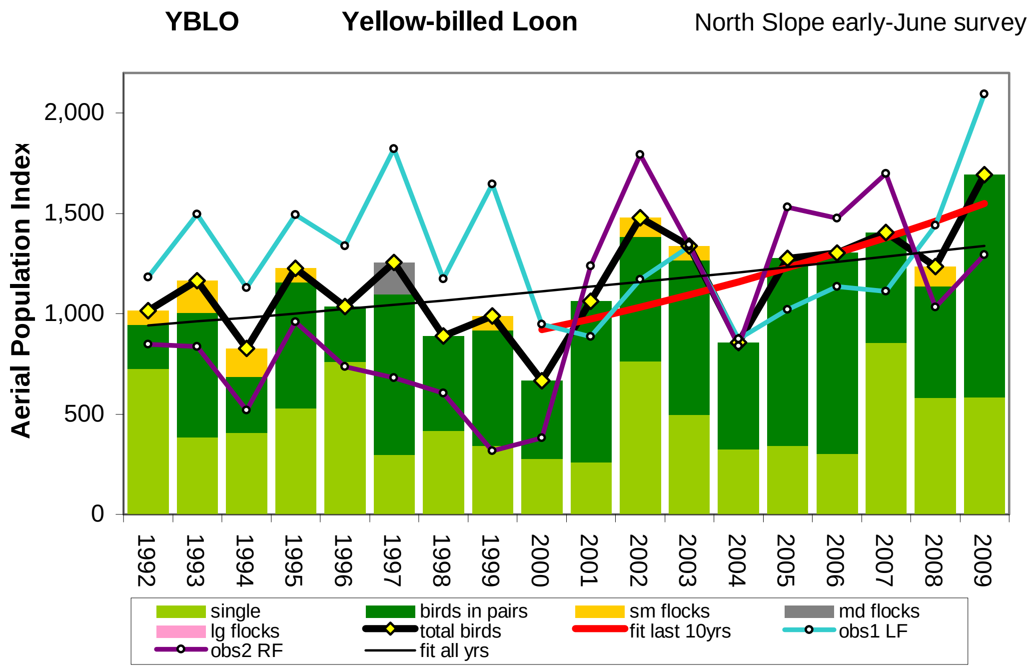
1. singles+(2*pairs)+flocked 2. 2*(singles+pairs)+flocked 3. *Stercorarius longicaudus, S. parasiticus, S. pomarinus* 4. *Charadrius sp., Pluvialis spp., Calidris spp., Arenaria sp., Numenius sp., Limnodromus sp.* et al. 5. Data from left-side observer only.

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)



NSE 10 strata =30,465 km2

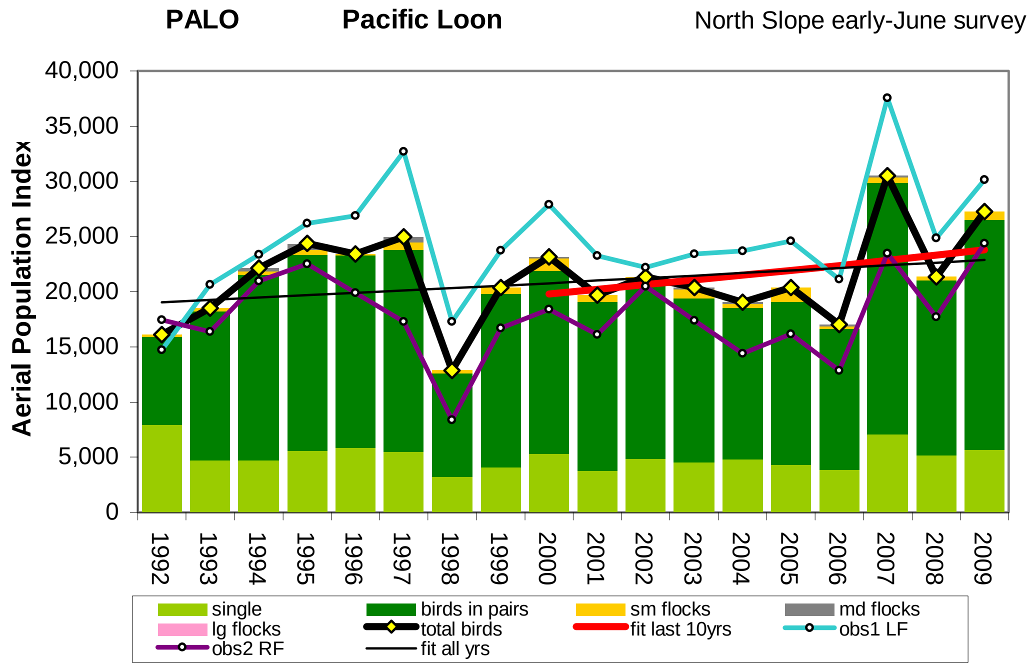
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	725	219	71	0	0	**1015**	179
1993	386	617	162	0	0	**1165**	267
1994	408	277	141	0	0	**826**	190
1995	527	628	70	0	0	**1226**	308
1996	761	275	0	0	0	**1036**	191
1997	297	801	0	157	0	**1254**	573
1998	416	474	0	0	0	**890**	200
1999	340	579	70	0	0	**989**	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

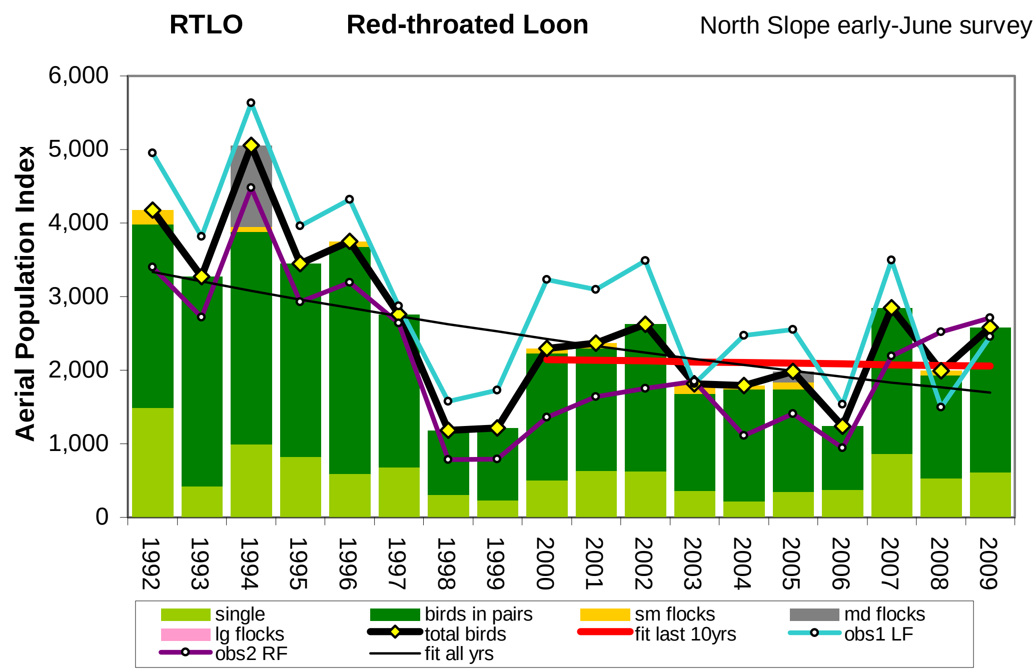
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	7931	7944	227	0	0	**16103**	1174
1993	4669	13592	251	0	0	**18512**	958
1994	4773	16753	354	266	0	**22146**	1329
1995	5592	17703	467	584	0	**24347**	1438
1996	5821	17495	71	0	0	**23387**	1193
1997	5497	18298	696	490	0	**24981**	1848
1998	3220	9392	222	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

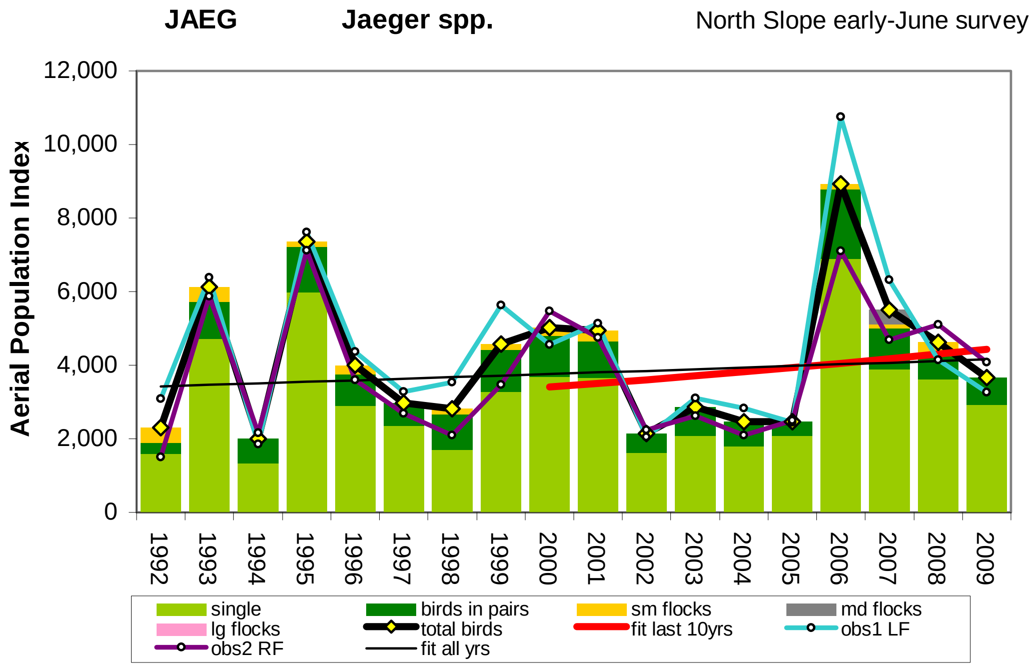
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	1487	2495	196	0	0	**4177**	453
1993	421	2850	0	0	0	**3271**	434
1994	993	2888	75	1099	0	**5054**	990
1995	827	2617	0	0	0	**3445**	476
1996	596	3087	73	0	0	**3756**	390
1997	683	2075	0	0	0	**2758**	415
1998	306	879	0	0	0	**1185**	251
1999	234	983	0	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.



NSE 10 strata =30,465 km2

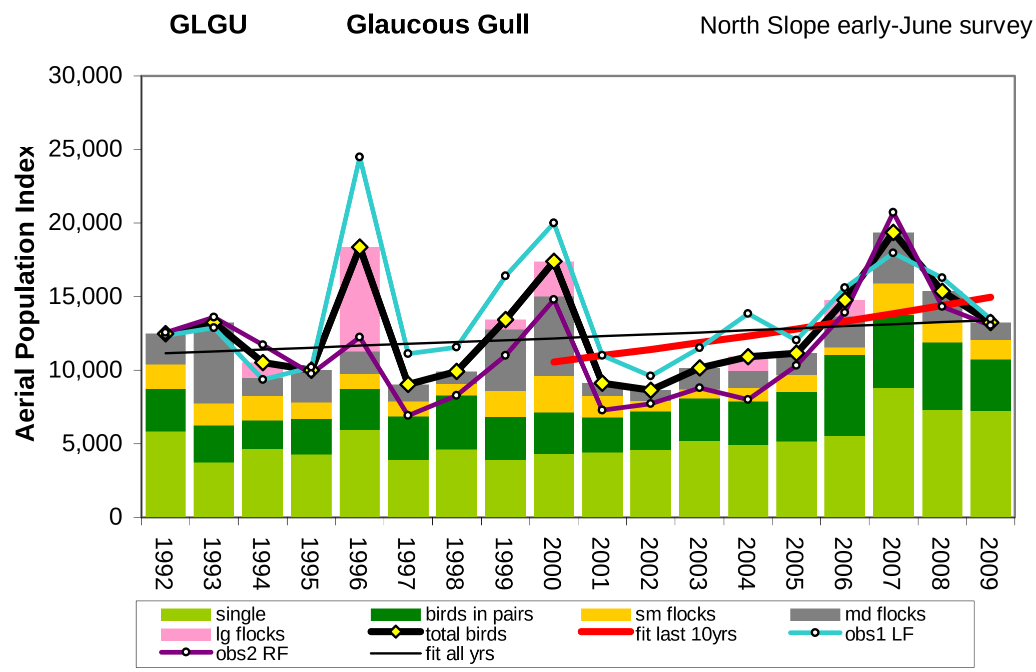
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	1588	301	409	0	0	**2298**	297
1993	4713	1014	405	0	0	**6131**	706
1994	1335	671	0	0	0	**2007**	353
1995	5989	1232	144	0	0	**7365**	650
1996	2897	842	253	0	0	**3992**	485
1997	2346	638	0	0	0	**2984**	316
1998	1702	952	164	0	0	**2817**	384
1999	3276	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

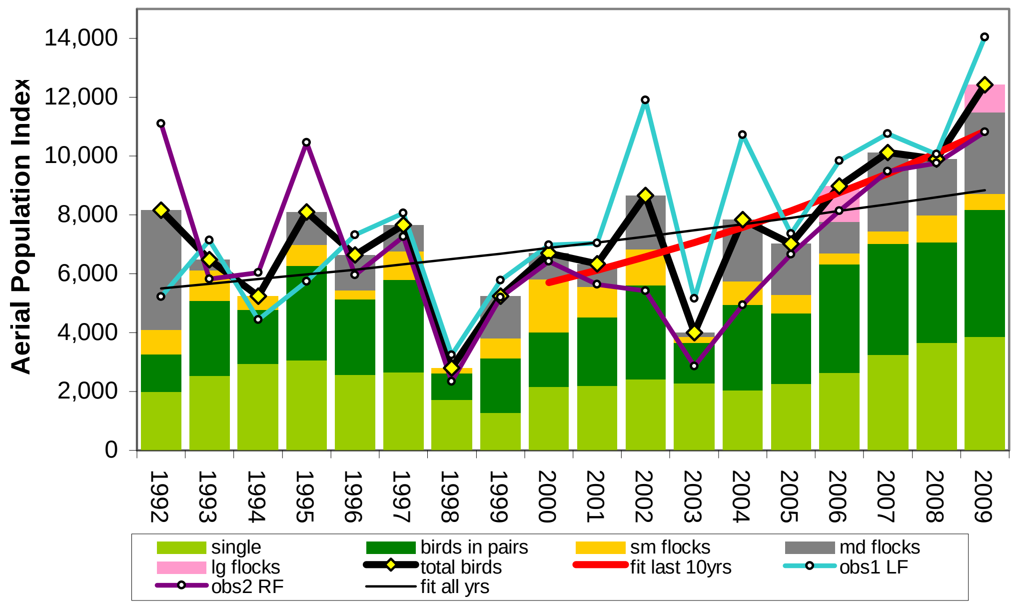
GLGU

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.

SAGU **Sabine's Gull** North Slope early-June survey



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

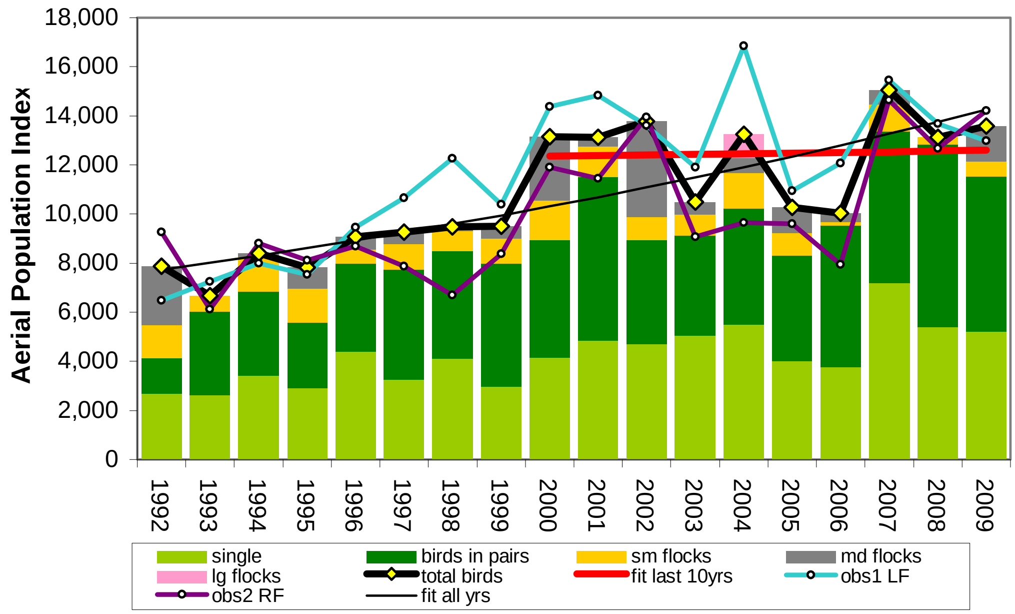
SAGU

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

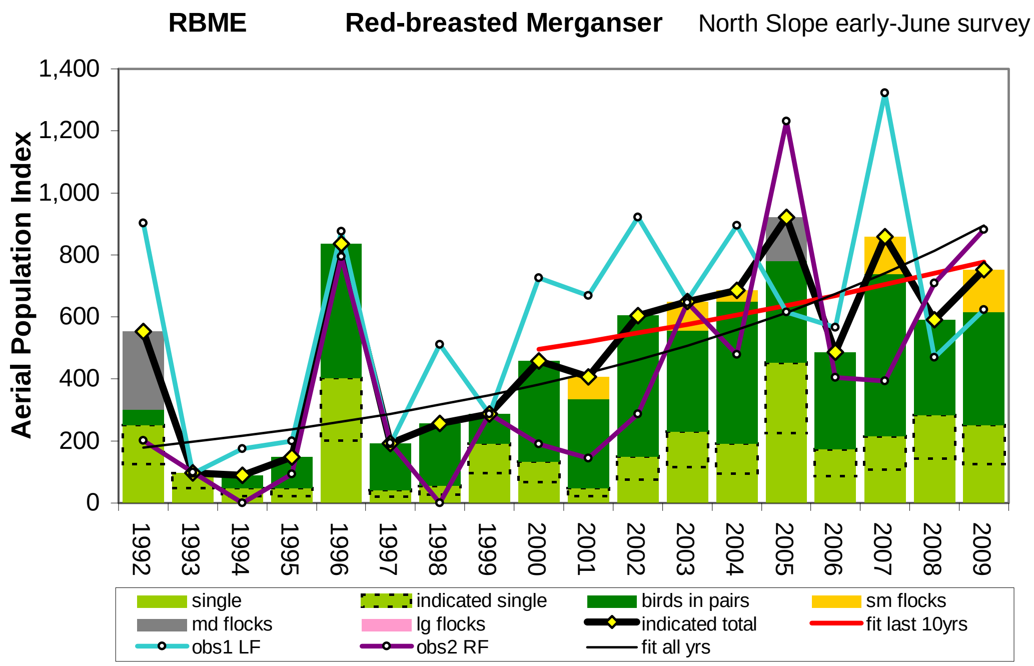
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	2691	1449	1327	2411	0	**7877**	1340
1993	2605	3425	652	0	0	**6682**	692
1994	3419	3417	1418	147	0	**8400**	933
1995	2905	2655	1393	879	0	**7832**	1186
1996	4398	3597	560	528	0	**9083**	906
1997	3252	4464	1069	488	0	**9274**	891
1998	4098	4409	806	179	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.



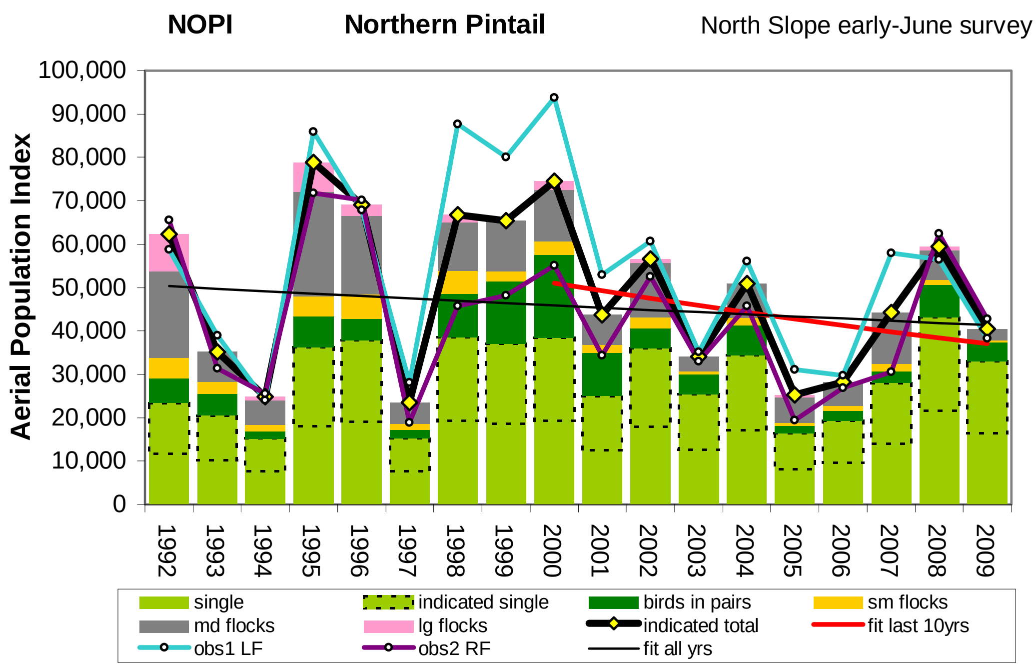
NSE 10 strata =30,465 km2

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 Mergansers (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.

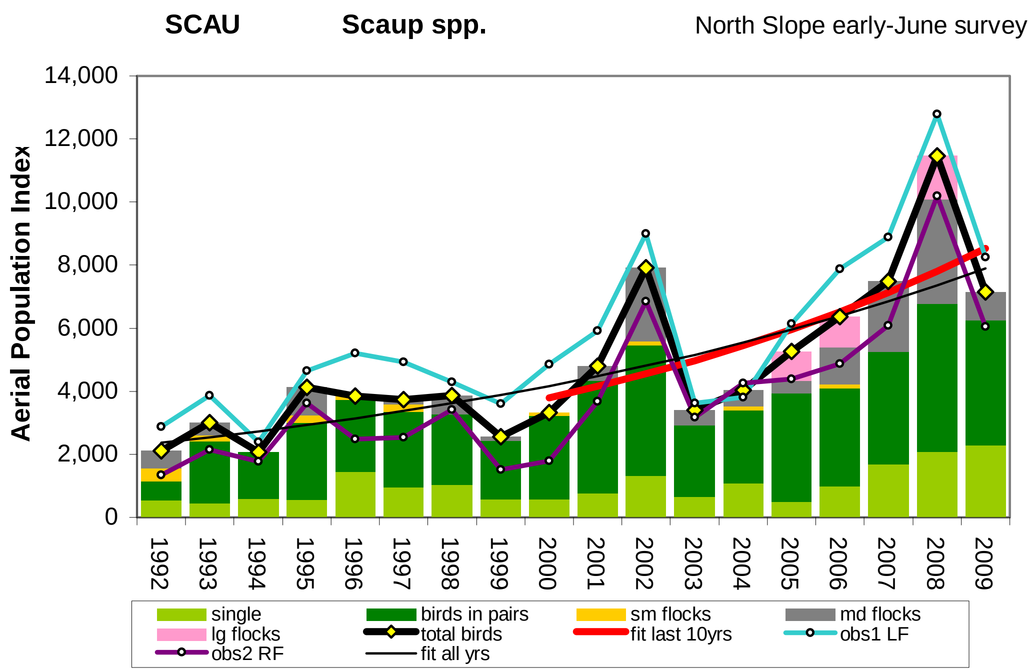


NSE 10 strata =30,465 km2

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.



NSE 10 strata =30,465 km2

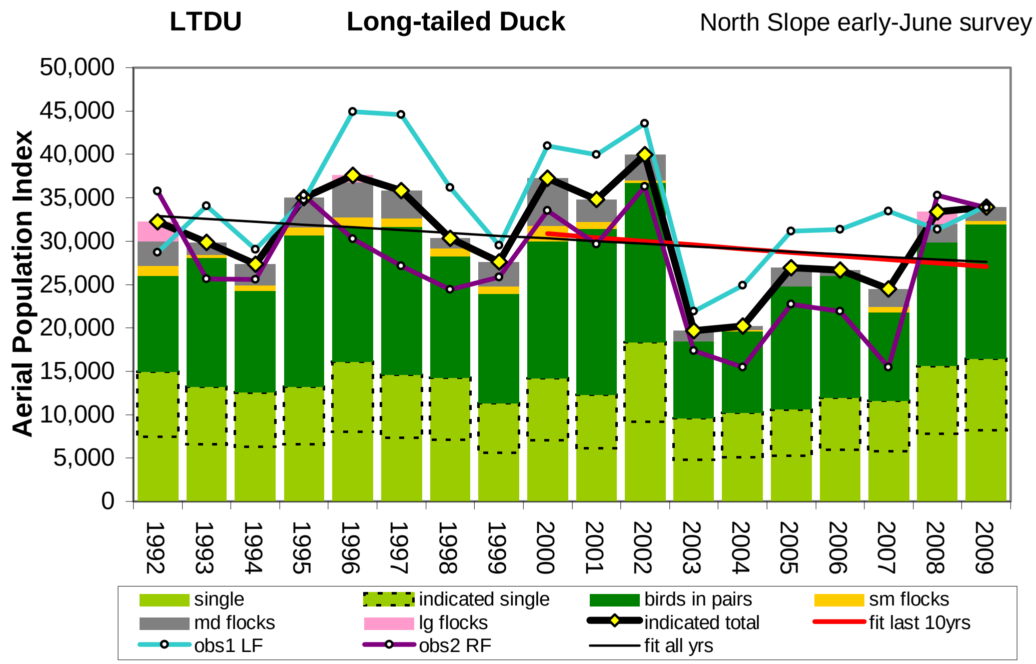
year	sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	539	607	400	563	0	**2109**	572
1993	455	1946	192	411	0	**3004**	636
1994	594	1486	0	0	0	**2080**	366
1995	560	2453	209	912	0	**4133**	719
1996	1437	2292	120	0	0	**3849**	526
1997	948	2396	245	145	0	**3735**	661
1998	1035	2240	0	582	0	**3857**	470
1999	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.



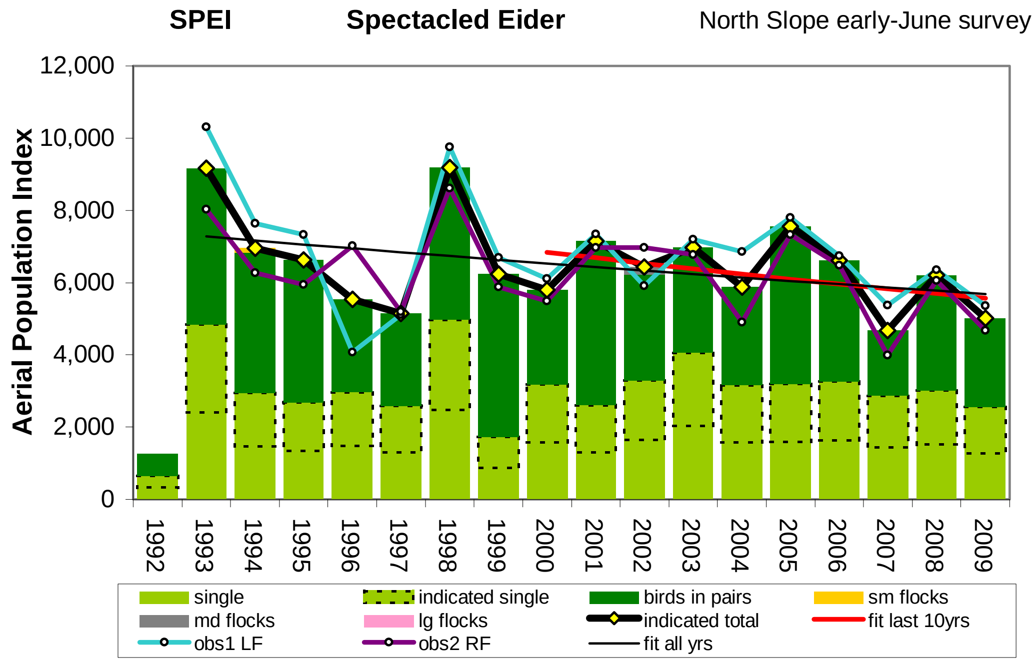
NSE 10 strata =30,465 km2

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

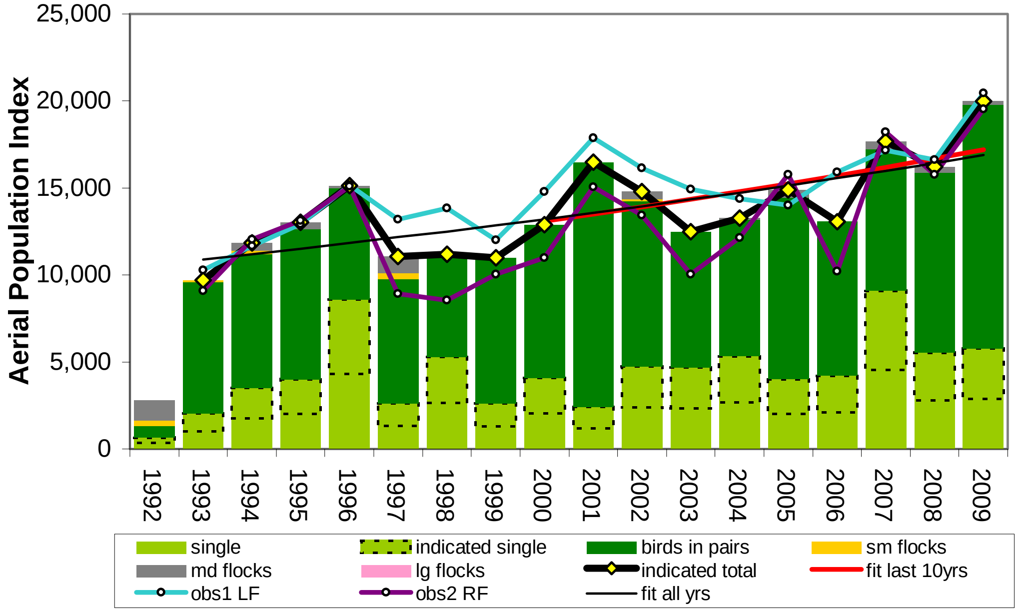
year	2*sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	657	602	0	0	0		
1993	4828	4339	0	0	0	**9167**	900
1994	2945	3885	122	0	0	**6951**	733
1995	2679	3951	0	0	0	**6630**	677
1996	2964	2580	0	0	0	**5544**	680
1997	2594	2553	0	0	0	**5148**	515
1998	4963	4223	0	0	0	**9186**	1001
1999	1723	4517	0	0	0	**6240**	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.

KIEI **King Eider** North Slope early-June survey



NSE 10 strata =30,465 km2

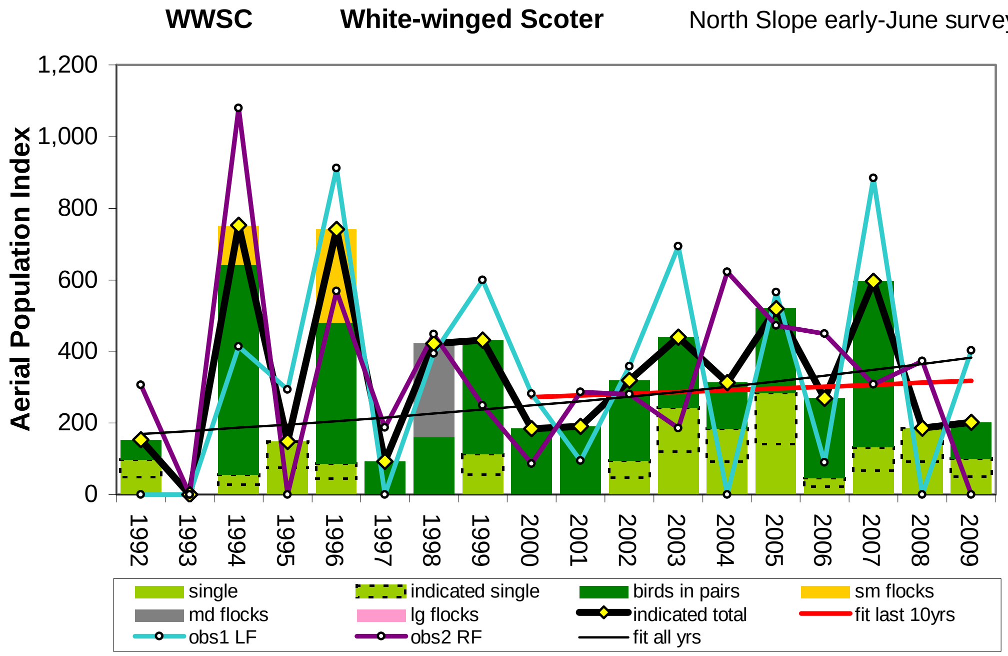
year	2*sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	661	677	290	1142	0		
1993	2029	7587	75	0	0	**9692**	1046
1994	3495	7695	212	451	0	**11853**	1052
1995	4013	8650	0	373	0	**13037**	1197
1996	8598	6400	0	146	0	**15143**	1395
1997	2618	7163	333	958	0	**11072**	962
1998	5295	5746	169	0	0	**11211**	852
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

Aerial index: Indicated total

n yrs =	17
mean pop index =	**13807**
std dev =	2705
std error =	656
low 90%ci =	12521
high 90%ci =	15093
trend over all years :	
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
trend of most recent 10 years :	
Growth Rate =	**1.031**
low 90%ci GR =	1.006
high 90%ci GR =	1.056
min yrs to detect -50%/20yr rate :	
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.



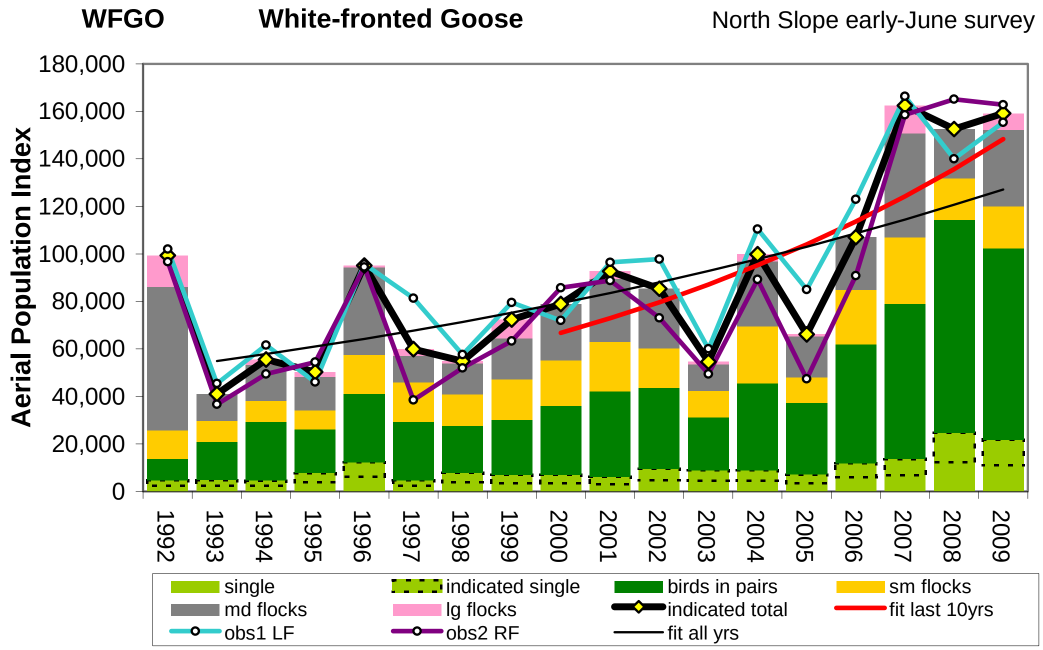
NSE 10 strata =30,465 km2

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.



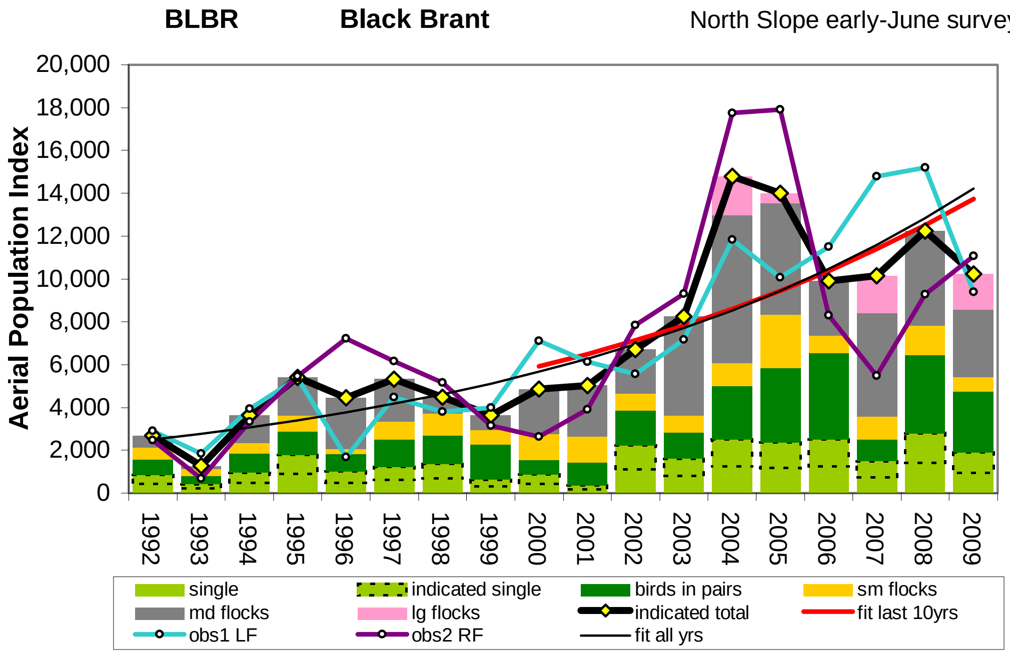
NSE 10 strata =30,465 km2

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.



NSE 10 strata =30,465 km2

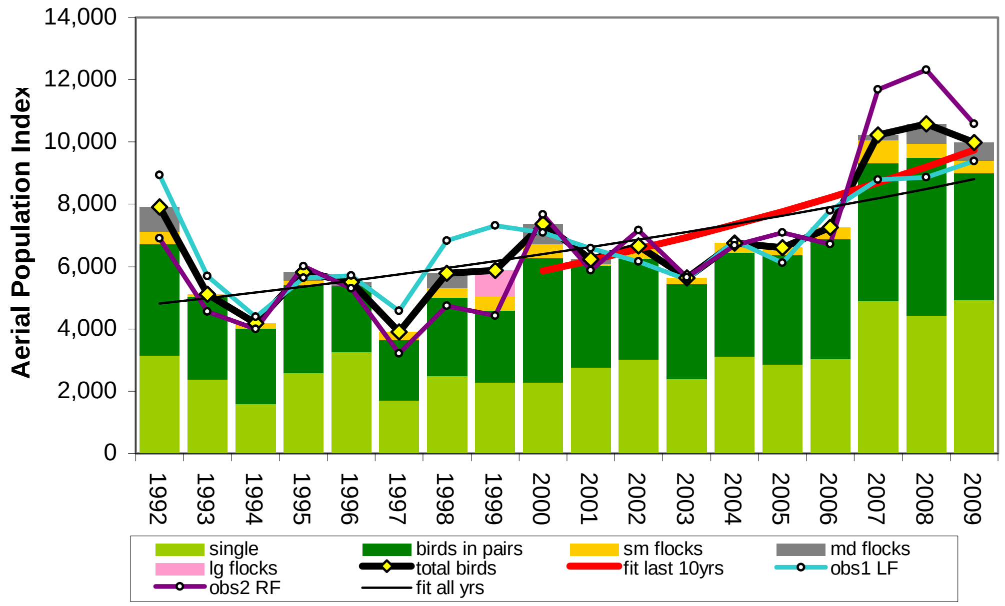
year	2*sg	2*npr	sm flk	md flk	lg flk	Index	StdErr
1992	844	737	566	549	0	**2695**	490
1993	413	376	331	141	0	**1262**	460
1994	960	893	479	1305	0	**3636**	888
1995	1780	1084	748	1795	0	**5407**	2452
1996	996	815	247	2387	0	**4445**	1439
1997	1224	1264	849	1983	0	**5320**	1758
1998	1357	1333	1015	768	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.

SWAN **Tundra Swan** North Slope early-June survey



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

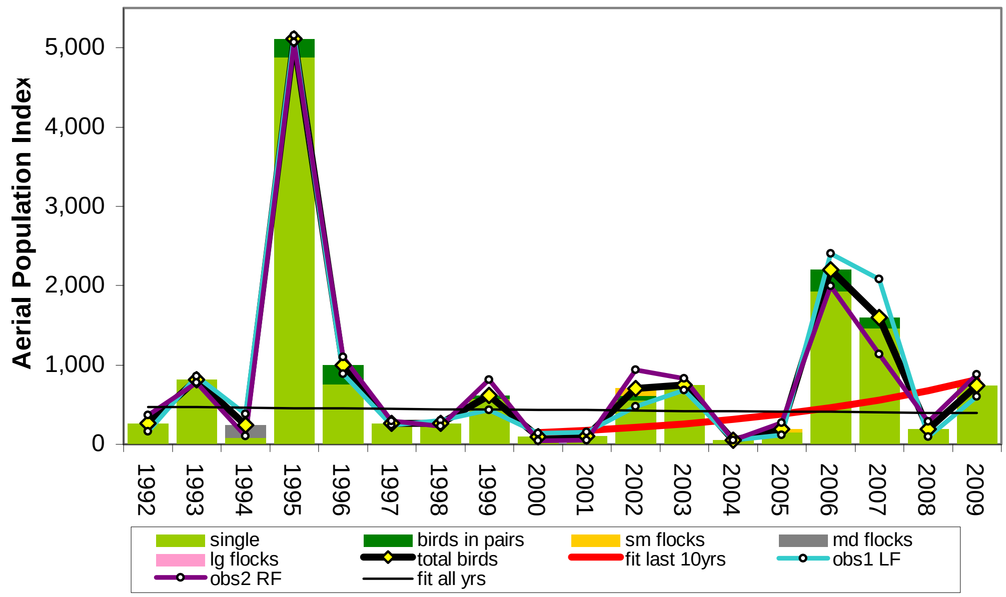
SWAN

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.

SNOW **Snowy Owl** North Slope early-June survey



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.

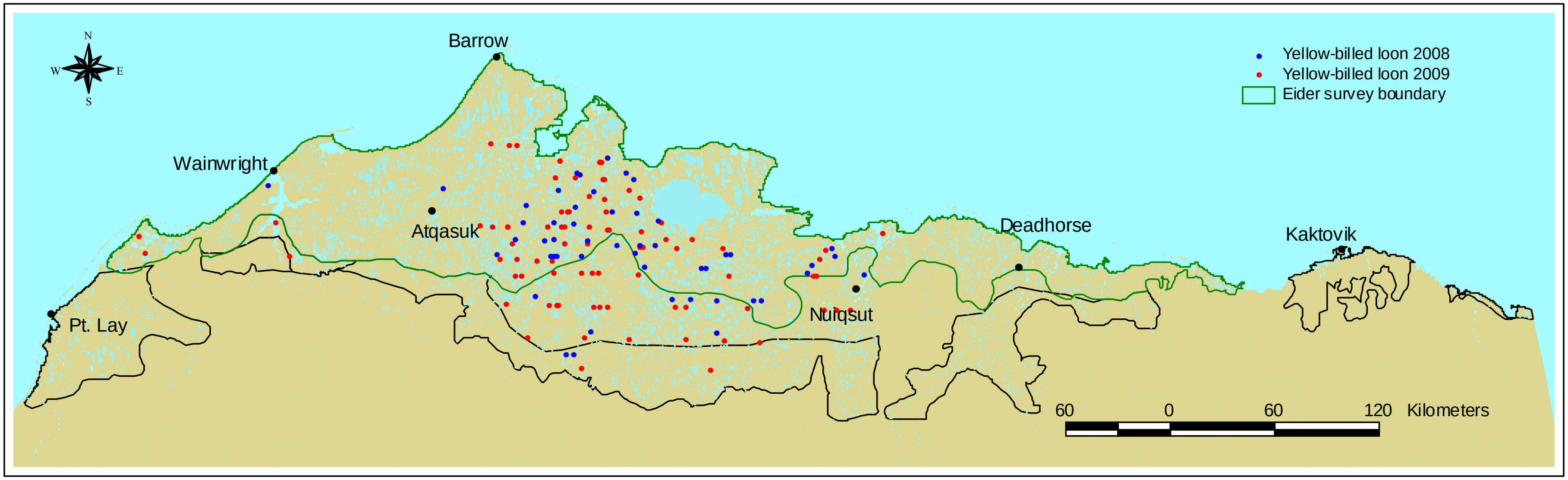


Figure 21. Location of yellow-billed loons observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

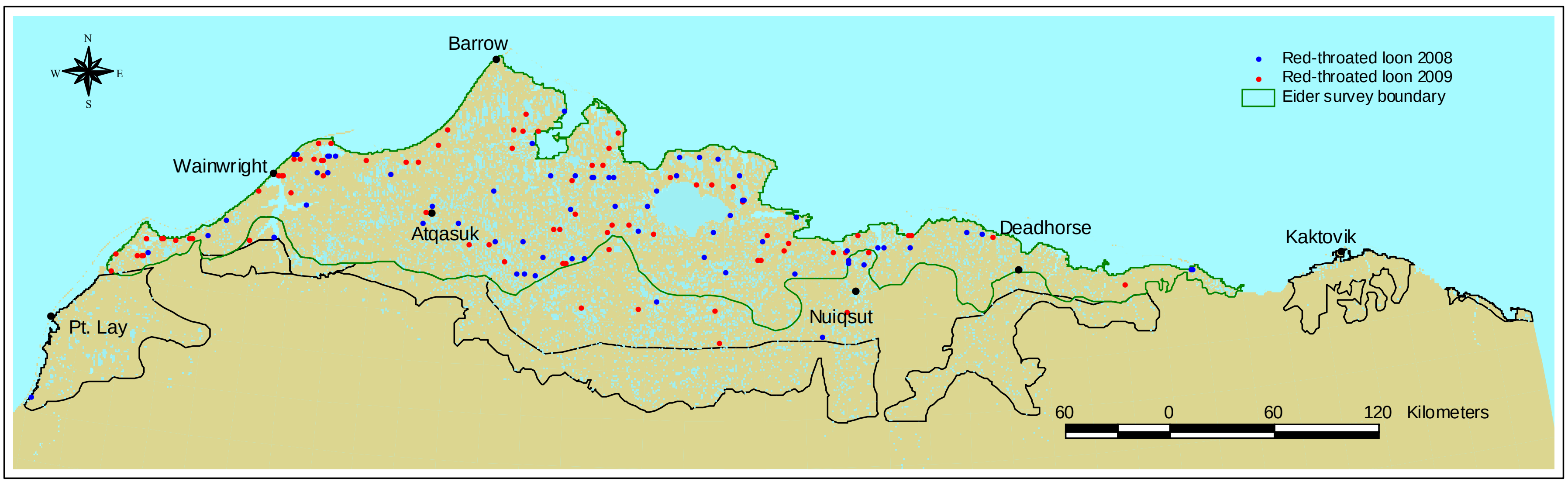


Figure 22. Location of red-throated loons observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

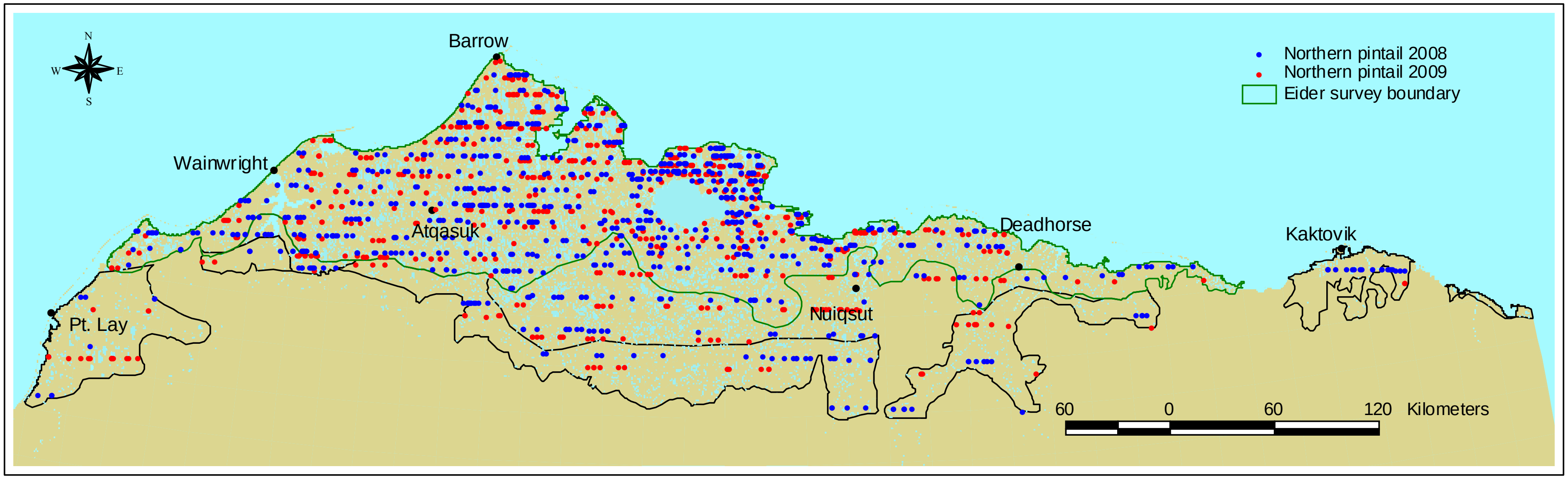


Figure 23. Location of northern pintails observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009

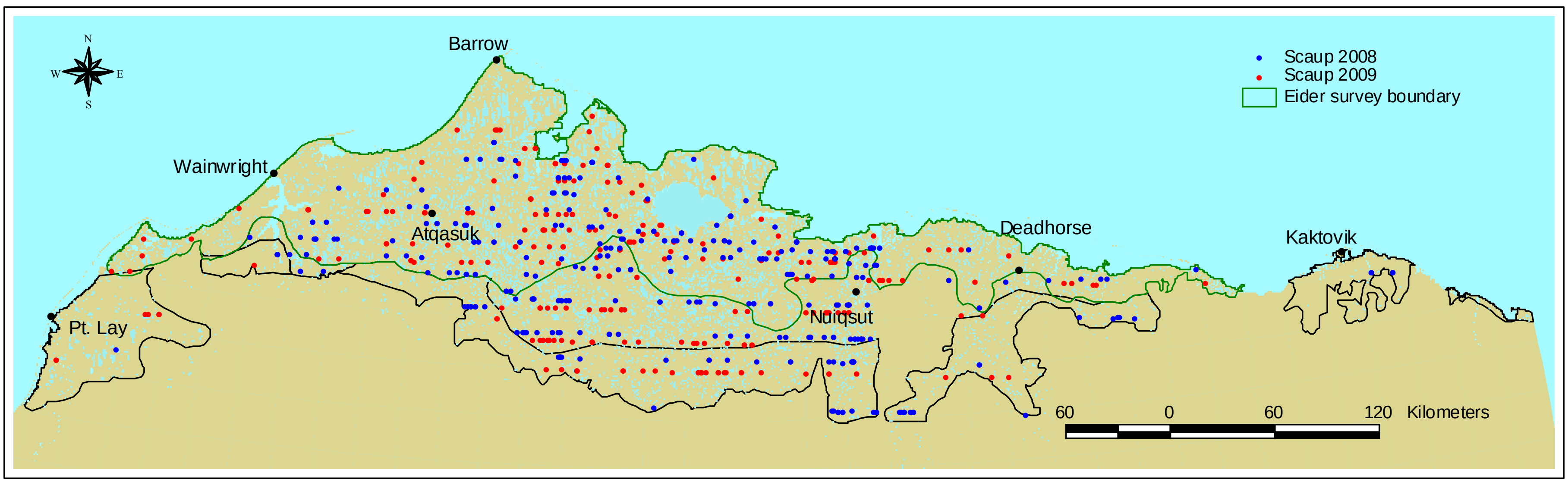


Figure 24. Location of scaups observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

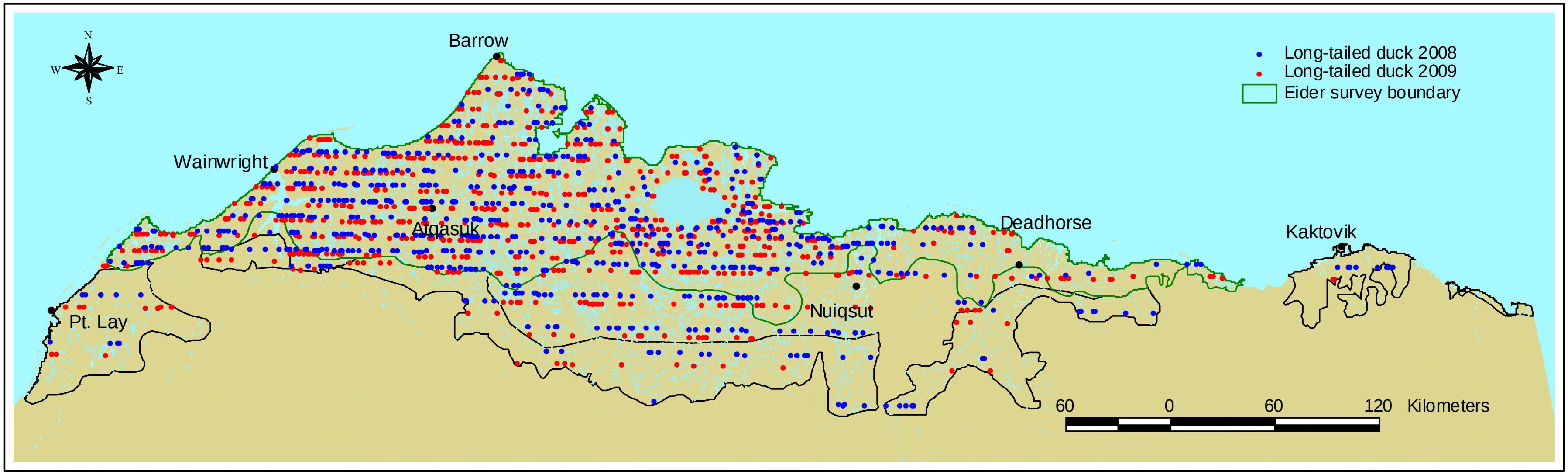


Figure 25. Location of long-tailed ducks observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

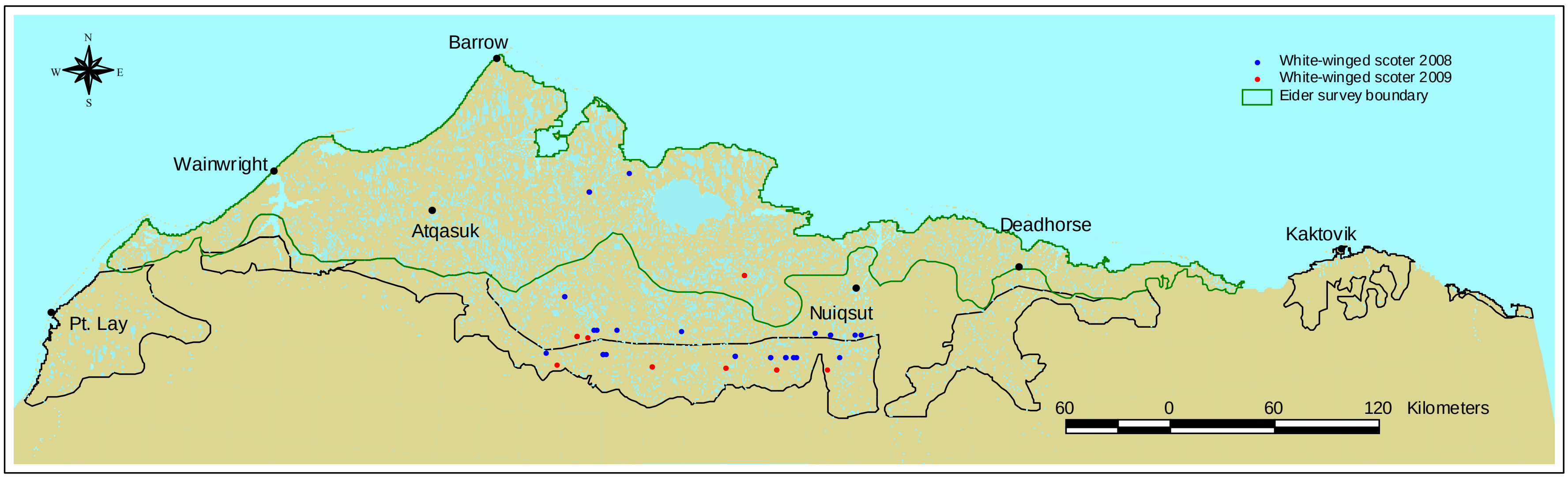


Figure 26. Location of white-winged scoters observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

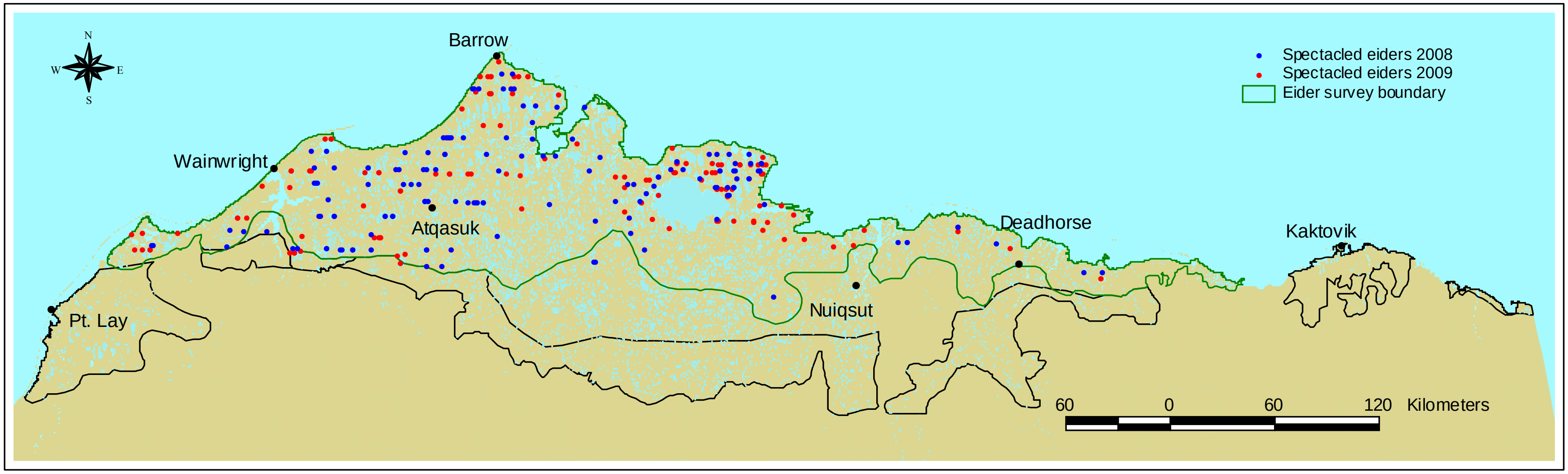


Figure 27. Location of spectacled eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

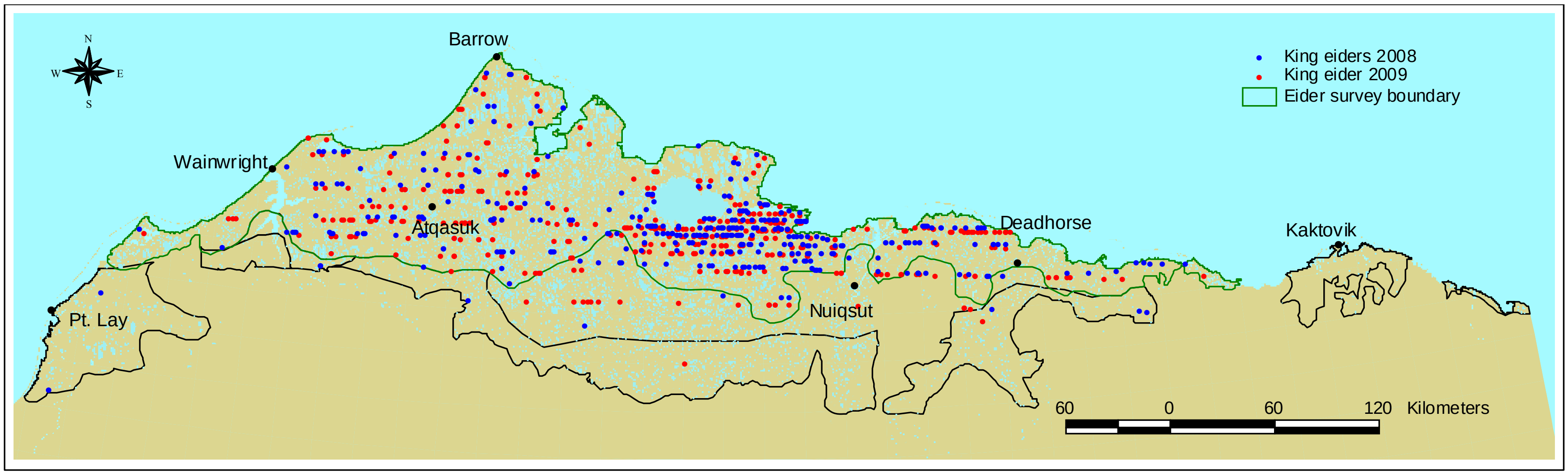


Figure 28. Location of king eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

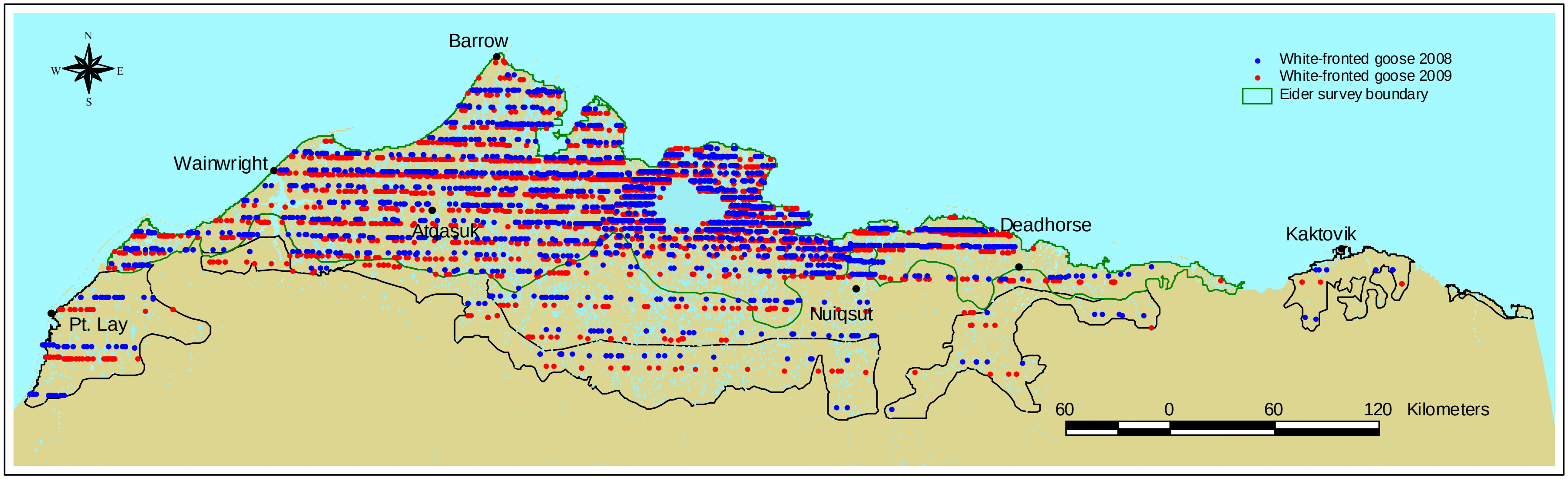


Figure 29. Location of white-fronted geese observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

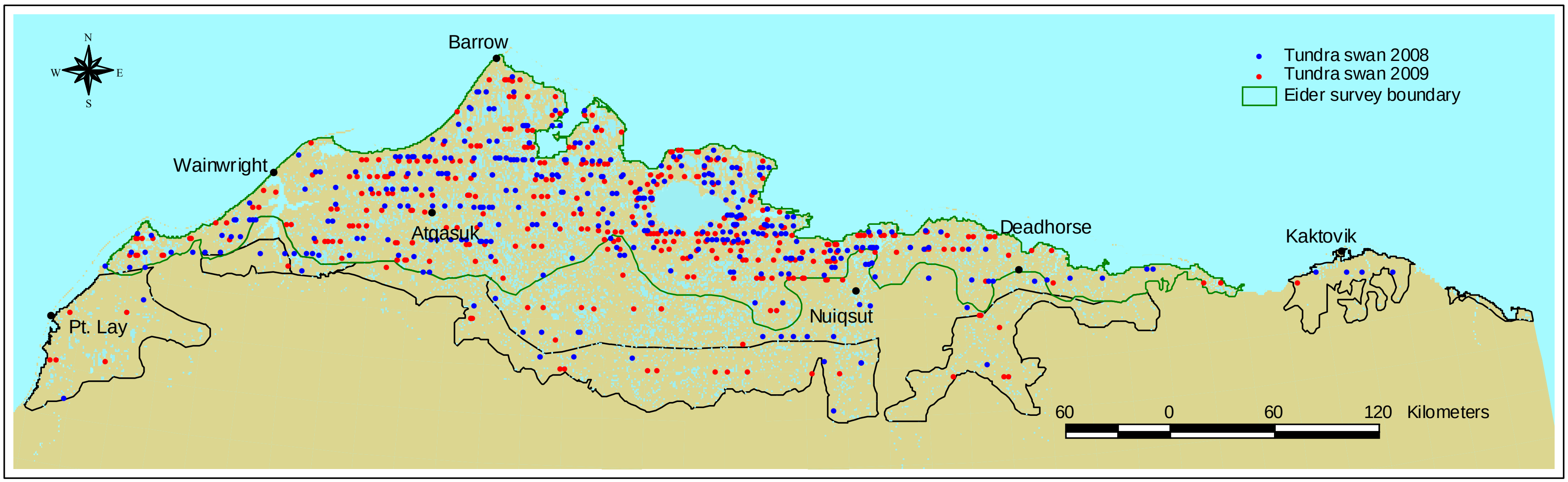


Figure 30. Location of tundra swans observed during aerial surveys, Arctic Coastal Plain, Alaska, June 2008 and 2009.

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*