EIDER BREEDING POPULATION SURVEY
ARCTIC COASTAL PLAIN, ALASKA
2005

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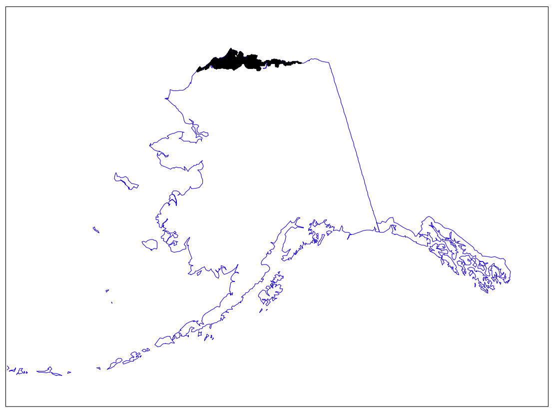

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October 13, 2005

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Abstract. The North Slope Eider Survey has been conducted for 14 consecutive years, 1992 to 2005. Survey techniques have remained constant, except that since1997 observations have been dictated directly into computers that were connected to an onboard Global Positioning System (GPS), yielding precise coordinates for all observations. The survey pilot was the same person for all years, while four different starboard observers participated during this period. In 1998 the survey area was split into 11 geographical strata based on habitat features and the boundaries of the National Petroleum Reserve of Alaska, northeast planning area. Data were re-analyzed for all years using the new stratification, which slightly improved precision of the estimates and facilitated area-wise comparisons. Spring arrived slightly late on the Arctic Coastal Plain in 2005, with extensive flooding and delayed ice and snow melt. We completed the survey from 10 to 19 June, with 3 days lost due to fog and wind. Procedures and design were identical to recent years except that sampling intensity was doubled within three strata in the Teshekpuk Lake region, for the second consecutive year, per request and funding by the Bureau of Land Management. The 2005 population index for spectacled eiders is 7,820, which is 13 percent above the long-term mean, but the1993 to 2005 mean annual population growth rate is not significantly different from 1.0 (a = 0.10). The king eider index (14,934) is 14 percent above the mean and the species is showing a significant positive growth rate of 1.021. Distributions of spectacled and king eiders were similar to previous years. Other species with long-term significant positive growth rates are arctic tern, red-breasted merganser, Greater scaup, White-winged scoter, snow goose, black brant, Tundra swan, and sandhill crane, while a significant negative rate is noted for red-throated loon and small shorebirds. Growth rates for other species have not indicated a significant departure from 1.0. In summary, the few barely-significant trends notwithstanding, results of this survey suggest that populations of spectacled and king eiders and other surveyed waterbirds breeding in the wet tundra portion of the Arctic Coastal Plain of Alaska were relatively stable from 1992 to 2005, with the possible exception of that of the red-throated loon.

Key Words: aerial, Alaska, arctic, breeding, eider, king, *Polysticta stelleri*, population, *Somateria fischeri, Somateria spectabilis*, spectacled, Steller's, survey, waterfowl,

INTRODUCTION

A comprehensive aerial waterfowl breeding population survey was initiated in the Arctic Coastal Plain (ACP) of Alaska in 1986, and has continued annually to the present time. That survey, however, conducted from late June through early July, is phenologically too late for an accurate assessment of eiders, the males of which typically begin to depart the breeding grounds for the post-nuptial molt by about 20 June. Accordingly, in anticipation of the listing of spectacled and Steller's eiders under the Endangered Species Act, a second, earlier survey was initiated in 1992 to obtain an accurate annual population index and distributional data for these two species. The latter survey has consistently provided useful data for spectacled eiders, king eiders, and several other species of waterfowl, but has proven inadequate in sampling intensity for Steller's eiders, which are present on the arctic coastal plain in very low densities. The survey has been conducted annually using essentially the same design since it's inception, though improvements in data collection technology and analysis have been added along the way. This report includes methods and results for the 2005 eider breeding population survey, and summaries for 1992-2005.

OBJECTIVES

Spectacled Eider Recovery Plan (U. S. Fish and Wildlife Service 1996) tasks related to the demographics of the spectacled eider North Slope breeding population are as follows:

B1.1. Determine the breeding range and relative abundance of spectacled eiders on the North Slope. This task is listed as completed as of 1996 by this and various other surveys conducted by agencies and industry.

B1.4. Monitor trends and generate breeding pair abundance estimates for the [North Slope] 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". It is generally known that aerial observers detect less than 100 percent of the birds within a sampled area, and naturally the recovery team would prefer to evaluate these criteria against estimates that have been adjusted for observer bias, rather than uncorrected indices, so they have requested that detection rate studies be conducted to determine these values (*Task B1.4.1.2*).
In addition, with growing interest in mineral resource extraction and transportation on the North Slope, there is increasing demand for precise waterfowl distributional data for permitting and other decision making, particularly for listed species such as spectacled and Steller's eiders, and other species of concern.

Our specific objectives, then, are:

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.

3. Develop and implement a detectability study to correct for birds present but not detected in the sample area by observers.

4. Describe the distribution of observed eiders within 500 meters of actual location, covering all known spectacled eider habitat on a rotational basis each 4 years using a systematic grid with less than 2 km between sampled strips. Use data to produce point location and density polygon maps describing location of observed eiders and areas with specified ranges of (multi-year mean) peak eider breeding density.

5. Collect, analyze and report similar data for all other ducks, geese, swans, cranes, loons, grebes, eagles, owls, ravens, gulls, terns, and jaegers within the spectacled eider survey area.

STUDY AREA AND METHODS

Aerial crew for 2005:
Pilot/port observer: **William Larned**, *Migratory Bird Management, Soldotna*
Starboard observer: **Tina Moran,** *Selawik National Wildlife Refuge, Kotzebue*

Survey design, navigation, and observation
Survey techniques followed those described by Butler et al. (1995). Transects were oriented roughly east-west, and consisted of computer-generated segments of great-circle routes, for compatibility with Global Positioning System (GPS) navigation. The lines, along with end-point coordinates, distance figures and segment end indicators, were machine-plotted on 1:250,000 scale U.S. Geological Survey topographic maps, which were used in conjunction with GPS for navigation. Transects were spaced systematically from a randomly-selected starting point, at intervals of 2.3 km. Every fourth transect was flown on a given year, with the sampling frame shifted incrementally each year, requiring 4 years for coverage of all transects. Thus the transects flown in 2005 were duplicates of those flown in 2001. However, the GIS base map for the survey area boundary was redrawn in 1998, and the survey lines for that year approximated but did not precisely duplicate those of prior years. The annual incremental frame shift was then resumed based on the new coverage. In 1998 we split the survey area into 11 geographical strata, based on a habitat classification map developed by Ducks Unlimited, and the boundaries of the National Petroleum Reserve of Alaska (NPRA) Northeast Planning Area (Fig. 1). All results presented in this report, including those from previous years, were calculated using this stratification, so slight differences may be seen when comparing data herein with corresponding figures from earlier reports. Advantages of this stratification system are that it decreased the variance for estimates of eiders and most other waterbirds, and it facilitated comparisons between different geographic areas within both the Eider Survey area and the area of the Standard ACP Breeding Population Survey (the strata for this survey are a subset of those for the ACP Survey (Fig. 1)). The survey transects flown in 2005 are depicted in Fig. 2. On request from, and supported by, additional funding from the Bureau of Land Management, we added survey lines midway between the planned 2005 transects for strata 9, 15, and 16 (Fig. 1, 2), which doubled the sampling intensity in those areas. The intent was to improve the density estimates and provide more distributional detail within the current focal area for oil and gas development. Flight hours required to complete the survey in 2004 totaled 34.7 on transects (Table 1), plus 2.0 hours for reconnaissance. These hours did not include ferry time to and from the survey area. This year the aerial crew consisted of Bill Larned (Pilot/port observer) and Tina Moran (starboard observer).

We used a Cessna 206 amphibian for all years of this survey. Navigation equipment included a GPS, a radar altimeter, and a Horizontal Situation Indicator (HSI) slaved to a remote compass, with integrated GPS course deviation indicator. We flew along the transect center lines at 38 m altitude and 176±19 km·hr^{-1} ground speed, while both the pilot and the right-hand observer recorded all water birds, avian predators and shorebirds observed within 200 m either side of the flight path. Observers used tape markers placed on the aircraft lift struts to aid in estimating the outer transect (strip) boundaries. The marker locations were determined trigonometrically and placed using a clinometer. We recorded bird observations as singles, pairs and flocked birds according to the protocol used for the North American Waterfowl Breeding Population Survey (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1987). We actively minimized observations in the "unknown eider" category by occasionally leaving the transect centerline to confirm identification of eiders. Additional birds seen as a result of these maneuvers were not included in the data set, and such deviations typically occur fewer than 10 times per annual survey.

Data recording and transcription

Beginning in 1997 a new data acquisition system was used, in which observations were entered vocally into a microphone connected to a laptop computer. The computer also received GPS position data concurrently via a serial connection from the panel-mounted GPS receiver. These two inputs resulted in a sound file (.wav format) with a linked .pos file containing location, date and time. To create a final data file, 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 containing a single observation including species code, group size, and latitude-longitude coordinates, as well as date, time, stratum and transect identifiers. Additionally, the system created a track file which is a list of position coordinates for the aircraft recorded every five seconds during flight. A separate computer was used by each observer, and each computer was connected to the GPS and supplied with power via a 28-volt DC to 110-volt AC inverter connected to the aircraft's electrical system. The 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. The resultant files may be used to produce map, tabular and other products describing population trends and distribution of the various taxa surveyed.

Data Analysis and survey timing

Waterfowl observation data were treated according to protocol described for the standard North American Waterfowl Breeding Population Surveys (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). That is, for all ducks except greater 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. In 2002 we began doubling single dark geese (white-fronted geese, Canada geese and black brant), to account for assumed undetected mates on nests, which is a departure from that protocol. Historical data were changed accordingly for multi-year analysis. For scaup (which are known to have sex ratios strongly skewed toward males) and all other surveyed species not mentioned above, singles were not doubled and population indices were based on total birds observed.

In this survey we attempted to provide an index to the number of individuals of each waterfowl species and other selected bird species that are present within the study area. The term index as used here is defined as a number (count) that represents an unknown proportion of the population of birds occupying the survey area during the nesting season and detected by the observers, based on adult males for eiders and other sexually dimorphic species, and on individuals seen for monomorphics. While unknown, the proportion is assumed to be constant among years, and the index is used to help track population changes through time. Bias in this survey comes primarily from three sources: *sampling error* due to the nonrandom distribution of birds within the sample, *timing* of the survey relative to bird breeding phenology, and variations in *detection* of birds in the sample. *Sampling error* is addressed using 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 presence of spectacled and king eider males, which are normally present on the breeding grounds only from arrival until shortly after nest initiation. 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 (Troy 1997). Most males have departed the area by 20 to 25 June. It is unknown how phenology in the Prudhoe Bay area compares with other parts of the Arctic Slope. King eider phenology is similar, but the period of male presence is normally more protracted and possibly less synchronous than that of spectacled eiders, perhaps because king eiders utilize a greater diversity of wetland types which thaw at different times, and because king eiders breeding on the Arctic Slope are widely distributed during the winter (Lynn Dickson,Canadian Wildlife Service, pers. comm.) and timing of spring arrival would likely vary somewhat among wintering populations. In general in the high arctic, king eiders begin to nest in the last half of June, about 2-3 weeks after arrival (Bellrose 1980). 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 (Abby Powell, University of Alaska, Fairbanks, 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 our survey we assumed that proper timing for spectacled eiders is adequate for king eiders as well.

Our procedure for determining proper survey timing consisted of the following: 1. We monitored weather, and ice and snow cover data, planning to arrive in the survey area when ponds and tundra vegetation were just becoming available to nesting eiders over most of the arctic slope. 2. We contacted biologists in Prudhoe Bay and Barrow for their observations on eider phenology. 3. We flew reconnaissance surveys to determine the distribution of spectacled eider pairs. When most eider pairs appeared to be occupying breeding territories rather than in mixed-sex flocks, we began the survey. Generally this occurs as soon as most shallow vegetated wetlands have extensive open water, and tundra vegetation is mostly snow-free around pond margins. Since the survey is timed for eiders, its appropriateness for other species varies and is likely questionable for some. We assume that the standard breeding population survey conducted in late June and early July is timed better for most of the other ducks, coastal-nesting geese, and other waterbirds. However, for early nesters such as white-fronted and Canada geese, which are joined by molt-migrants from other breeding areas beginning in mid- to late June, the timing of the eider survey may well be more appropriate. Unfortunately, the study area for the eider survey excludes much upland goose habitat that is covered by the later survey.

We have used two methods to determine retrospectively the appropriateness of the timing of our survey. Beginning in 1997 we used a ratio of lone drakes (males unaccompanied by females) to total males (with and without females), averaged over the entire survey sample as an index for spectacled and king eiders, to help compare survey timing among years for these primary target species (Larned and Balogh 1997). 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, as females spend more time with nesting activities. This index is clearly more valid for most dabbling ducks which often linger longer after nest initiation and molt in nearby wetlands, with eiders there is a greater tendency for males to depart the breeding grounds for distant marine molting habitats immediately after nest initiation, rendering them unavailable for observation. Nonetheless, it’s acknowledged shortcomings notwithstanding, the overall index, and a plot of daily totals of this ratio are helpful when considered in conjunction with other indicators of phenology, especially in determining the beginning of the survey window.

For the second method, primarily because we had no consistent ground-based sources of phenology data in the western portion of the coastal plain, in 1999 we selected a 97.4 km^2 irregular polygon plot located within the high density spectacled and king eider habitat about 10 km northwest of Atqasuk, to use as a reference for waterfowl phenology. From 1999 through 2003 we surveyed this polygon as often during the survey period as practicable, collecting bird data as in the operational survey. Data consisting of daily counts of total birds and relative numbers of singles, pairs and flocked birds enabled us to evaluate our survey timing in relation to apparent breeding phenology. We did not use these data to adjust our survey data in any way to compensate for errors resulting from inappropriate survey timing. Due to funding constraints, weather delays and concerns that the additional workload of the phenology plot would result in our not completing the operational survey before male departure, we did not use this method in 2004 or 2005. We hope to be able to resume it in the future.

We have made little progress in addressing the *detection rate* objective. The survey is assumed to track the population of birds that visits the survey area 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. The observers fail to see them due to any of several variables of detection bias, such as 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 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 survey we conducted a fixed-wing/helicopter detectability study covering a 270 km^2 subset of our operational transects. The results of this study were not satisfactory in that our fixed-wing count often exceeded the helicopter count. Therefore we are still left with an unadjusted annual index to abundance, for which we strive diligently to minimize observer changes and standardize techniques, thereby minimizing the effects of observer bias.

RESULTS AND CONCLUSIONS

Habitat conditions and survey timing

We arrived in the survey area on 9 June, and during the flight to Deadhorse we looked over some of the ponds between Nuiqsut and Deadhorse. Conditions seemed about normal for that date, with less than 10 percent snow cover on the tundra remaining in scattered patches, most of the shallow vegetated wetlands partly to mostly open, and most of the deeper ponds completely ice-covered or with narrow thawed margins. Eiders seemed to already be well-distributed in that area, but all in pairs, with occasional small flocks of king eiders. The weather was low stratus and fog, with temperatures a degree or two above freezing. The next day we flew a survey flight to Atqasuk and back along the southern edge of the survey area, finding much the same conditions with very high water levels across the slope. However, the area north and west of Atqasuk had continuous ice and snow, with eiders and other ducks staging in rivers, as they held the only open water. Distribution of eiders and most other waterbirds seemed about normal for the southern transects flown, and spectacled and king eiders were in pairs, with no lone drakes present. Cold, foggy and often windy weather persisted, and since waterfowl phenology was still early, we waited until 14 June to resume the survey. By this time some progress had occurred in ice cover melting from ponds, and we began to see a few king and spectacled eider lone drakes on transect (Fig. 3). By 15 June the area north of Atqasuk had thawed considerably, though water levels were still way above normal. The rest of the survey was completed by 19 June, among continued frequent periods of fog and wind, especially near the Beaufort coast.

The overall ratio of lone males to total males during the survey, a rough measure of survey timing in relation to nest initiation, was below average for both king and spectacled eiders, which is consistent with our impression of a comparatively late spring (Table 2). The daily trend in this measure was remarkably similar for both species, showing an increase in lone drakes through the survey period, while those for pintails and long-tailed ducks showed their usual slightly upward steady trend (Fig. 3). The long-tailed duck trend line was at a lower level than that of 2004, suggesting a late spring for this species as well. All in all, we felt that the survey was timed reasonably, but it would have been desirable to re-fly the portion flown on 10 June later had this been possible, as there were likely some eiders and other birds still in transit at that time.

Population estimates and breeding distribution for selected species

Table 3 presents tallies for sample data (single, pair and flocked bird totals in the sample), as well as indices calculated from these data, for 2005. Table 4 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 growth or decline of 50 percent in 20 years. Figures 10-34 include stacked bar graphs depicting annual sample composition (singles, pairs, flocked birds), annual population indices with 95 percent confidence limits based on within-year sampling error among transects as stratified by 11 physiographic regions, and average annual growth rate as determined by log-linear regression. Growth rates are given both for the full 13-14 years of data (depending on species) and for the most recent 7 years, which in a few cases are significantly different. Annual indices and other values are shown for singles, pairs, birds in flocks, and total indicated birds.

Loons

The Yellow-billed loon index was above the long-term mean this year, continuing its erratic pattern and slight, non-significant upward trend (Fig. 10). The 2005 Pacific loon index (Fig. 11) was about average, continuing a very stable level trend since 1999. The 2005 red-throated loon index remained well below average, maintaining a significantly negative long-term growth rate (0.941), but a relatively stable level trend for the most recent 7 years (1.014, Fig. 12).

Jaegers

Jaeger species are combined for this survey to help prevent dilution of observer focus from eiders and other higher priority species. The jaeger index fluctuates widely following microtine prey abundance, and is unchanged from last years' well below average index this year (Fig. 13). The declining trend is steeper for the most recent 7 years (growth rate 0.870) than for the long-term (0.974) (Fig. 13).

Gulls & terns

Discounting birds in flocks, which can vary widely if the year's transects happen to cross large breeding colonies or transient flocks, the glaucous gull index has remained level and stable in both short and long terms (Fig. 14). In contrast, Sabine's gull counts have been erratic, though level in the long term (Fig. 15). Sabine's gull indices from this survey do not appear to correlate well with the more stable index produced by the later ACP breeding Pair survey (Mallek unpubl. data). Likely this relates to a survey timing issue for this relatively late, long-distance migrant, so the latter data set is probably better for tracking this species. The trend for the Arctic tern index appears to have leveled off in the most recent 7 years, after a fairly steady and significant increase through 2000 (Fig. 16).

Eiders

The spectacled eider index of 7,820 is above both last year's index of 5,985 and the long-term average of 6,916 (Fig. 17). The 13-year trend remains essentially level, but that of the last 7 years shows a slight insignificant increase (growth rate 1.025, Fig. 17). Distribution was similar to prior years, as can be seen by viewing this year's observations overlain to the density polygons calculated using a complete (1999-2002) four-year rotation of observation data (Fig. 4). Note that the data set used for figure 4 does not include observations from the extra transects funded by BLM for the Northeast Planning Area. The King eider index of 14,934 falls on the significantly positive (1.021) long-term trend line, and is above the index for 2004 (13461) and the 13-year mean of 13,084(Fig. 18). The projection of the 2005 locations over the density polygons derived from 1999-2002 survey data (Fig. 5) reveals no surprises, with the three largest concentrations between the Colville River and Prudhoe Bay, a large area around Atqasuk, and the area southeast of Teshekpuk Lake, the latter being the densest. Common eiders nest primarily on barrier islands and other coastal habitats, which are not adequately sampled by this survey. A special coastal survey is conducted for this species, by C. Dau and others (Dau and Larned 2004). There are so few Steller's eiders detected during this survey that it is of little value for detecting a useful trend (Fig. 19). This year we observed one lone male near Barrow and a pair 28 km southeast of Wainwright.

Other ducks

The red-breasted merganser index continued its steadily increasing trend, which is significant at p=0.10 (Fig. 20). The 2005 index of 942 is the highest to date and more than double the long-term mean of 434. Mergansers are widely scattered in the central coastal plain, mostly well inland from the coast. The American wigeon is uncommon on the North Slope. We usually see a few in the south-central portion of the survey area along rivers, but in 2005 our three observations were in the Teshekpuk Lake region. The trend is level, with this year's estimate 205 (Fig. 21). The Northern pintail index of 25,346 is the second lowest index of the 14 years of this survey, and about one-half the mean index (Fig. 22). Our annual index for this species is very erratic and correlates strongly with the timing of the snow and ice melt. The years with the latest springs, such as this one, have had the lowest breeding indices, and vice-versa. This is another species whose results do not track well with those of the ACP survey, plus the geographic coverage misses much important habitat, therefore we favor the ACP survey for Pintails. That said, it should still be noted that both surveys show a level long-term trend for this species. The greater scaup index of 5,347 is slightly above the 14-year mean of 4,080, and the positive trend is slight (1.046) but currently significantly greater than 1.0 at p=0.10 (Fig. 23). This species is widely distributed, primarily over the central part of the North Slope, and associated mainly with river drainages more inland than coastal. The 2005 long-tailed duck index of 27,135 is slightly below the mean of 31,379, and on the gently downward-sloping trend line (Fig. 24). This statistically insignificant decline results from the three most recent years, whose relatively low indices we feel resulted mostly from survey timing in relation to late spring arrival. However, there is some agreement with the ACP survey's more convincing negative slope, so the species warrants close monitoring (Mallek, 2004). Though erratic in the early years of the survey, white-winged scoter indices have exhibited a positive growth rate, which is significant in both 7 and 14-year time scales (Fig. 25).

Geese

The greater white-fronted goose index was 8 percent below the long-term mean, but the long-term trend retains a steady though non-significant positive trend (Fig. 26). The erratic nature of the annual index is driven mostly by the variable flocked bird component, which is more sensitive to survey timing than are singles and pairs. This survey does not adequately sample colonial-nesting snow geese, though our data for the species shows a long-term trend significantly greater than 1.0 (Table 4), which is consistent with the findings of Ritchie et al. (2002) who conduct annual surveys of snow goose and black brant colonies for the North Slope Borough. Black brant are also primarily colonial nesters on the North Slope, so trends are difficult to detect using our transect design. Our data suggest a significant positive growth rate over the survey's 14-year history (Fig. 27), but we suspect this may be adventitious, as much of our annual brant sample consists of a variable component of non-breeders or failed breeders from western Alaska (Ritchie et al. 2002). Neither Ritchie et al. (2002) nor Mallek et al. (2003) have detected a significant upward trend in breeding black brant on the North Slope. Canada geese are clustered on the North Slope, and most that we see are in large flocks. Most observations are near the coast east of Dease Inlet, especially north of Teshekpuk lake. The 2005 index of 6,672 was close to the long-term mean and both trend lines, which are essentially level (Fig. 28). The 2005 tundra swan index was slightly above the long-term mean and on the trend line, which shows a slight but significant positive slope (Fig. 29).

Raptors, Ravens, other birds

Owl populations are extremely variable on the North Slope, following primarily the lemming cycles. Both Short-eared and snowy owls were scarce this year (Figs. 30 and 31). 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 not detected a positive growth rate from our small sample (Fig. 32). We see very few sandhill cranes during this survey, though the very slight positive growth rate (1.080) is now significant at P=0.10 (Fig. 33). We have recorded shorebirds during this survey beginning in 1997, largely as a measure of timing of arrival on the breeding grounds, and large-scale distribution. For consistency with the Standard Breeding Pair Survey on the Arctic Coastal Plain, we split shorebirds into categories of “small” and “large” (see Table 3 for a list of species included in this category). Observations of large shorebirds have been few, variable, and our confidence in consistently discriminating them from small shorebirds is low. The short-term downward slope calculated so far for this group is significantly less than 1.0 (Fig. 34), but I suspect the low indices from the past three years resulted from survey timing in relation to the late springs.

Expanded coverage in the Teshekpuk Lake region

We doubled our sampling intensity in strata 9, 15 and 16 by adding intermediate transects between our standard lines again as we did in 2004, in response to a request and funding from the U. S. Bureau of Land Management (Fig. 2). BLM’s objectives were primarily to increase the precision of the estimates and the resolution of the distributional data in this area, which has high potential for oil and gas leasing and development, as well as extremely high wildlife resource values, including waterfowl such as nesting and molting geese and swans, and nesting ducks such as the king eider and the listed spectacled eider.

Data in Table 5 compare estimates of selected waterfowl species in strata 9, 15 and 16 with and without the added transects. In the current year context, doubling the sampling intensity significantly increased the precision of the estimates for most of those species whose abundance was great enough to overcome the effect sampling error can have with small samples. For example, in stratum 9, we recorded 24 observations of spectacled eiders in the standard transects with a coefficient of variation of 52 percent, compared with 48 observations when we doubled the sample, with a CV of 29 percent (Table 5a). In contrast, in Stratum 16 we recorded 4 spectacled eider observations on the standard transects, with a CV of 57 percent, but by doubling the number of transects we saw no more eiders, while the CV increased to 75 percent (Table 5c). The distributional characteristics can be seen graphically in Figures 6a and 6b., where the standard transect observations in Fig. 6a show a sparse and somewhat clustered distribution, while those of the doubled sample in Fig. 6b show a better-defined and more homogeneous distribution. Likewise, of the three strata, King eiders are by far most abundant in Stratum 16, which can be seen more readily and with finer resolution with the greater sampling intensity (Figs. 7a, 7b), and it is also evident in the lower doubled transect CV in stratum 16 (Table 5c).

To provide a more precise multi-year graphic representation of the pattern of habitat use within the NE Planning Area we have projected all observations of Spectacled and King eiders over the period from1998 to 2005, or two complete 4-year survey cycles (Figs. 8a and 8b). This is especially valuable because single year data, no matter how intense the sampling, reflect the annual conditions of weather, snow and ice distribution, thaw patterns, disturbance, etc. Multi-year data should reflect both the central tendency pattern of habitat preference, and the equally important alternate, perhaps marginal habitats used when preferred habitats are unavailable due to natural or anthropogenic causes. The displayed data show an obvious pattern of fairly uniform preference of certain broad areas, with clusters that represent repeated use of certain wetlands. Note that the distributions of the two eider species are somewhat complementary on a regional scale. The Slope-wide "big picture" over this time period is illustrated in Figures 9a and 9b. To give a sense of relative importance of different strata, our 2001 report included a table of average indices and densities by species and stratum over the period from 1992-2001 (Larned et al. 2001). This analysis showed that the area including strata 9, 15 and 16 accounted for 14 percent of the spectacled eiders and 18 percent of the king eiders within the entire survey area. Naturally, the multi-year distribution pattern would be even more precise with the sampling intensity doubled over the entire study area each year, but this would approximately double the cost of the project and require a second aircraft and survey crew to complete it within the phenological survey window. An attractive compromise might entail a strategic reallocation of effort increasing sampling intensity in areas with high likelihood of resource development, and/or based on distribution of species of greatest interest, from historical survey data. The trade-off would be a degradation of data sets for those species not favored in the allocation process.

ACKNOWLEDGMENTS

The authors would like to thank Tina Moran for the excellent job during her first season as observer. Thanks also to the citizens of Atqasuk, especially Melvin Wong, for their hospitality and logistic assistance. Special thanks to the Bureau of Land Management for supporting the additional aerial coverage in the Teshekpuk Lake region.

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Table 1. Survey design, North Slope Eider Survey, 1992-2004.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Recon. dates (June)	NA	8	10-12	8	6	5-10	6	8	11	9-10	8	8	9	9-10
Survey dates (June)	20-29	9-18	12-19	9-18	7-17	11-20	6-15	11-17	11-18	11-17	9-14	9-18	11-17	10-19
Total transect length (km)	2784	3146	3193	3248	3199	3232	3527	3478	2905	3200	3145	3160	3343	3590
Sample area (km^2)	1113	1253	1277	1300	1279	1292	1410	1391	1162	1280	1258	1264	1337	1436
Survey area (km^2)	30755	30755	30755	30755	30755	30755	30755	30755	30755	30755	30755	30755	30755	30755
Sample % of survey area	3.6	4.1	4.2	4.2	4.2	4.2	4.6	4.5	3.8	4.2	4.1	4.1	4.3	4.7
Pilot/observer[1]	BL	BL	BL	BL	BL	BL	BL	BL	BL	BL	BL	BL	BL	BL
Observer[2]	GB	GB	GB	GB	GB	TT	TT	TT	JF	JF	AB	AB	AB	TM
Survey flight hours	40.2	50.5	50.3	54.5	53.1	50.2	49.0	51.5	41.7	33.8	38.1	37.0	34.1	34.7

1. BL:Bill Larned 2. GB:Gregory Balogh, TT:Tim Tiplady, JF:Julian Fischer, AB:Alan Brackney, TM:Tina Moran

Table 2. Ratio of total lone males to total males (lone males plus males in pairs) in the sample for king eider and spectacled eider, 1992-2004 North Slope Eider Survey, Alaska. We suggest that higher numbers indicate later average breeding phenology for the survey.

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	Avg.
King eider	.54	.21	.31	.33	.58	.27	.48	.25	.32	.14	.34	.38	.41	.28	.35
Spectacled eider	.52	.52	.44	.42	.55	.53	.56	.29	.55	.37	.53	.59	.53	.42	.49

Table 3. Combined observations of birds by pilot and right-hand observer on aerial survey transects sampling tundra habitats on the arctic coastal plain, Alaska, June, 2005 with observable indicated population indices calculated from these data. Expanded coverage in the Teshekpuk Lake area is included.

Species	Single	pair	grouped birds	Indicated Total	Density birds·km^{-2}	Pop. Index	Pop. Std. Error	%CV
Yellow-billed loon	16	19	0	54[1]	0.042	1,282	262	20
Pacific loon	205	343	63	954[1]	0.680	20,910	1,654	8
Red-throated loon	15	32	10	89[1]	0.063	1,940	316	16
Jaeger spp.	97	9	0	115[1]	0.081	2,500	293	12
Glaucous gull	241	77	121	516[1]	0.370	11,371	1,135	10
Sabine’s gull	114	60	104	338[1]	0.234	7,205	985	14
Arctic tern	188	99	86	472[1]	0.344	10,589	988	9
Red-breasted merganser	10	7	6	40[2]	0.031	942	367	39
Mallard	0	0	0	0[2]				
American wigeon	0	2	6	10[2]	0.007	205	146	71
Am. green-winged teal	2	0	0	4[2]	0.002	73	51	69
Northern pintail	425	47	434	1,378[2]	0.824	25,346	2,297	9
Northern shoveler	0	0	0	0[2]				
Greater scaup	26	76	58	236[1]	0.174	5,347	1,068	20
Long-tailed duck	249	321	113	1,253[2]	0.882	27,135	1,573	6
Spectacled eider	73	102	0	350[2]	0.254	7,820	1,002	13
Common eider	4	5	0	18[2]	0.015	456	288	63
King eider	100	256	19	731[2]	0.486	14,934	1,232	8
Steller’s eider	1	1	0	4[2]	0.003	99	71	72
White-winged scoter	6	5	0	22[2]	0.018	553	439	79
Snow goose	2	13	264	292[1]	0.189	5,807	2,939	51
White-fronted goose	179	719	1,435	3,231[2]	2.195	67,499	5,631	8
Canada goose	15	26	389	471[2]	0.217	6,672	1,902	29
Black brant	73	95	499	835[2]	0.464	14,264	2,738	19
Tundra swan	145	82	15	324[1]	0.219	6,728	472	7
Sandhill crane	4	0	0	4[1]	0.002	125	60	48
Unid. small shorebird	427	252	294	1,225[1]	0.867	26,653	2,277	9
Unid. large shorebird	45	17	36	115[1]	0.086	2,657	599	23
Common raven	1	0	0	1[1]	0.001	25	21	82
Short-eared owl	2	0	0	2[1]	0.001	35	26	72
Snowy owl	9	0	3	12[1]	0.006	191	76	40
Golden eagle	2	0	0	2[1]	0.002	48	50	104

1. singles+(2*pairs)+flocked birds 2. 2*(singles+pairs)+flocked birds 3. Black- bellied plover, lesser golden plover, red-necked phalarope, red phalarope, dowitcher spp., ruddy turnstone, dunlin, semipalmated sandpiper, pectoral sandpiper, and others. 4. bar-tailed godwit, Hudsonian godwit, whimbrel and others.

Table 4. Average 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 1992-2005 sampling North Slope wetlands, Alaska. Variance estimates used were based on within-year sampling error among transects as stratified by 11 physiographic regions. Significant growth rates are in bold font.

Species	Measure[1]	Years	n years	Mean pop. index	Log-linear Slope	Mean population Growth Rate	Mean Population Growth Rate 90% CI	Avg. sampling error coef. of variation	Years to detect a Slope of 0.0341
Yellow-billed loon	S + 2*Pr+FL	1992-2005	14	1,090	0.007	1.007	0.983 - 1.032	0.22	14.3
Pacific loon	S + 2*Pr+FL	1992-2005	14	20,876	0.004	1.004	0.984 - 1.025	0.07	6.5
Red-throated loon	S + 2*Pr+FL	1992-2005	14	2,656	-0.061	**0.941**	**0.907 - 0.976**	0.15	11.4
Jaeger spp.	S + 2*Pr+FL	1992-2005	14	3,770	-0.026	0.974	0.931 - 1.019	0.12	9.4
Glaucous gull	S + 2*Pr+FL	1992-2005	14	11,648	-0.002	0.998	0.971 - 1.025	0.14	10.9
Sabine's gull	S + 2*Pr+FL	1992-2005	14	6,580	-0.003	0.997	0.962 - 1.034	0.13	10.4
Arctic tern	S + 2*Pr+FL	1992-2005	14	10,320	0.047	**1.048**	**1.031 - 1.066**	0.11	9.1
Red-breasted merganser	2*(S+Pr)+Fl	1992-2005	14	434	0.130	**1.138**	**1.065 - 1.217**	0.43	22.8
Mallard	2*(S+Pr)+Fl	1992-2005	14	216	-0.120	0.887	0.781 - 1.007	0.57	27.5
American wigeon	2*(S+Pr)+Fl	1992-2005	14	372	-0.004	0.996	0.898 - 1.106	0.66	30.3
Northern shoveler	2*(S+Pr)+Fl	1992-2005	14	256	0.022	1.022	0.867 - 1.206	0.34	19.3
Northern pintail	2*(S+Pr)+Fl	1992-2005	14	51,036	-0.010	0.990	0.943 - 1.039	0.09	8.0
Greater scaup	S + 2*Pr+FL	1992-2005	14	4,080	0.045	**1.046**	**1.013 - 1.080**	0.19	13.1
Long-tailed duck	2*(S+Pr)+Fl	1992-2005	14	31,379	-0.019	0.981	0.957 - 1.005	0.06	6.4
Spectacled eider	2*(S+Pr)+Fl	1993-2005	13	6,916	-0.003	0.997	0.975 - 1.019	0.10	8.8
King eider	2*(S+Pr)+Fl	1993-2005	13	13,084	0.021	**1.021**	**1.005 - 1.037**	0.10	8.6
Steller's eider	2*(S+Pr)+Fl	1992-2005	14	157	0.000	1.000	0.866 - 1.154	0.49	24.6
White-winged scoter	2*(S+Pr)+Fl	1992-2005	14	329	0.105	**1.111**	**1.010 - 1.223**	0.60	28.4
Snow goose	S + 2*Pr+FL	1992-2005	14	3,124	0.201	**1.223**	**1.105 - 1.353**	0.57	27.5
Gr. White-fronted goose	S + 2*Pr+FL	1992-2005	14	73,235	0.022	1.022	0.991 - 1.054	0.08	7.5
Canada goose	S + 2*Pr+FL	1993-2005	13	7,552	-0.012	0.988	0.943 - 1.036	0.28	17.0
Black brant	S + 2*Pr+FL	1992-2005	14	6,265	0.126	**1.134**	**1.087 - 1.184**	0.29	17.5
Tundra swan	S + 2*Pr+FL	1992-2005	14	6,060	0.020	**1.020**	**1.003 - 1.038**	0.11	9.4
Sandhill crane	S + 2*Pr+FL	1992-2005	14	128	0.077	**1.080**	**1.001 - 1.165**	0.61	28.6
Unident. small shorebird	S + 2*Pr+FL	1997-2005	9	43,236	-0.064	**0.938**	**0.888 - 0.992**	0.08	7.2
Common raven	S + 2*Pr+FL	1992-2005	14	65	-0.025	0.975	0.905 - 1.050	0.71	31.7
Short-eared owl	S + 2*Pr+FL	1992-2005	14	83	0.019	1.019	0.913 - 1.138	0.33	18.9
Snowy owl	S + 2*Pr+FL	1992-2005	14	747	-0.112	0.894	0.790 - 1.012	0.36	20.3

1. S = single, Pr = pair, Fl = flocked birds not in discernable pairs.

Table 5a. Comparison of selected waterfowl estimates in stratum 9 with and without extra transects, arctic slope, Alaska, 2005

	Without extra transects						With extra transects					
Species*	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%
YBLO	7	79.3	1	0.01	0.01	87	16	163.5	1	0.01	0.01	93
PALO	7	79.3	35	0.44	0.06	14	16	163.5	74	0.45	0.10	22
RTLO	7	79.3	8	0.10	0.03	24	16	163.5	14	0.09	0.02	23
NOPI	7	79.3	310	3.91	0.29	7	16	163.5	453	2.77	0.48	17
GRSC	7	79.3	1	0.01	0.01	78	16	163.5	9	0.06	0.03	51
LTDU	7	79.3	68	0.86	0.17	19	16	163.5	155	0.95	0.23	24
SPEI	7	79.3	24	0.30	0.16	52	16	163.5	48	0.29	0.09	29
KIEI	7	79.3	16	0.20	0.12	60	16	163.5	24	0.15	0.06	40
WFGO	7	79.3	293	3.69	1.40	38	16	163.5	385	2.36	0.88	37
TUSW	7	79.3	18	0.23	0.07	32	16	163.5	36	0.22	0.04	17

Table 5b. Comparison of selected waterfowl estimates in stratum 15 with and without extra transects, arctic slope, Alaska, 2005

	Without extra transects						With extra transects					
Species*	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%
YBLO	5	27.3	4	0.15	0.11	74	8	57.8	4	0.07	0.05	75
PALO	5	27.3	28	1.02	0.36	35	8	57.8	46	0.80	0.18	23
RTLO	5	27.3	0	0			8	57.8	0	0		
NOPI	5	27.3	6	0.22	0.07	31	8	57.8	12	0.21	0.06	29
GRSC	5	27.3	3	0.11	0.12	113	8	57.8	10	0.17	0.08	44
LTDU	5	27.3	4	0.15	0.12	84	8	57.8	24	0.42	0.21	50
SPEI	5	27.3	6	0.22	0.06	26	8	57.8	8	0.14	0.05	37
KIEI	5	27.3	4	0.15	0.12	79	8	57.8	12	0.21	0.10	47
WFGO	5	27.3	130	4.76	1.31	28	8	57.8	204	3.53	1.00	28
TUSW	5	27.3	5	0.18	0.09	51	8	57.8	14	0.24	0.08	33

Table 5c. Comparison of selected waterfowl estimates in stratum 16 with and without extra transects, arctic slope, Alaska, 2005

	Without extra transects						With extra transects					
Species*	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%	#transects	Tr km^2	# obs.	Birds/km^2	SE dens.	CV%
YBLO	5	82.2	0	0			7	126.1	0	0		
PALO	5	82.2	41	0.50	0.33	65	7	126.1	74	0.59	0.23	40
RTLO	5	82.2	3	0.04	0.02	57	7	126.1	5	0.04	0.02	37
NOPI	5	82.2	139	1.69	0.07	4	7	126.1	187	1.48	0.19	13
GRSC	5	82.2	4	0.05	0.02	31	7	126.1	16	0.13	0.05	39
LTDU	5	82.2	72	0.88	0.09	10	7	126.1	100	0.79	0.14	17
SPEI	5	82.2	4	0.05	0.03	57	7	126.1	4	0.03	0.02	75
KIEI	5	82.2	126	1.53	0.52	34	7	126.1	188	1.49	0.34	23
WFGO	5	82.2	245	2.98	1.05	35	7	126.1	341	2.70	0.63	23
TUSW	5	82.2	25	0.30	0.07	24	7	126.1	46	0.37	0.08	22

* YBLO = Yellow-billed loon, PALO = Pacific loon, RTLO = Red-throated loon, NOPI = Northern pintail, GRSC = Greater scaup, LTDU = Long-tailed duck, SPEI = Spectacled eider, KIEI = King eider, WFGO = White-fronted goose, TUSW = Tundra swan

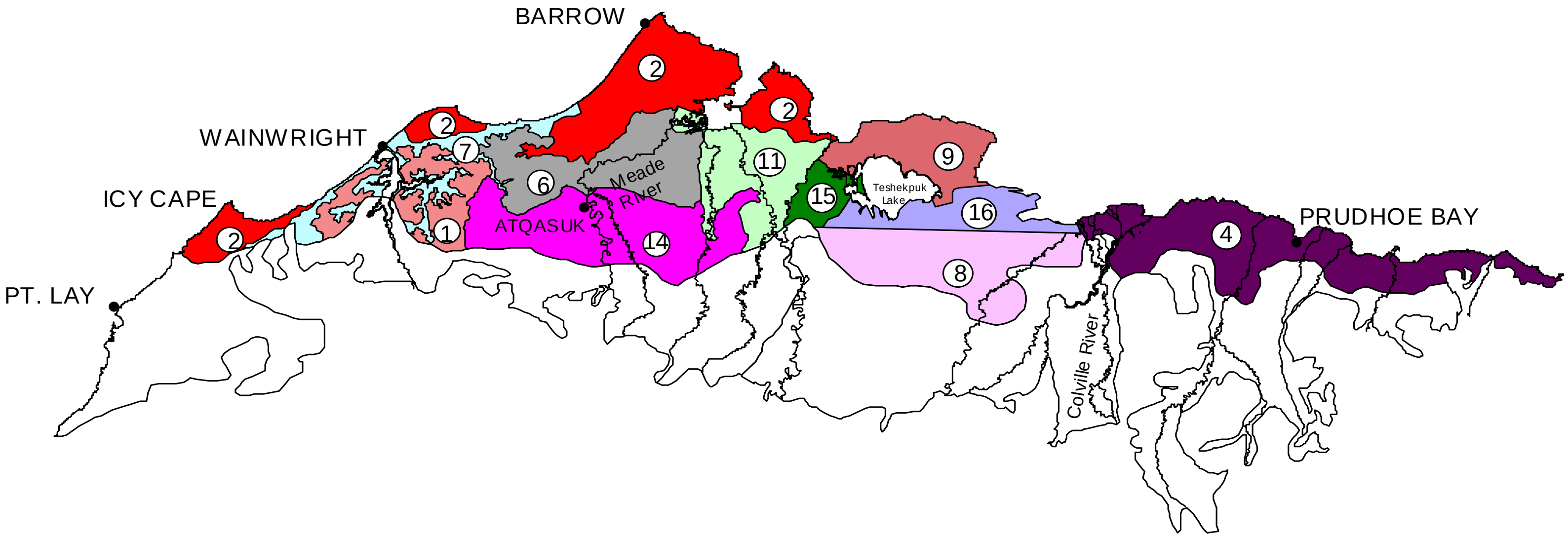


Figure 1. Survey strata for the North Slope Eider Survey, Alaska, with major hydrographic and cultural features. Unshaded units south of the eider survey area are strata surveyed by the Standard Breeding Population Survey in late June - early July.

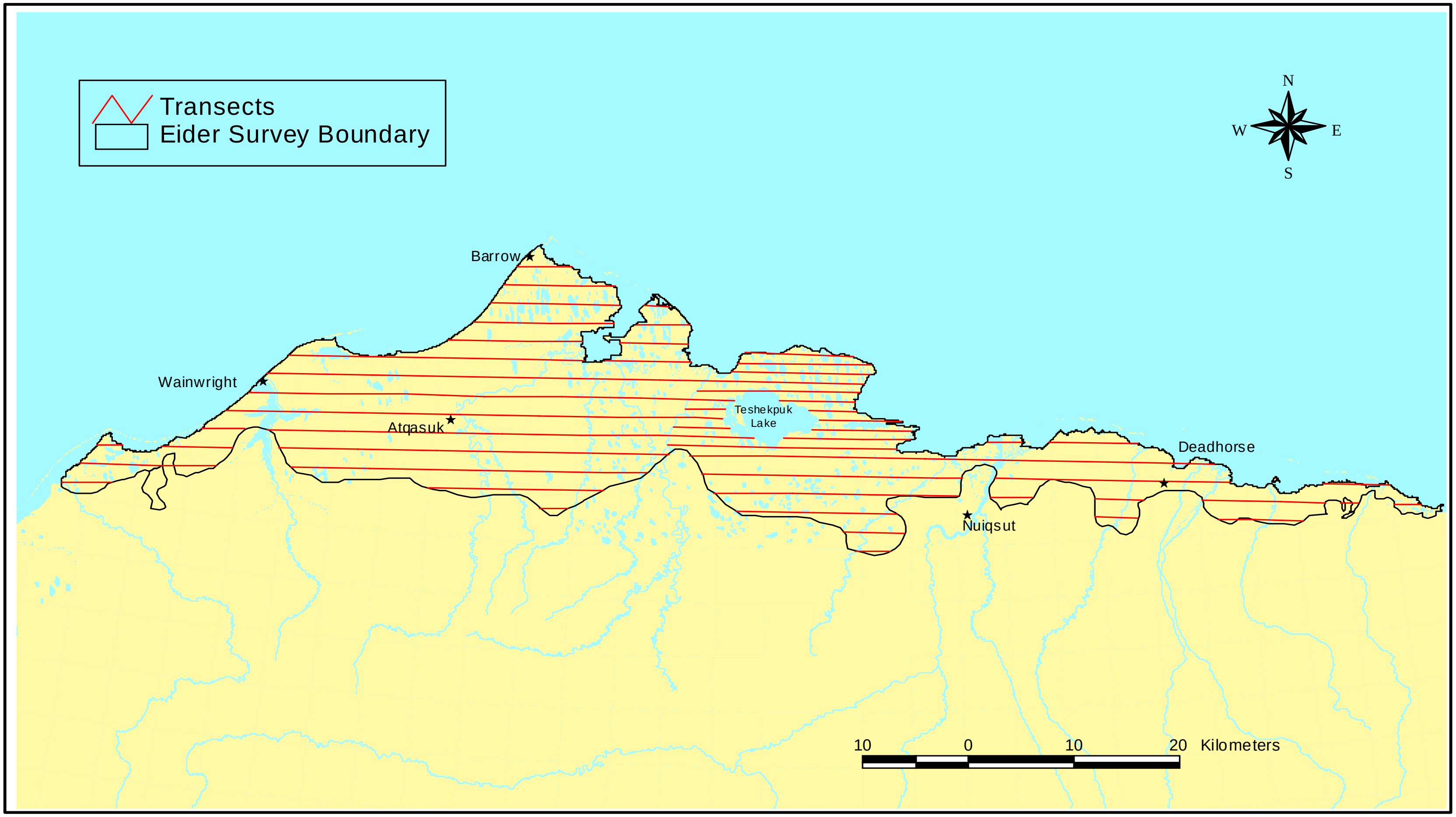


Figure 2. Aerial transects flown during the North Slope eider breeding population survey, Alaska, June 11-17, 2005..

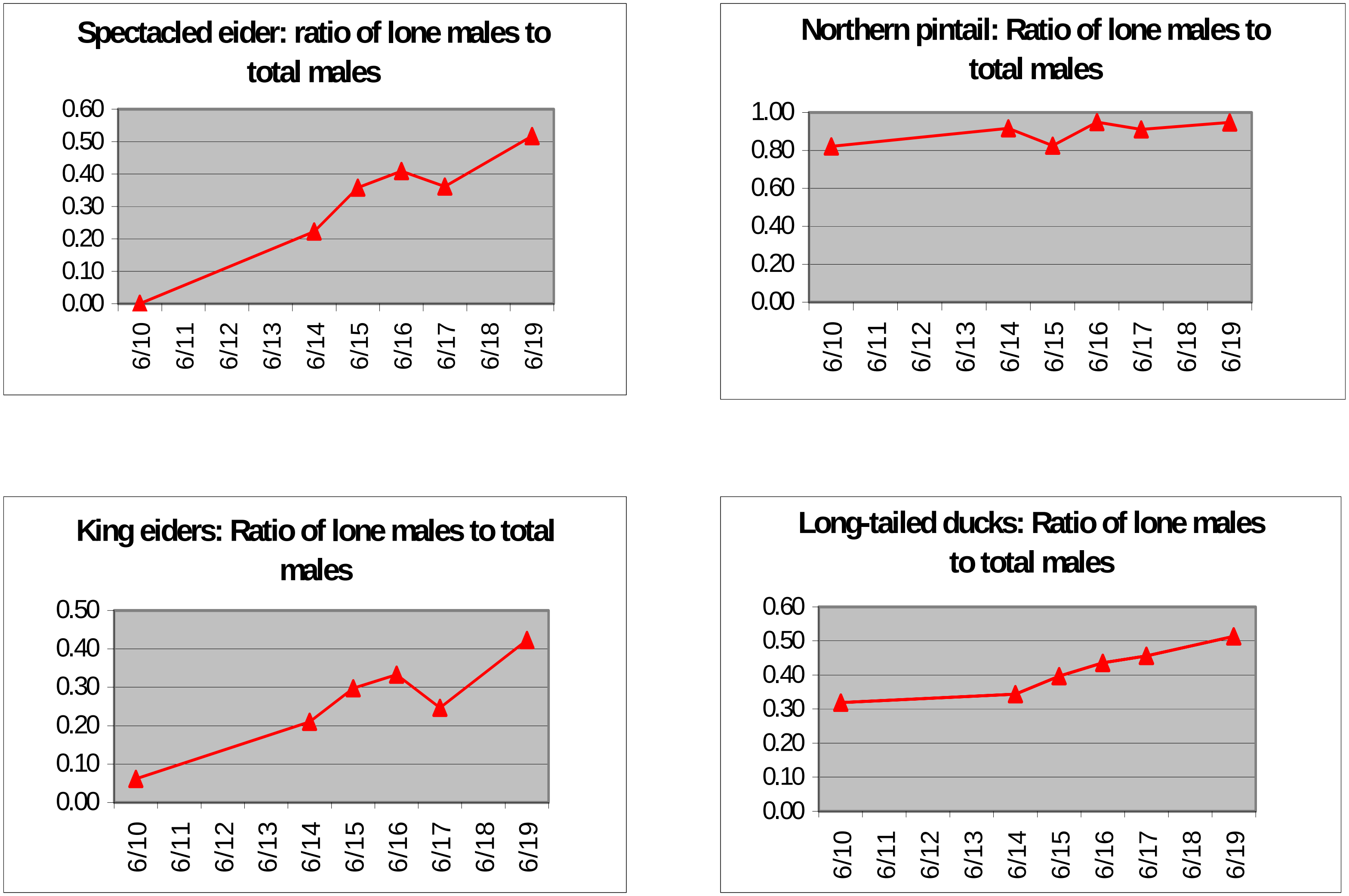


Figure 3.

Daily ratios of lone males to total males (lone males plus males in pairs) of selected duck species observed during the North Slope Eider Survey, June, 2005.

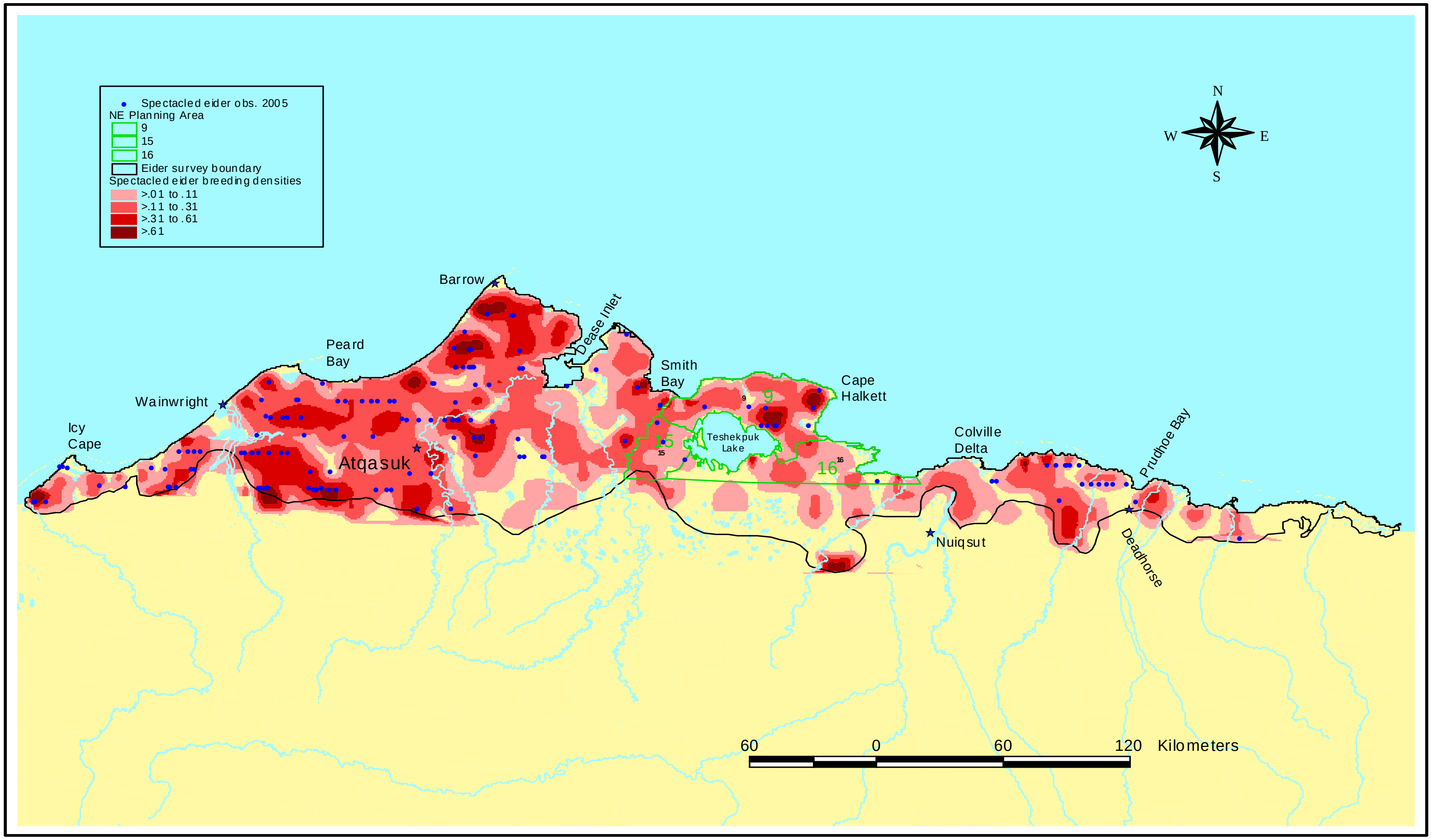


Figure 4. Locations of spectacled eiders observed during aerial surveys of the arctic coastal plain of Alaska, June, 2005, displayed over spectacled eider breeding density polygons created from1999-2002 data from this study.

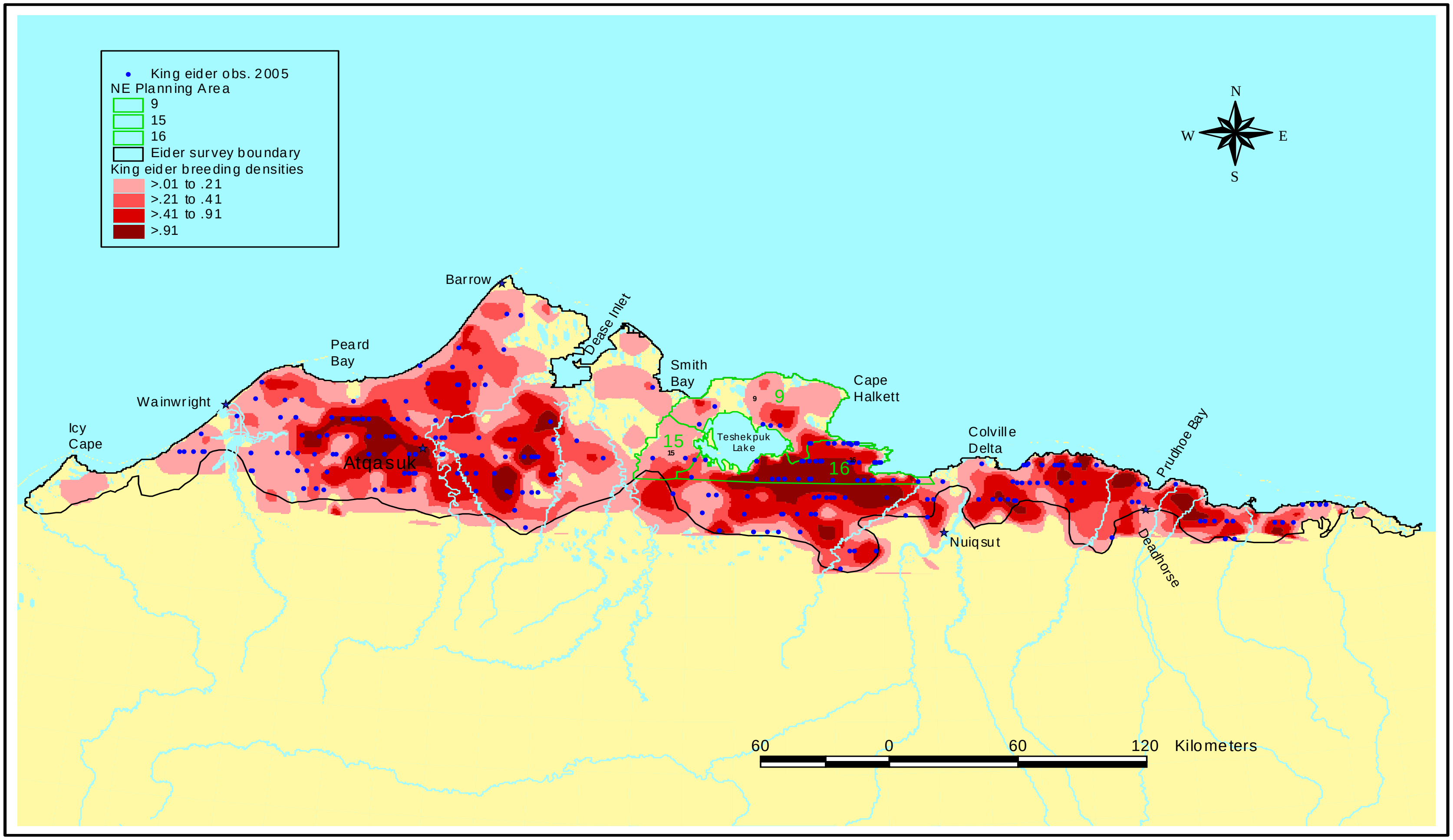


Figure 5. Locations of king eiders observed during aerial surveys of the arctic coastal plain of Alaska, June, 2005, displayed over king eider breeding density polygons created from1999-2002 data from this study.

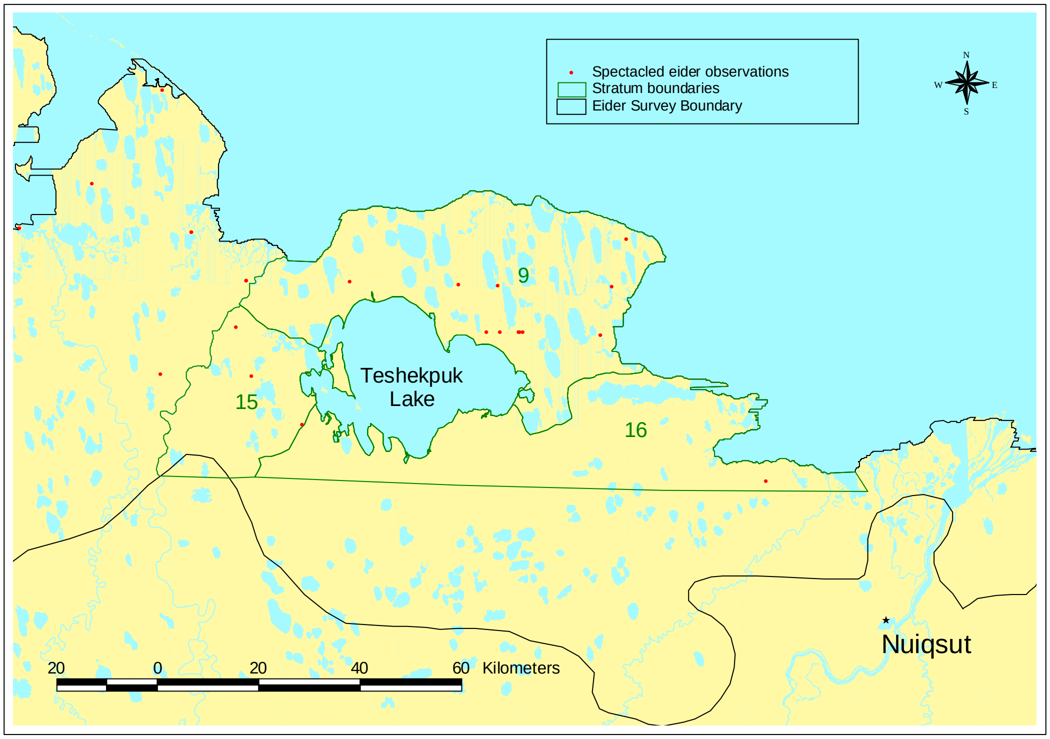


Figure 6a. Teshekpuk Lake area (strata 9, 15, and 16 (see fig. 1), with spectacled eider observations on primary transects only, Arctic Coastal Plain, Alaska, June, 2005.

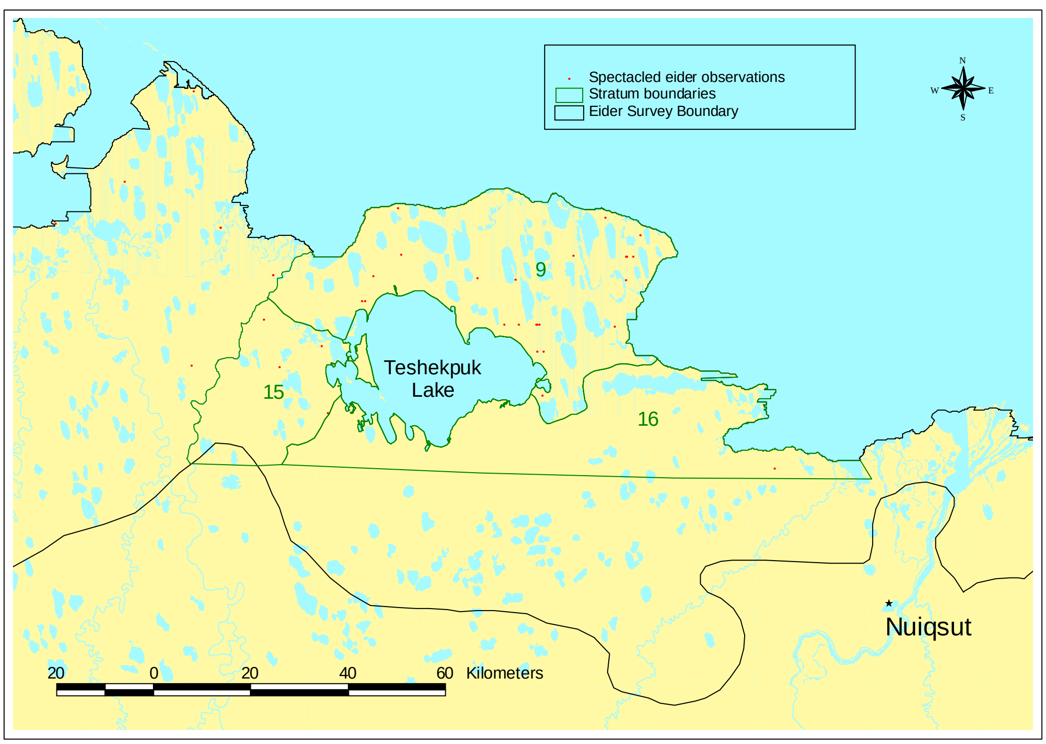


Figure 6b. Teshekpuk Lake area with spectacled eider observations on primary and secondary transects, Arctic Coastal Plain, Alaska, June, 2005.

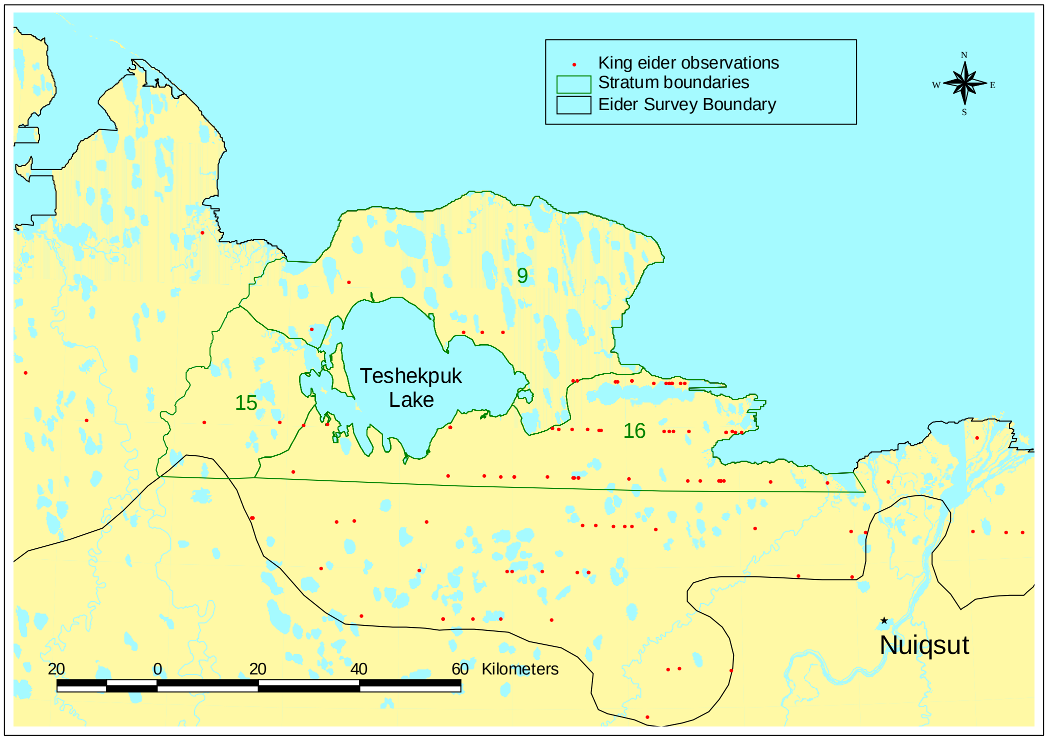


Figure 7a. Teshekpuk Lake area (strata 9, 15, and 16 (see fig. 1), with king eider observations on primary transects only, Arctic Coastal Plain, Alaska, June, 2005.

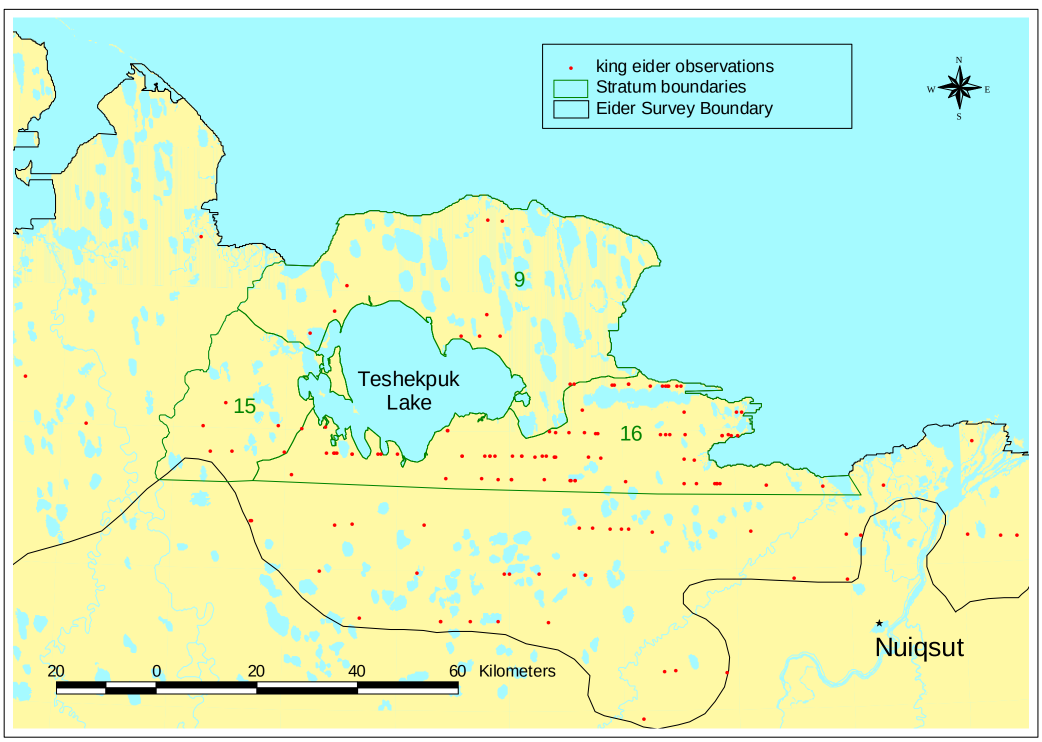


Figure 7b. Teshekpuk Lake area with king eider observations on primary and supplementary transects, Arctic Coastal Plain, Alaska, June, 2005.

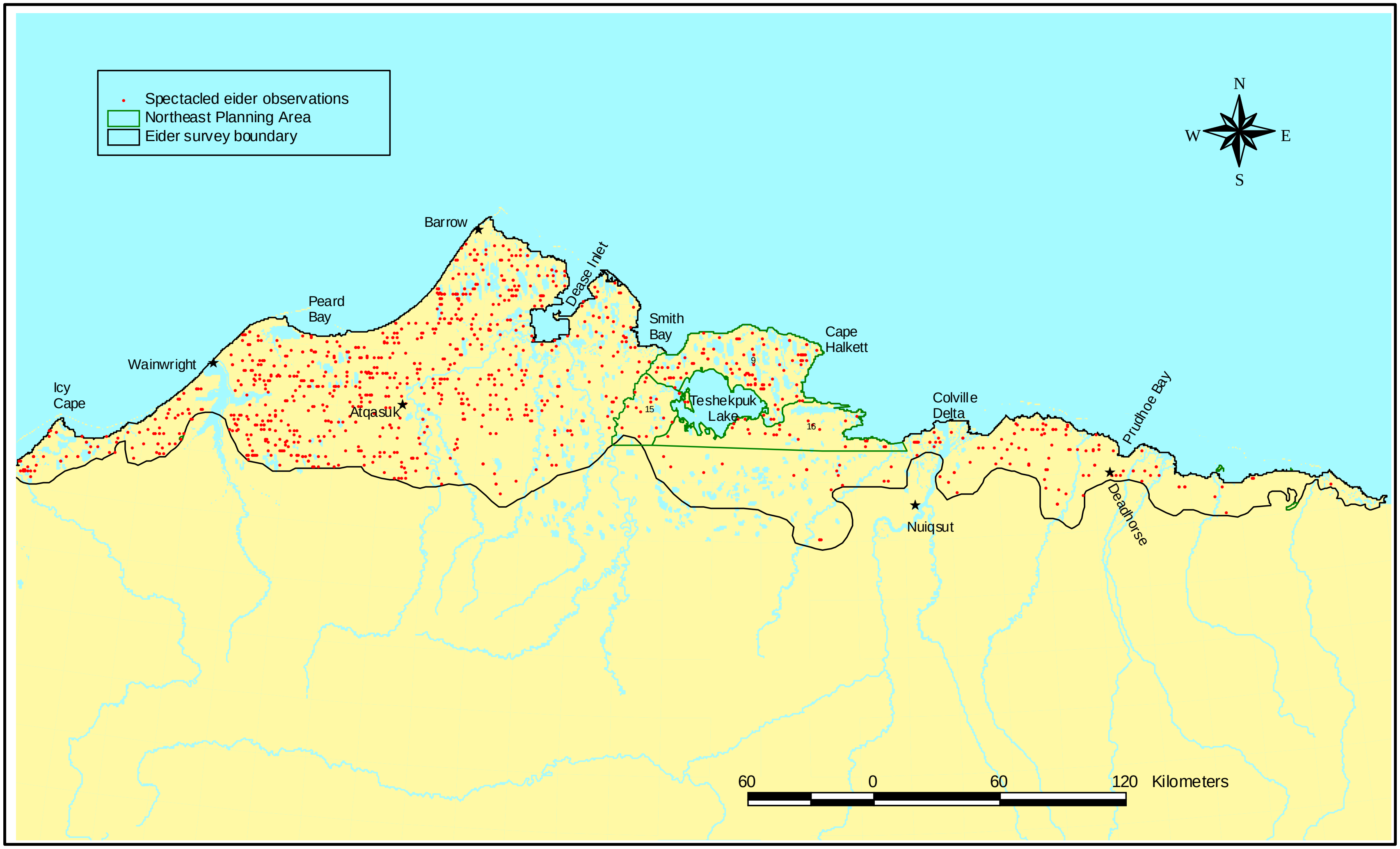


Figure 9a. Spectacled eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, during June, 1998-2005. Data from extra transects flown in NE Planning Area are not included in data set.

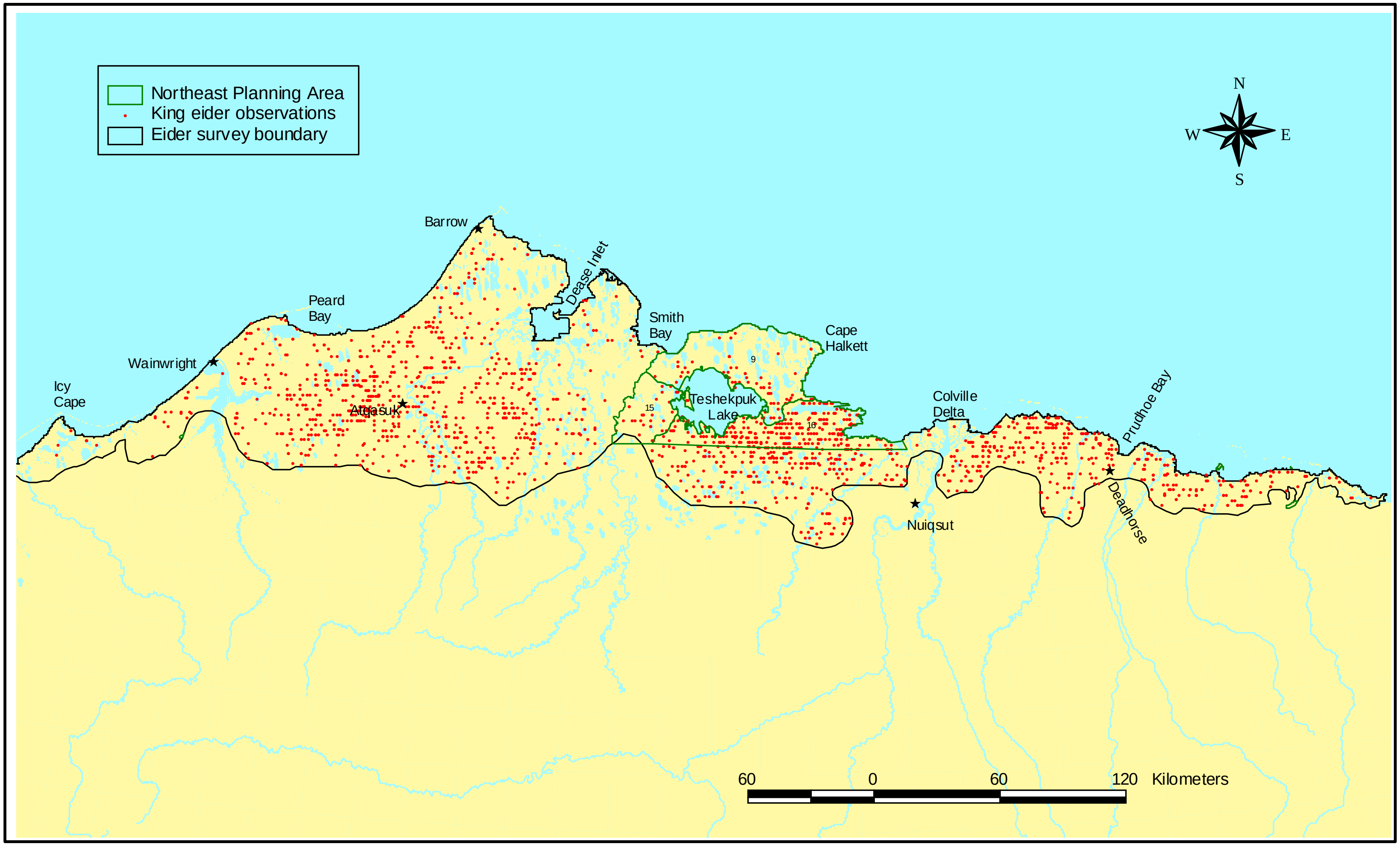
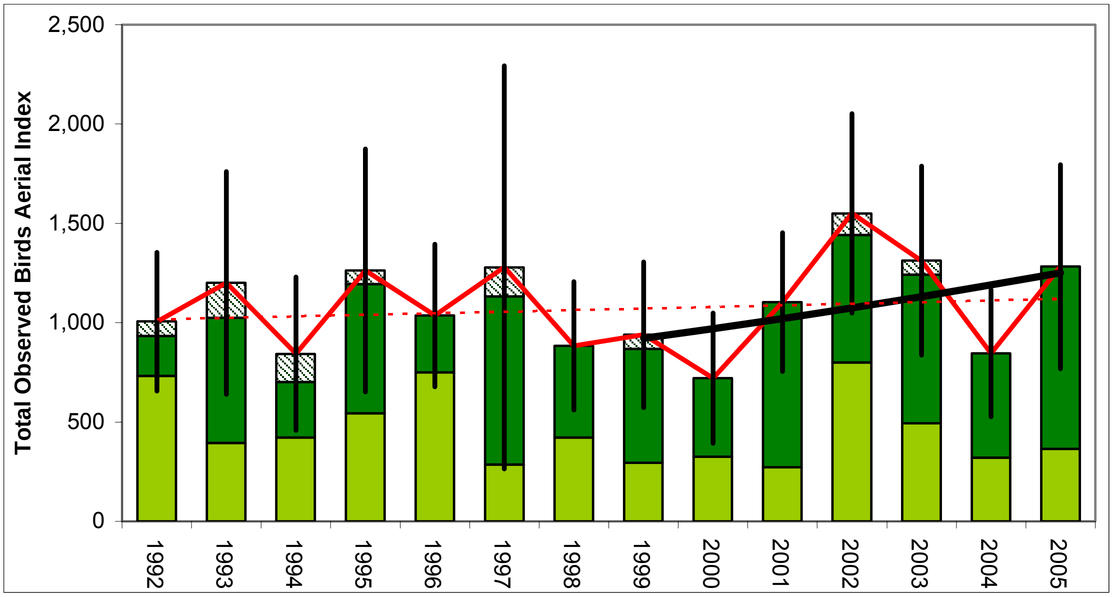


Figure 9b. King eiders observed during aerial surveys, Arctic Coastal Plain, Alaska, during June, 1998-2005. Data from extra transects flown in NE Planning Area are not included in data set.

Yellow-billed Loon North Slope early-June survey



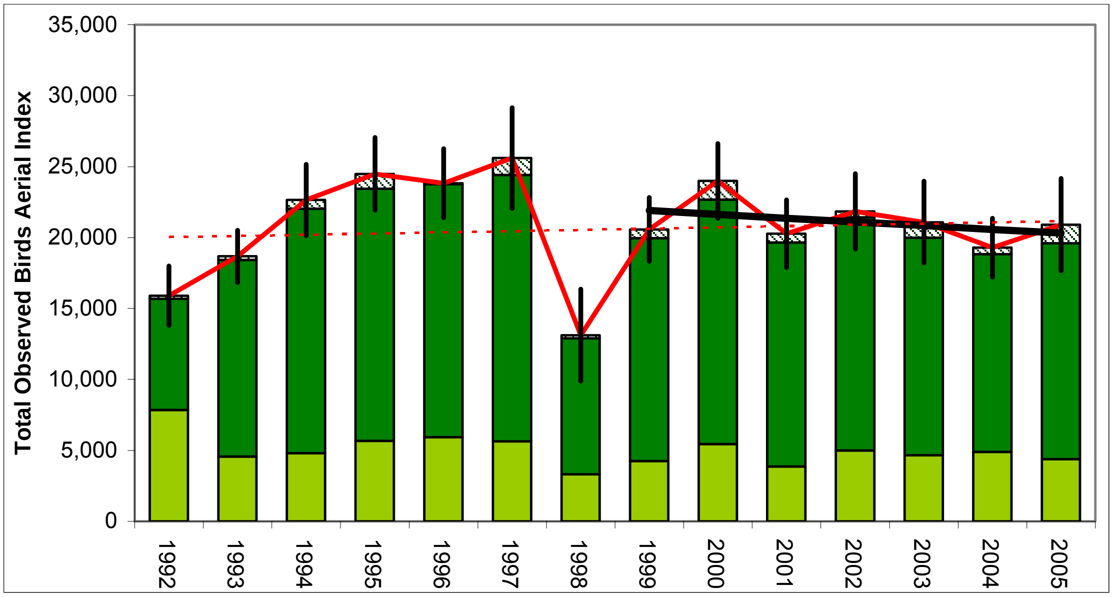
Aerial index: Total birds observed — S6d strata (n=11) — YBLO

year	sg	2*pr	flocks	Index	Std Err
1992	731	202	73	**1005**	178
1993	394	630	176	**1200**	286
1994	422	280	141	**844**	197
1995	544	650	69	**1263**	312
1996	750	286	0	**1036**	183
1997	285	848	145	**1279**	518
1998	422	462	0	**884**	165
1999	295	574	70	**939**	187
2000	325	396	0	**721**	167
2001	272	832	0	**1104**	178
2002	800	642	108	**1551**	256
2003	494	748	71	**1312**	243
2004	321	524	0	**846**	163
2005	364	918	0	**1282**	262

n yrs =	14
mean =	**1090**
std dev =	233
ln linear slope =	0.0074
SE slope =	0.0148
Growth Rate =	**1.007**
low 90%ci GR =	0.983
high 90%ci GR =	1.032
regression resid CV =	0.223
avg sampling err CV =	0.215
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	14.7
w/ sample error CV =	14.3
most recent 7 years :	
Growth Rate =	**1.052**
low 90%ci GR =	0.967
high 90%ci GR =	1.145

Figure 10. Population trend for Yellow-billed Loons (*Gavia adamsii*) observed on aerial survey transects sampling 30,755 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 11 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.

Pacific Loon North Slope early-June survey

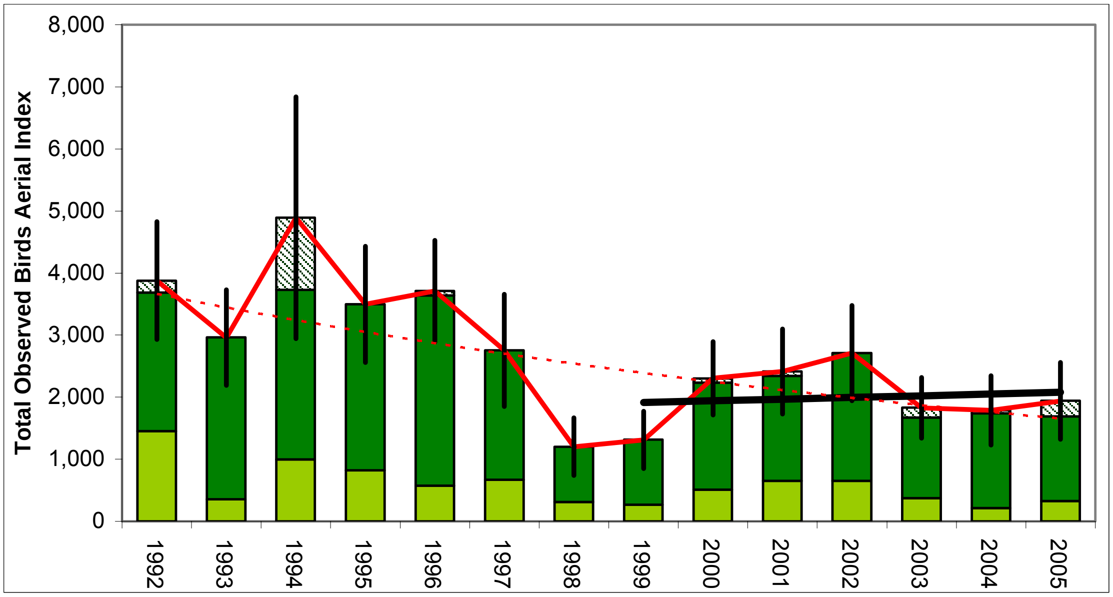


Aerial index: Total birds observed — S6d strata (n=11) — PALO

year	sg	2*pr	flocks	Index	Std Err
1992	7833	7858	215	**15906**	1067
1993	4559	13860	253	**18671**	942
1994	4803	17228	618	**22648**	1286
1995	5664	17772	1052	**24488**	1307
1996	5928	17832	71	**23832**	1240
1997	5623	18798	1189	**25610**	1808
1998	3315	9580	226	**13120**	1650
1999	4245	15702	628	**20575**	1149
2000	5444	17240	1310	**23994**	1342
2001	3864	15788	621	**20273**	1210
2002	5004	16418	428	**21850**	1356
2003	4659	15346	1086	**21091**	1470
2004	4898	13928	463	**19290**	1055
2005	4383	15218	1310	**20910**	1654

n yrs =	14
mean =	**20876**
std dev =	3405
ln linear slope =	0.0042
SE slope =	0.0123
Growth Rate =	**1.004**
low 90%ci GR =	0.984
high 90%ci GR =	1.025
regression resid CV =	0.186
avg sampling err CV =	0.065
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	13.0
w/ sample error CV =	6.5
most recent 7 years :	
Growth Rate =	**0.988**
low 90%ci GR =	0.967
high 90%ci GR =	1.009

Figure 11. Population trend for Pacific Loons (*Gavia pacifica*) observed on aerial survey transects sampling 30,755 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 11 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.



Aerial index: Total birds observed S6d strata (n=11)

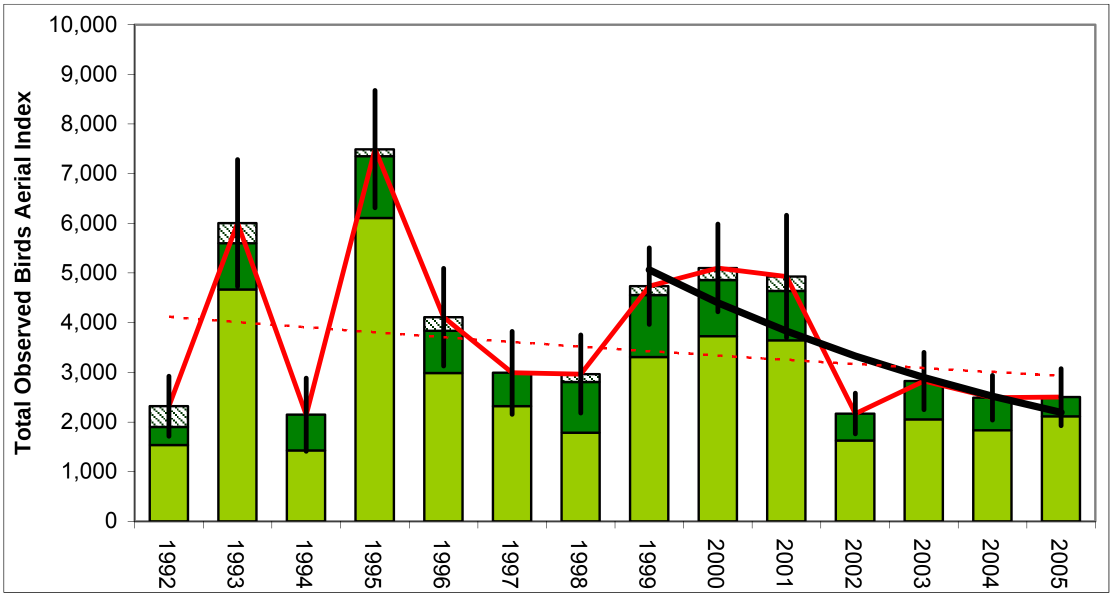
year	sg	2*pr	flocks	Index	Std Err
1992	1453	2236	188	**3878**	485
1993	357	2604	0	**2960**	393
1994	997	2732	1162	**4891**	994
1995	823	2672	0	**3495**	476
1996	571	3066	72	**3709**	417
1997	670	2084	0	**2754**	461
1998	311	890	0	**1202**	236
1999	266	1048	0	**1313**	235
2000	511	1724	69	**2305**	300
2001	649	1694	72	**2415**	350
2002	649	2062	0	**2711**	391
2003	375	1298	156	**1828**	249
2004	215	1524	49	**1787**	285
2005	324	1368	249	**1940**	316

RTLO

n yrs =	14
mean =	**2656**
std dev =	1055
ln linear slope =	-0.0611
SE slope =	0.0221
Growth Rate =	**0.941**
low 90%ci GR =	0.907
high 90%ci GR =	0.976
regression resid CV =	0.334
avg sampling err CV =	0.152
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	19.2
w/ sample error CV =	11.4
most recent 7 years :	
Growth Rate =	**1.014**
low 90%ci GR =	0.935
high 90%ci GR =	1.100

Figure 12. Population trend for Red-throated Loons (*Gavia stellata*) observed on aerial survey transects sampling 30,755 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 11 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.

Jaeger spp North Slope early-June survey



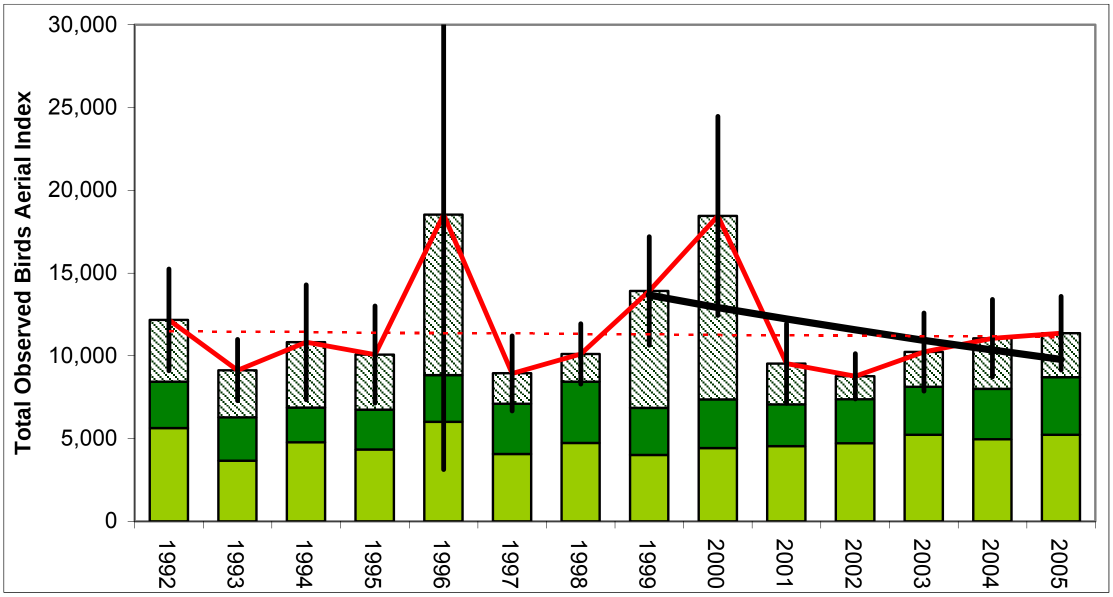
Aerial index: Total birds observed — S6d strata (n=11) — JAEG

year	sg	2*pr	flocks	Index	Std Err
1992	1534	366	418	**2318**	308
1993	4670	928	408	**6006**	652
1994	1425	722	0	**2146**	377
1995	6106	1244	145	**7496**	602
1996	2985	854	271	**4109**	502
1997	2318	674	0	**2991**	427
1998	1783	1020	160	**2964**	401
1999	3307	1248	181	**4736**	394
2000	3730	1128	245	**5103**	452
2001	3640	996	294	**4930**	629
2002	1630	540	0	**2170**	209
2003	2054	770	0	**2824**	294
2004	1833	656	0	**2489**	228
2005	2114	386	0	**2500**	293

n yrs =	14
mean =	**3770**
std dev =	1659
ln linear slope =	-0.0262
SE slope =	0.0274
Growth Rate =	**0.974**
low 90%ci GR =	0.931
high 90%ci GR =	1.019
regression resid CV =	0.414
avg sampling err CV =	0.115
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	22.1
w/ sample error CV =	9.4
most recent 7 years :	
Growth Rate =	**0.870**
low 90%ci GR =	0.807
high 90%ci GR =	0.937

Figure 13. Population trend for jaeger species (*Stercorarius parasiticus*, *S. pomarinus*, *S. longicaudus*) observed on aerial survey transects sampling 30,755 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 11 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.

Glaucous Gull North Slope early-June survey



Aerial index: Total birds observed S6d strata (n=11)

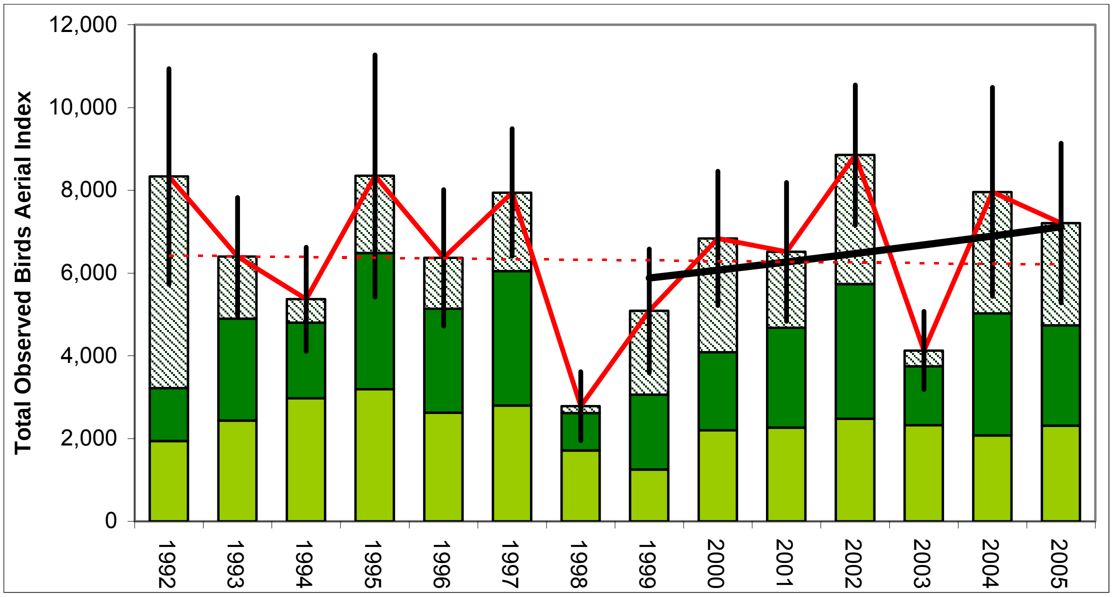
year	sg	2*pr	flocks	Index	Std Err
1992	5635	2792	3732	**12160**	1571
1993	3667	2616	2850	**9134**	940
1994	4766	2108	3945	**10818**	1771
1995	4342	2406	3331	**10080**	1496
1996	6002	2828	9699	**18529**	7859
1997	4060	3050	1825	**8934**	1154
1998	4728	3704	1672	**10104**	930
1999	4001	2844	7078	**13923**	1673
2000	4423	2936	11084	**18445**	3068
2001	4538	2524	2456	**9519**	1227
2002	4718	2658	1385	**8762**	694
2003	5221	2904	2105	**10229**	1204
2004	4957	3042	3065	**11063**	1192
2005	5223	3488	2660	**11371**	1135

GLGU

n yrs =	14
mean =	**11648**
std dev =	3205
ln linear slope =	-0.0024
SE slope =	0.0167
Growth Rate =	**0.998**
low 90%ci GR =	0.971
high 90%ci GR =	1.025
regression resid CV =	0.252
avg sampling err CV =	0.144
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	15.9
w/ sample error CV =	10.9
most recent 7 years :	
Growth Rate =	**0.946**
low 90%ci GR =	0.877
high 90%ci GR =	1.020

Figure 14. Population trend for Glaucous Gulls (*Larus hyperboreus*) observed on aerial survey transects sampling 30,755 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 11 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.

Sabine's Gull North Slope early-June survey



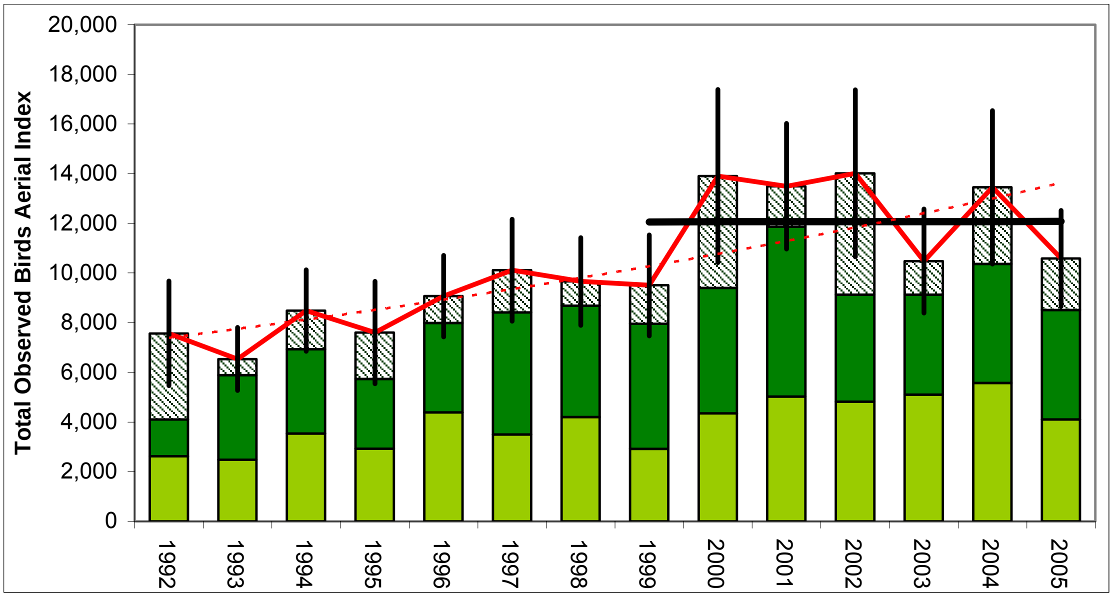
Aerial index: Total birds observed S6d strata (n=11)

year	sg	2*pr	flocks	Index	Std Err
1992	1939	1284	5111	**8333**	1329
1993	2431	2462	1505	**6399**	729
1994	2976	1824	567	**5367**	640
1995	3191	3290	1866	**8348**	1493
1996	2621	2516	1232	**6369**	839
1997	2801	3248	1896	**7945**	787
1998	1711	906	166	**2784**	423
1999	1250	1808	2026	**5084**	762
2000	2201	1890	2746	**6836**	828
2001	2268	2406	1837	**6511**	856
2002	2480	3256	3116	**8851**	864
2003	2325	1420	380	**4127**	482
2004	2073	2952	2933	**7959**	1288
2005	2307	2432	2465	**7205**	985

	SAGU
n yrs =	14
mean =	**6580**
std dev =	1750
ln linear slope =	-0.0026
SE slope =	0.0220
Growth Rate =	**0.997**
low 90%ci GR =	0.962
high 90%ci GR =	1.034
regression resid CV =	0.332
avg sampling err CV =	0.134
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	19.1
w/ sample error CV =	10.4
most recent 7 years :	
Growth Rate =	**1.032**
low 90%ci GR =	0.947
high 90%ci GR =	1.126

Figure 15. Population trend for Sabine's Gulls (*Xema sabini*) observed on aerial survey transects sampling 30,755 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 11 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.

Arctic Tern North Slope early-June survey

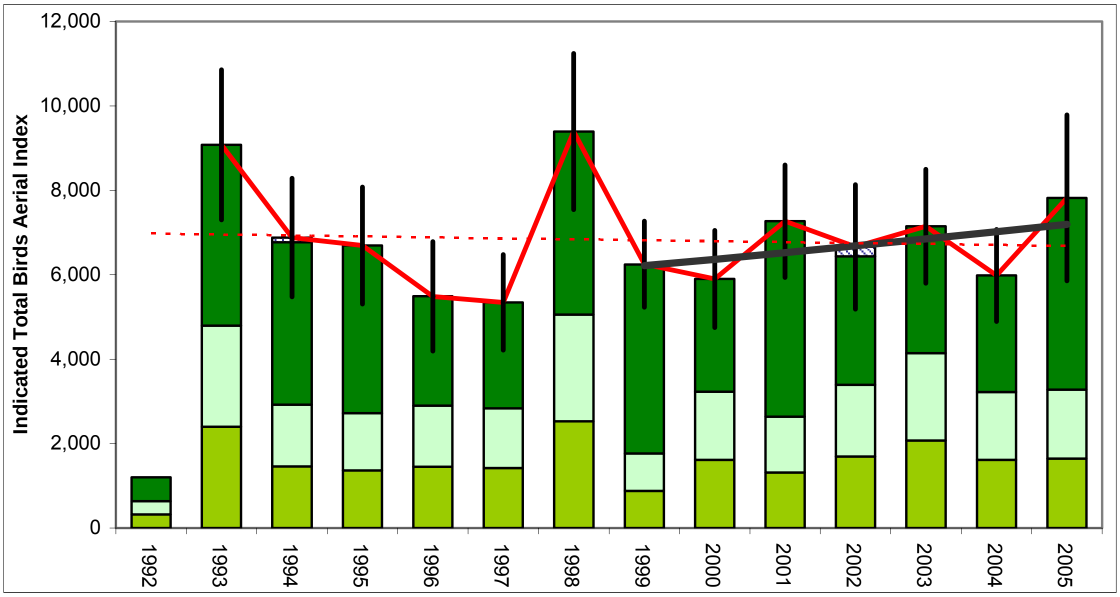


Aerial index: Total birds observed — S6d strata (n=11) — ARTE

year	sg	2*pr	flocks	Index	Std Err
1992	2621	1478	3472	**7571**	1077
1993	2473	3412	652	**6537**	646
1994	3530	3404	1551	**8486**	836
1995	2932	2802	1863	**7597**	1053
1996	4380	3608	1080	**9068**	836
1997	3500	4918	1694	**10112**	1047
1998	4206	4480	978	**9663**	901
1999	2911	5038	1554	**9503**	1040
2000	4347	5056	4503	**13907**	1778
2001	5024	6836	1634	**13495**	1292
2002	4819	4314	4882	**14014**	1717
2003	5097	4040	1347	**10484**	1069
2004	5573	4794	3082	**13449**	1577
2005	4109	4408	2072	**10589**	988

n yrs =	14
mean =	**10320**
std dev =	2509
ln linear slope =	0.0471
SE slope =	0.0101
Growth Rate =	**1.048**
low 90%ci GR =	1.031
high 90%ci GR =	1.066
regression resid CV =	0.152
avg sampling err CV =	0.110
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	11.3
w/ sample error CV =	9.1
most recent 7 years :	
Growth Rate =	**1.000**
low 90%ci GR =	0.946
high 90%ci GR =	1.058

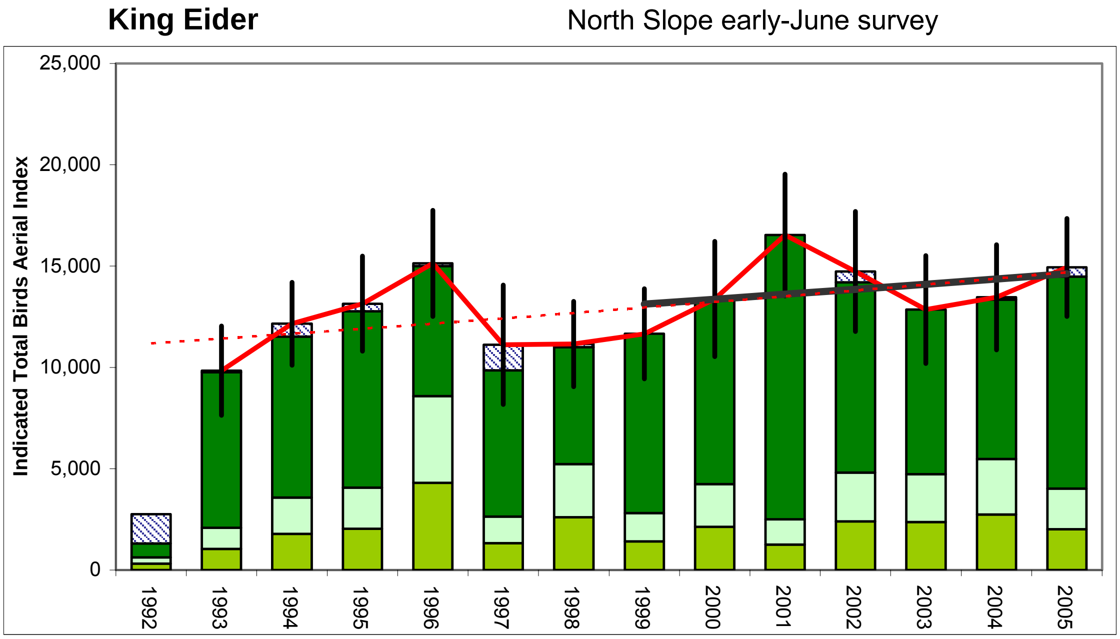
Figure 16. Population trend for Arctic Terns (*Sterna paradisaea*) observed on aerial survey transects sampling 30,755 km2 of wetland tundra on the North Slope of Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 11 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.



Aerial index: Indicated total birds				S6d strata (n=11)	
year	2*sg	2*pr	flocks	Index	Std Err
1992	638	564	0		
1993	4796	4284	0	**9079**	909
1994	2920	3848	113	**6882**	717
1995	2722	3970	0	**6693**	707
1996	2902	2588	0	**5489**	663
1997	2838	2506	0	**5345**	577
1998	5060	4332	0	**9392**	944
1999	1764	4482	0	**6247**	521
2000	3228	2672	0	**5900**	585
2001	2634	4636	0	**7270**	679
2002	3390	3048	224	**6662**	752
2003	4144	3006	0	**7149**	690
2004	3222	2762	0	**5985**	556
2005	3282	4538	0	**7820**	1002

	SPEI
n yrs =	13
mean =	**6916**
std dev =	1251
ln linear slope =	-0.0033
SE slope =	0.0134
Growth Rate =	**0.997**
low 90%ci GR =	0.975
high 90%ci GR =	1.019
regression resid CV =	0.181
avg sampling err CV =	0.104
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	12.8
w/ sample error CV =	8.8
most recent 7 years :	
Growth Rate =	**1.025**
low 90%ci GR =	0.993
high 90%ci GR =	1.058

Figure 17. Population trend for Spectacled Eider (*Somateria fischeri*) observed on aerial survey transects sampling 30,755 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 11 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 of 1,202 in 1992 was excluded from trend calculation because the survey was flown too late in June.



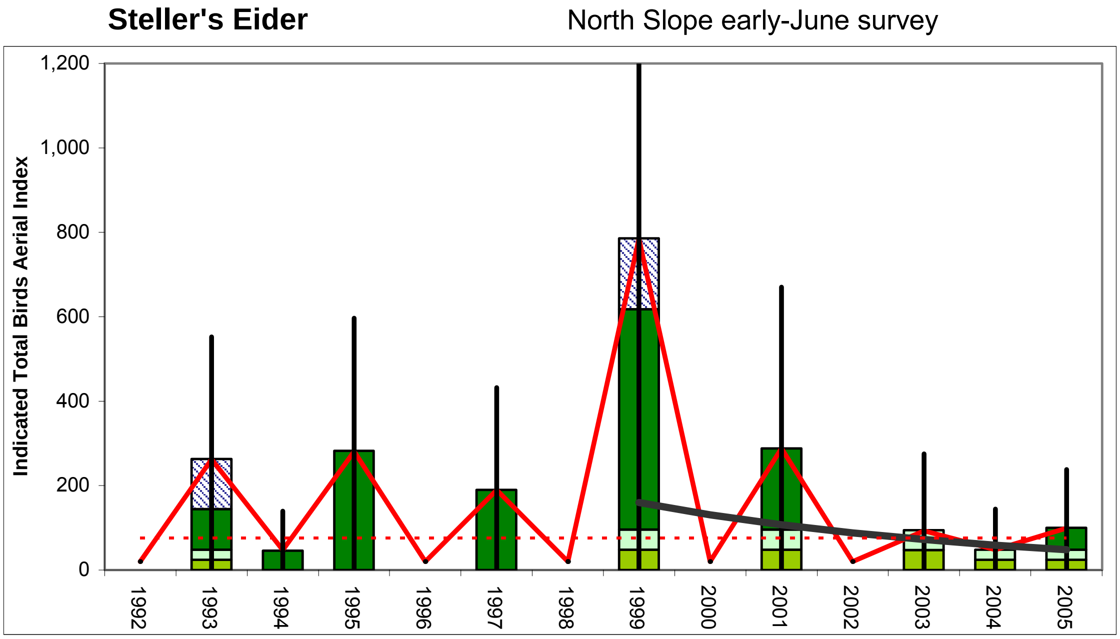
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	632	682	1440		
1993	2084	7672	77	**9832**	1125
1994	3564	7950	638	**12152**	1044
1995	4066	8704	371	**13141**	1196
1996	8590	6404	144	**15137**	1335
1997	2640	7208	1273	**11120**	1503
1998	5220	5770	167	**11156**	1074
1999	2814	8846	0	**11659**	1134
2000	4242	9136	0	**13378**	1452
2001	2502	14030	0	**16533**	1537
2002	4804	9398	527	**14730**	1512
2003	4738	8114	0	**12853**	1360
2004	5482	7872	107	**13461**	1327
2005	4014	10468	452	**14934**	1232

KIEI

n yrs =	13
mean =	**13084**
std dev =	1906
ln linear slope =	0.0210
SE slope =	0.0095
Growth Rate =	**1.021**
low 90%ci GR =	1.005
high 90%ci GR =	1.037
regression resid CV =	0.128
avg sampling err CV =	0.100
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	10.1
w/ sample error CV =	8.6
most recent 7 years :	
Growth Rate =	**1.018**
low 90%ci GR =	0.982
high 90%ci GR =	1.056

Figure 18. Population trend for King Eider (*Somateria spectabilis*) observed on aerial survey transects sampling 30,755 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 11 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 of 2,754 in 1992 was excluded from trend calculation because the survey was flown too late in June.



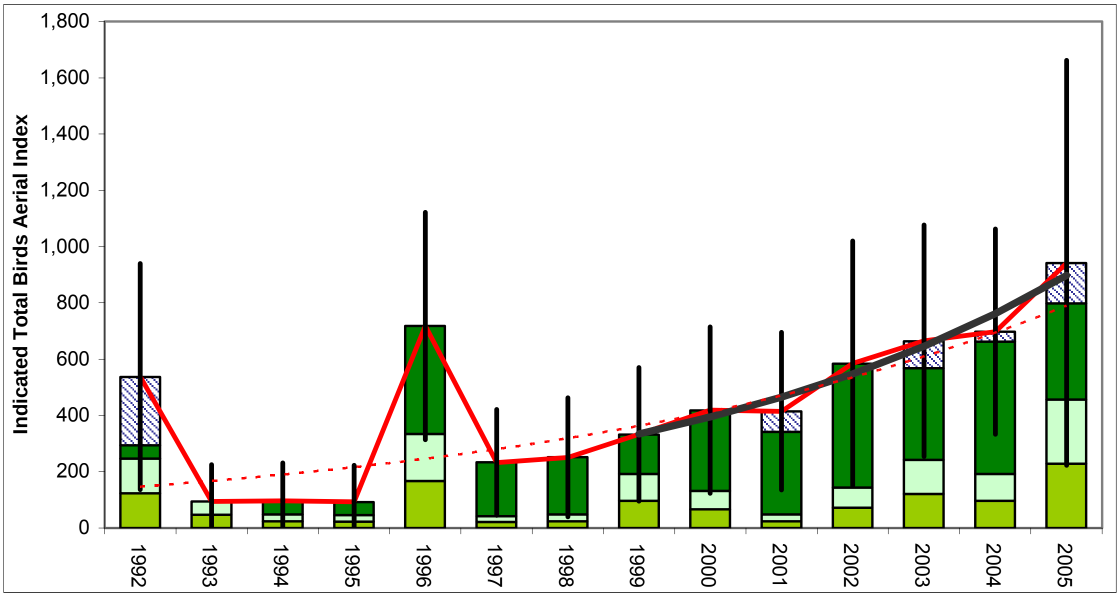
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	0	0	0	**20**	0
1993	48	96	119	**262**	148
1994	0	46	0	**47**	47
1995	0	282	0	**281**	161
1996	0	0	0	**20**	0
1997	0	190	0	**189**	124
1998	0	0	0	**20**	0
1999	96	522	168	**785**	460
2000	0	0	0	**20**	0
2001	96	192	0	**288**	195
2002	0	0	0	**20**	0
2003	94	0	0	**93**	93
2004	48	0	0	**48**	49
2005	48	52	0	**99**	71

	STEI
n yrs =	14
mean =	**157**
std dev =	208
ln linear slope =	0.0001
SE slope =	0.0872
Growth Rate =	**1.000**
low 90%ci GR =	0.866
high 90%ci GR =	1.154
regression resid CV =	1.319
avg sampling err CV =	0.485
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	47.9
w/ sample error CV =	24.6
most recent 7 years :	
Growth Rate =	**0.819**
low 90%ci GR =	0.529
high 90%ci GR =	1.267

Figure 19. Population trend for Steller's Eider (*Polysticta stelleri*) observed on aerial survey transects sampling 30,755 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 11 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.

Red-breasted Merganser North Slope early-June survey



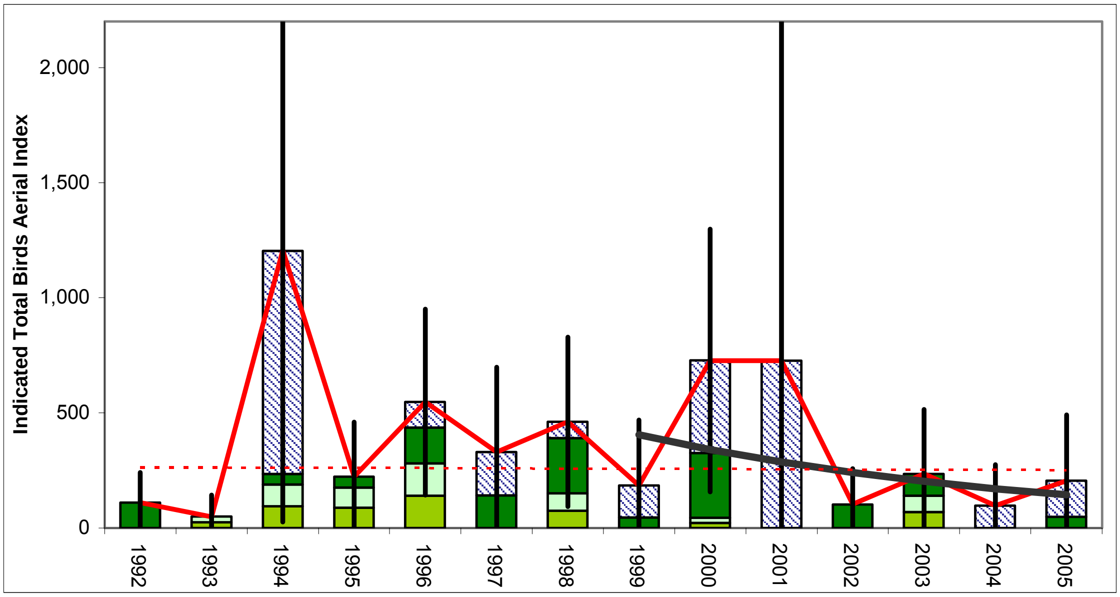
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	246	48	243	**538**	205
1993	94	0	0	**94**	67
1994	48	48	0	**96**	69
1995	46	46	0	**93**	66
1996	334	384	0	**718**	206
1997	42	192	0	**233**	96
1998	48	204	0	**251**	108
1999	192	140	0	**333**	121
2000	132	286	0	**419**	151
2001	48	294	73	**415**	143
2002	144	440	0	**585**	222
2003	242	326	95	**665**	210
2004	192	470	36	**698**	186
2005	456	342	144	**942**	367

	RBME
n yrs =	14
mean =	**434**
std dev =	267
ln linear slope =	0.1295
SE slope =	0.0406
Growth Rate =	**1.138**
low 90%ci GR =	1.065
high 90%ci GR =	1.217
regression resid CV =	0.613
avg sampling err CV =	0.434
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	28.8
w/ sample error CV =	22.8
most recent 7 years :	
Growth Rate =	**1.179**
low 90%ci GR =	1.150
high 90%ci GR =	1.209

Figure 20. Population trend for Red-breasted Megansers (*Mergus serrator*) observed on aerial survey transects sampling 30,755 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 11 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.

American Wigeon North Slope early-June survey



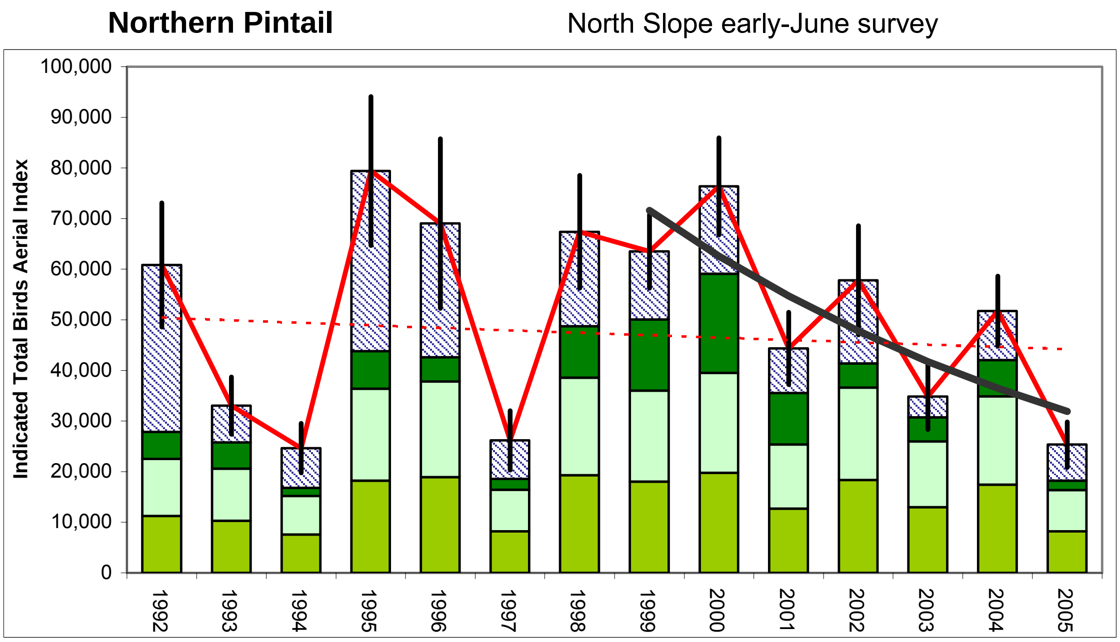
Aerial index: Indicated total birds S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	0	110	0	**110**	67
1993	50	0	0	**49**	48
1994	188	46	970	**1206**	602
1995	176	46	0	**223**	121
1996	280	156	111	**547**	206
1997	0	142	188	**330**	188
1998	150	240	71	**461**	188
1999	0	46	138	**185**	145
2000	44	282	402	**727**	291
2001	0	0	727	**727**	798
2002	0	102	0	**103**	79
2003	140	94	0	**236**	142
2004	0	0	97	**97**	91
2005	0	48	158	**205**	146

AMWI

n yrs =	14
mean =	**372**
std dev =	330
ln linear slope =	-0.0035
SE slope =	0.0634
Growth Rate =	**0.996**
low 90%ci GR =	0.898
high 90%ci GR =	1.106
regression resid CV =	0.957
avg sampling err CV =	0.663
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	38.7
w/ sample error CV =	30.3
most recent 7 years :	
Growth Rate =	**0.841**
low 90%ci GR =	0.655
high 90%ci GR =	1.081

Figure 21. Population trend for American Wigeon (*Anas americana*) observed on aerial survey transects sampling 30,755 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 11 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.

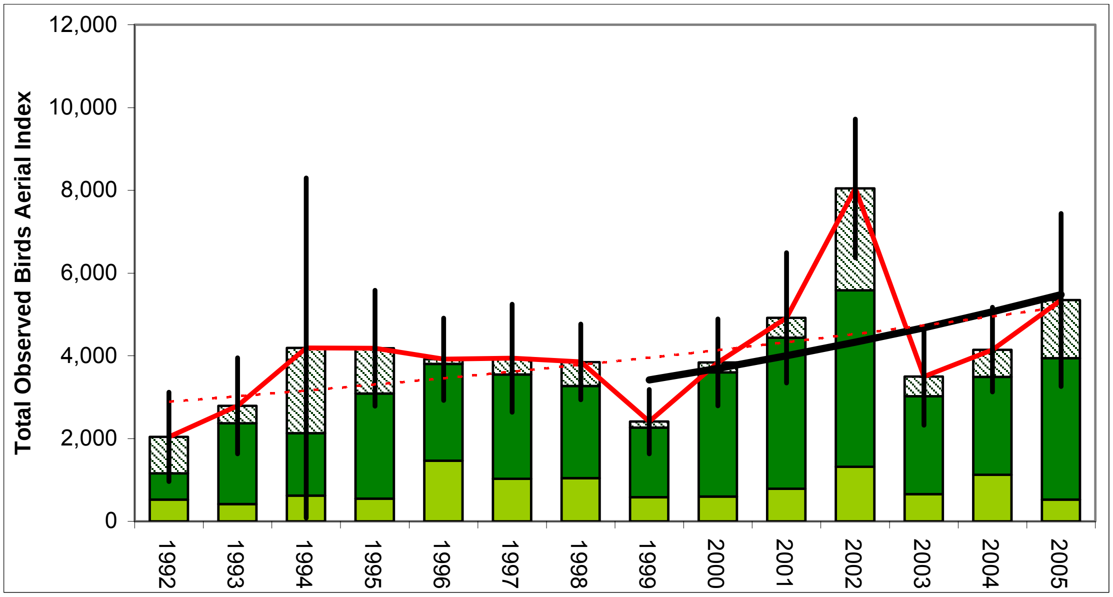


Aerial index: Indicated total birds — S6d strata (n=11) — NOPI

year	2*sg	2*pr	flocks	Index	Std Err
1992	22482	5390	32969	**60842**	6249
1993	20604	5164	7260	**33028**	2880
1994	15172	1624	7864	**24660**	2496
1995	36392	7392	35626	**79409**	7508
1996	37798	4840	26386	**69024**	8545
1997	16428	2138	7614	**26181**	2990
1998	38574	10168	18623	**67366**	5686
1999	36022	14060	13429	**63510**	3701
2000	39496	19586	17286	**76368**	4876
2001	25382	10174	8802	**44358**	3637
2002	36620	4766	16434	**57819**	5495
2003	25946	4784	4110	**34839**	3324
2004	34904	7098	9744	**51747**	3520
2005	16394	1792	7160	**25346**	2297

n yrs =	14
mean =	**51036**
std dev =	19493
ln linear slope =	-0.0101
SE slope =	0.0292
Growth Rate =	**0.990**
low 90%ci GR =	0.943
high 90%ci GR =	1.039
regression resid CV =	0.441
avg sampling err CV =	0.090
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	23.1
w/ sample error CV =	8.0
most recent 7 years :	
Growth Rate =	**0.874**
low 90%ci GR =	0.806
high 90%ci GR =	0.948

Figure 22. Population trend for Northern Pintail (*Anas acuta*) observed on aerial survey transects sampling 30,755 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 11 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.

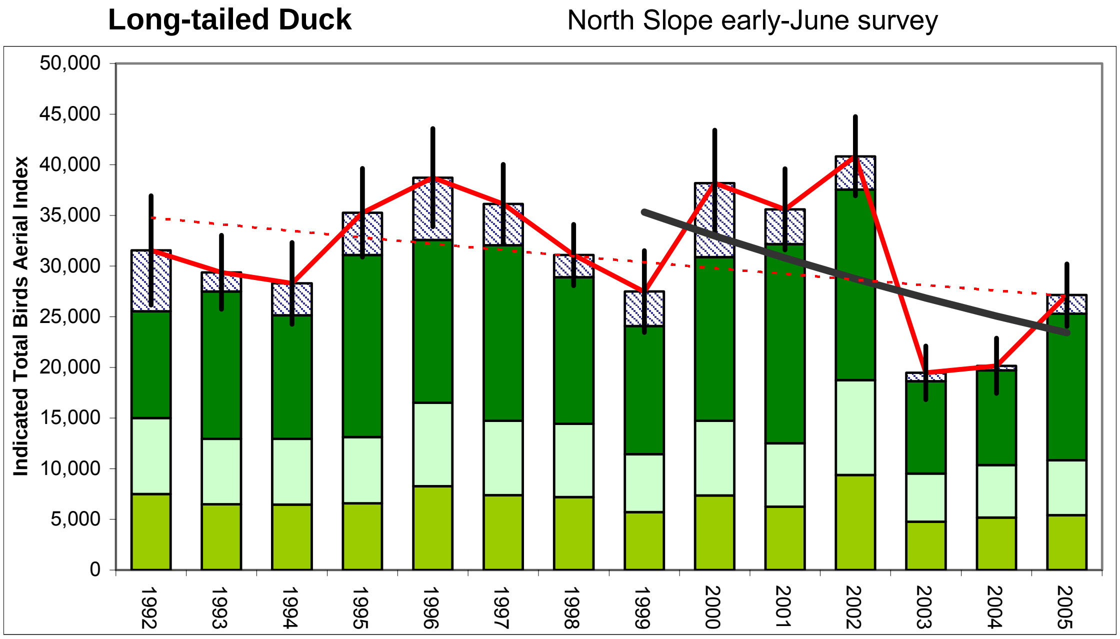


Aerial index: Total birds observed — S6d strata (n=11) — SCAU

year	sg	2*pr	flocks	Index	Std Err
1992	525	630	884	**2039**	549
1993	417	1954	420	**2791**	590
1994	617	1510	2065	**4192**	2097
1995	547	2540	1096	**4182**	713
1996	1462	2340	116	**3917**	508
1997	1029	2520	392	**3940**	665
1998	1039	2230	581	**3851**	466
1999	581	1684	144	**2410**	396
2000	601	2998	240	**3838**	535
2001	787	3652	479	**4918**	803
2002	1319	4260	2467	**8046**	855
2003	658	2368	468	**3494**	597
2004	1121	2372	655	**4149**	523
2005	524	3418	1405	**5347**	1068

n yrs =	14
mean =	**4080**
std dev =	1446
ln linear slope =	0.0449
SE slope =	0.0192
Growth Rate =	**1.046**
low 90%ci GR =	1.013
high 90%ci GR =	1.080
regression resid CV =	0.290
avg sampling err CV =	0.189
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	17.5
w/ sample error CV =	13.1
most recent 7 years :	
Growth Rate =	**1.082**
low 90%ci GR =	0.965
high 90%ci GR =	1.213

Figure 23. Population trend for Greater Scaup (*Aythya marila*) observed on aerial survey transects sampling 30,755 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 11 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.



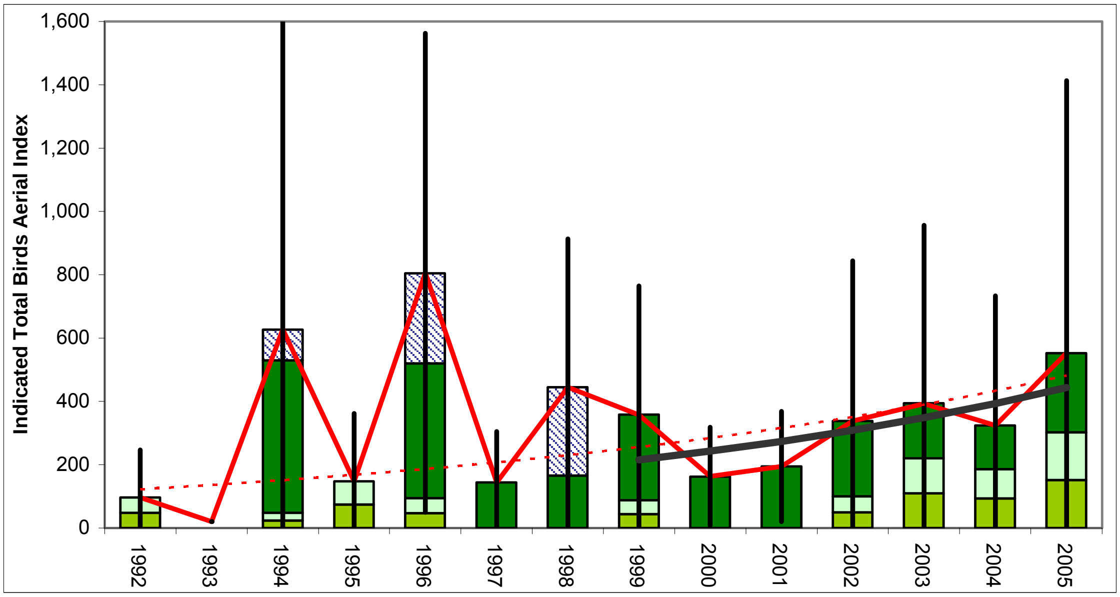
Aerial index: Indicated total birds — S6d strata (n=11) — LTDU

year	2*sg	2*pr	flocks	Index	Std Err
1992	15012	10520	6020	**31552**	2752
1993	12958	14534	1886	**29380**	1862
1994	12934	12202	3159	**28295**	2054
1995	13138	17966	4162	**35265**	2230
1996	16522	16064	6136	**38722**	2467
1997	14742	17304	4076	**36122**	1997
1998	14422	14474	2192	**31087**	1536
1999	11428	12652	3406	**27485**	2063
2000	14720	16168	7291	**38179**	2677
2001	12496	19688	3425	**35609**	2044
2002	18748	18804	3293	**40846**	1992
2003	9518	9106	850	**19473**	1349
2004	10366	9330	463	**20159**	1390
2005	10848	14456	1832	**27135**	1573

n yrs =	14
mean =	**31379**
std dev =	6562
ln linear slope =	-0.0194
SE slope =	0.0147
Growth Rate =	**0.981**
low 90%ci GR =	0.957
high 90%ci GR =	1.005
regression resid CV =	0.221
avg sampling err CV =	0.064
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	14.6
w/ sample error CV =	6.4
most recent 7 years :	
Growth Rate =	**0.934**
low 90%ci GR =	0.855
high 90%ci GR =	1.020

Figure 24. Population trend for Long-tailed Duck (*Clangula hyemalis*) observed on aerial survey transects sampling 30,755 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.

White-winged Scoter North Slope early-June survey



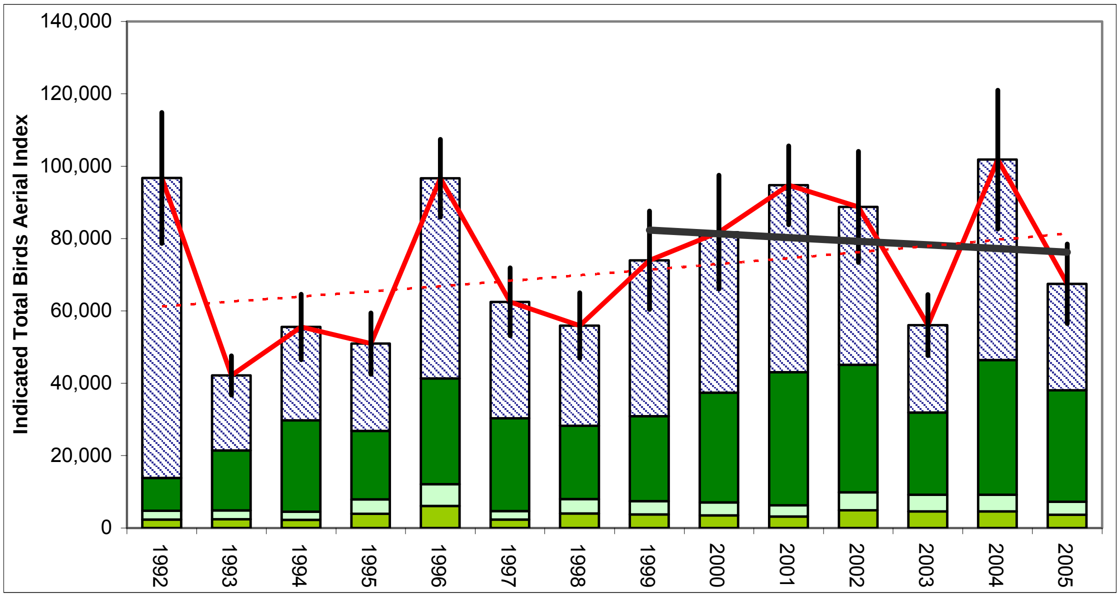
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	96	0	0	**96**	77
1993	0	0	0	**20**	0
1994	48	482	97	**628**	526
1995	148	0	0	**148**	109
1996	94	426	285	**806**	386
1997	0	144	0	**144**	82
1998	0	166	279	**445**	239
1999	88	270	0	**357**	208
2000	0	162	0	**163**	79
2001	0	194	0	**194**	89
2002	100	238	0	**338**	258
2003	220	174	0	**392**	288
2004	186	138	0	**324**	209
2005	302	250	0	**553**	439

	WWSC
n yrs =	14
mean =	**329**
std dev =	223
ln linear slope =	0.1054
SE slope =	0.0582
Growth Rate =	**1.111**
low 90%ci GR =	1.010
high 90%ci GR =	1.223
regression resid CV =	0.879
avg sampling err CV =	0.602
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	36.6
w/ sample error CV =	28.4
most recent 7 years :	
Growth Rate =	**1.129**
low 90%ci GR =	1.010
high 90%ci GR =	1.262

Figure 25. Population trend for White-winged Scoters (*Melanitta fusca*) observed on aerial survey transects sampling 30,755 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 11 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.

White-fronted Goose North Slope early-June survey



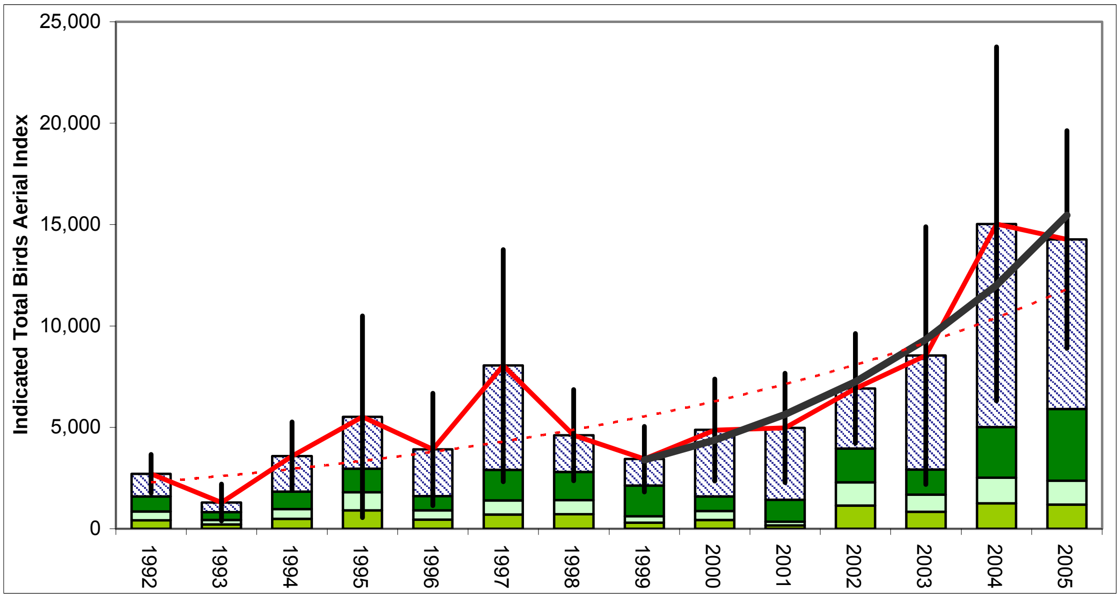
Aerial index: Indicated total birds | S6d strata (n=11) | WFGO

year	2*sg	2*pr	flocks	Index	Std Err
1992	4724	9112	82955	**96790**	9227
1993	4792	16634	20741	**42168**	2753
1994	4518	25216	25811	**55543**	4612
1995	7880	18942	24149	**50970**	4320
1996	12120	29232	55314	**96667**	5466
1997	4642	25702	32181	**62525**	4782
1998	8028	20240	27685	**55952**	4612
1999	7424	23526	43039	**73991**	6933
2000	7082	30374	44308	**81765**	8021
2001	6266	36806	51653	**94724**	5543
2002	9822	35276	43662	**88762**	7830
2003	9168	22736	24179	**56085**	4289
2004	9146	37260	55440	**101845**	9771
2005	7264	30784	29451	**67499**	5631

n yrs =	14
mean =	**73235**
std dev =	20025
ln linear slope =	0.0219
SE slope =	0.0185
Growth Rate =	**1.022**
low 90%ci GR =	0.991
high 90%ci GR =	1.054
regression resid CV =	0.280
avg sampling err CV =	0.081
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	17.1
w/ sample error CV =	7.5
most recent 7 years :	
Growth Rate =	**0.987**
low 90%ci GR =	0.920
high 90%ci GR =	1.059

Figure 26. Population trend for Greater White-fronted Geese (*Anser albifrons frontalis*) observed on aerial survey transects sampling 30,755 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 11 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.

Black Brant North Slope early-June survey

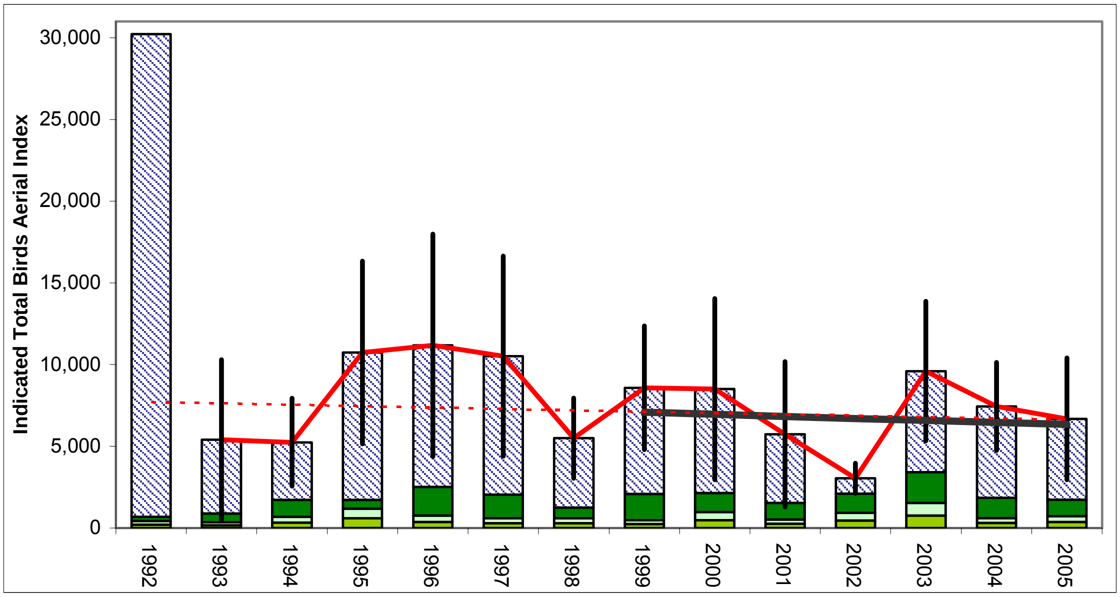


Aerial index: Indicated total birds S6d strata (n=11) BRAN

year	2*sg	2*pr	flocks	Index	Std Err
1992	848	738	1121	**2707**	484
1993	430	388	476	**1294**	463
1994	972	858	1751	**3581**	858
1995	1808	1154	2560	**5522**	2533
1996	904	710	2300	**3914**	1414
1997	1402	1494	5151	**8047**	2919
1998	1420	1384	1808	**4611**	1146
1999	610	1520	1302	**3432**	825
2000	876	718	3281	**4873**	1283
2001	338	1098	3535	**4972**	1374
2002	2296	1658	2964	**6919**	1381
2003	1676	1246	5618	**8542**	3242
2004	2508	2506	10020	**15033**	4454
2005	2372	3530	8362	**14264**	2738

n yrs =	14
mean =	**6265**
std dev =	4064
ln linear slope =	0.1261
SE slope =	0.0258
Growth Rate =	**1.134**
low 90%ci GR =	1.087
high 90%ci GR =	1.184
regression resid CV =	0.390
avg sampling err CV =	0.290
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	21.3
w/ sample error CV =	17.5
most recent 7 years :	
Growth Rate =	**1.287**
low 90%ci GR =	1.233
high 90%ci GR =	1.343

Figure 27. Population trend for Pacific Black Brant (*Branta bernicla nigricans*) observed on aerial survey transects sampling 30,755 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 11 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.



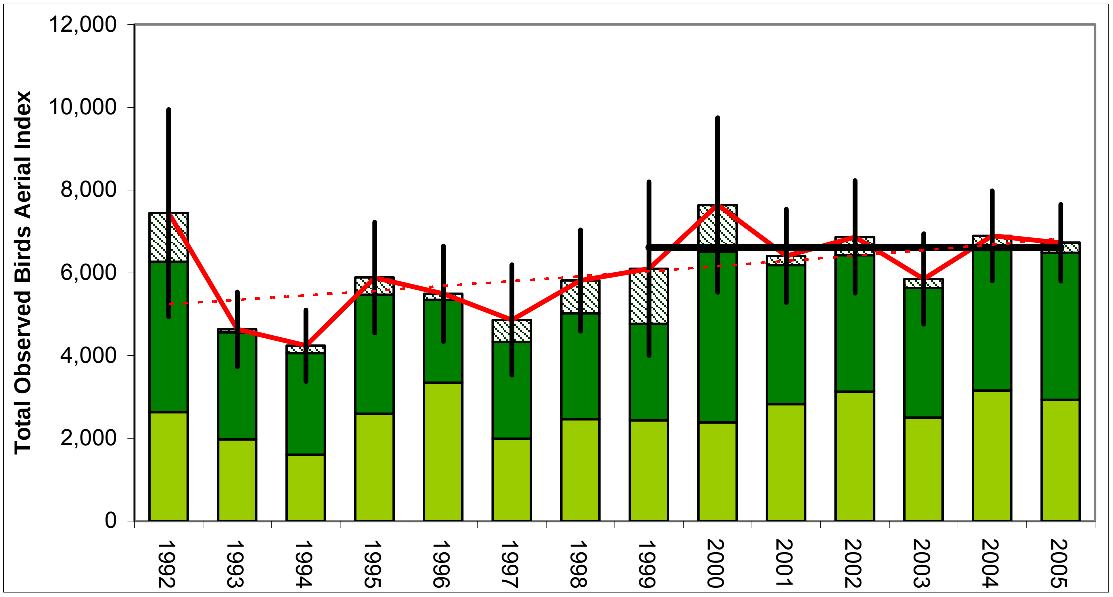
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	422	262	29537		
1993	348	540	4524	**5413**	2496
1994	674	1044	3529	**5246**	1369
1995	1186	538	9018	**10742**	2853
1996	750	1764	8670	**11183**	3473
1997	588	1464	8470	**10523**	3124
1998	592	670	4234	**5496**	1254
1999	486	1606	6488	**8581**	1928
2000	976	1158	6366	**8502**	2829
2001	520	1004	4219	**5743**	2267
2002	924	1174	945	**3045**	467
2003	1524	1896	6183	**9603**	2181
2004	610	1242	5579	**7432**	1374
2005	728	1014	4931	**6672**	1902

	CAGO
n yrs =	13
mean =	**7552**
std dev =	2531
ln linear slope =	-0.0117
SE slope =	0.0288
Growth Rate =	**0.988**
low 90%ci GR =	0.943
high 90%ci GR =	1.036
regression resid CV =	0.389
avg sampling err CV =	0.279
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	21.3
w/ sample error CV =	17.0
most recent 7 years :	
Growth Rate =	**0.982**
low 90%ci GR =	0.861
high 90%ci GR =	1.120

Figure 28. Population trend for Canada Geese (*Branta canadensis*) observed on aerial survey transects sampling 30,755 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 11 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 high index in 1992 was excluded from trend calculation because the survey was flown too late in June.

Tundra Swan North Slope early-June survey



Aerial index: Total birds observed S6d strata (n=11)

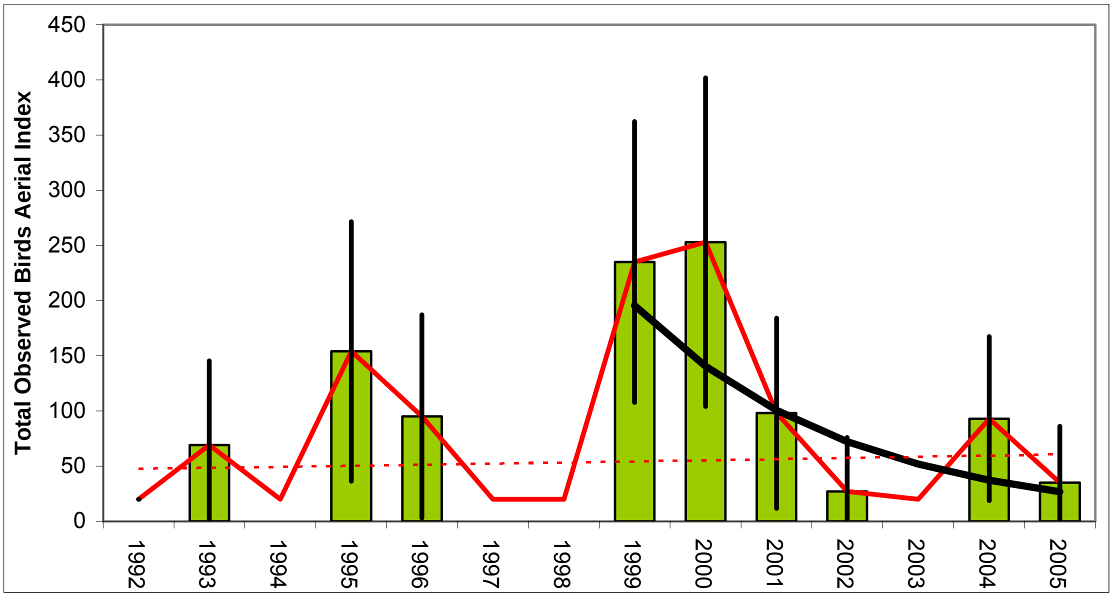
year	sg	2*pr	flocks	Index	Std Err
1992	2633	3636	1174	**7444**	1278
1993	1973	2588	73	**4633**	462
1994	1606	2452	179	**4237**	442
1995	2595	2874	415	**5883**	681
1996	3344	2006	142	**5493**	588
1997	1989	2342	526	**4858**	681
1998	2461	2562	793	**5815**	624
1999	2437	2330	1330	**6097**	1071
2000	2379	4130	1130	**7640**	1075
2001	2828	3358	220	**6406**	575
2002	3124	3300	441	**6865**	693
2003	2498	3132	221	**5852**	557
2004	3154	3394	344	**6891**	553
2005	2930	3552	247	**6728**	472

SWAN

n yrs =	14
mean =	**6060**
std dev =	1022
ln linear slope =	0.0203
SE slope =	0.0106
Growth Rate =	**1.020**
low 90%ci GR =	1.003
high 90%ci GR =	1.038
regression resid CV =	0.160
avg sampling err CV =	0.114
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	11.8
w/ sample error CV =	9.4
most recent 7 years :	
Growth Rate =	**1.000**
low 90%ci GR =	0.970
high 90%ci GR =	1.030

Figure 29. Population trend for Tundra Swans (*Cygnus columbianus*) observed on aerial survey transects sampling 30,755 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 11 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.

Short-eared Owl North Slope early-June survey



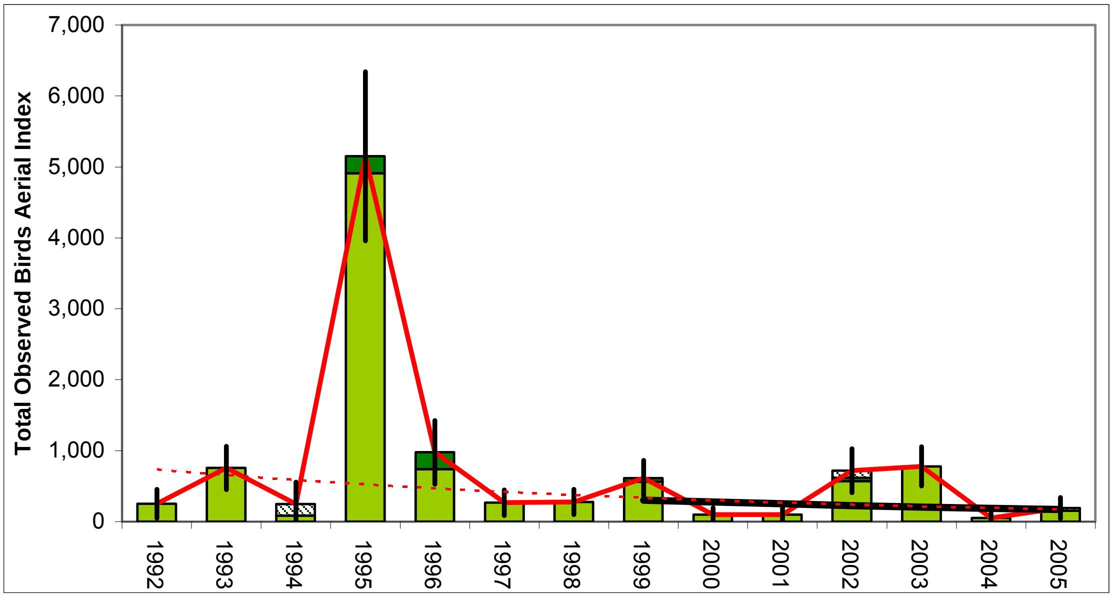
Aerial index: Total birds observed S6d strata (n=11)

year	sg	2*pr	flocks	Index	Std Err
1992	0	0	0	**20**	0
1993	69	0	0	**69**	39
1994	0	0	0	**20**	0
1995	154	0	0	**154**	60
1996	95	0	0	**95**	47
1997	0	0	0	**20**	0
1998	0	0	0	**20**	0
1999	235	0	0	**235**	65
2000	253	0	0	**253**	76
2001	98	0	0	**98**	44
2002	27	0	0	**27**	25
2003	0	0	0	**20**	0
2004	93	0	0	**93**	38
2005	35	0	0	**35**	26

	SEOW
n yrs =	14
mean =	**83**
std dev =	80
ln linear slope =	0.0189
SE slope =	0.0668
Growth Rate =	**1.019**
low 90%ci GR =	0.913
high 90%ci GR =	1.138
regression resid CV =	1.010
avg sampling err CV =	0.325
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	40.1
w/ sample error CV =	18.9
most recent 7 years :	
Growth Rate =	**0.717**
low 90%ci GR =	0.560
high 90%ci GR =	0.919

Figure 30. Population trend for Short-eared Owls (*Asio flammeus*) observed on aerial survey transects sampling 30,755 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 11 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.

Snowy Owl North Slope early-June survey

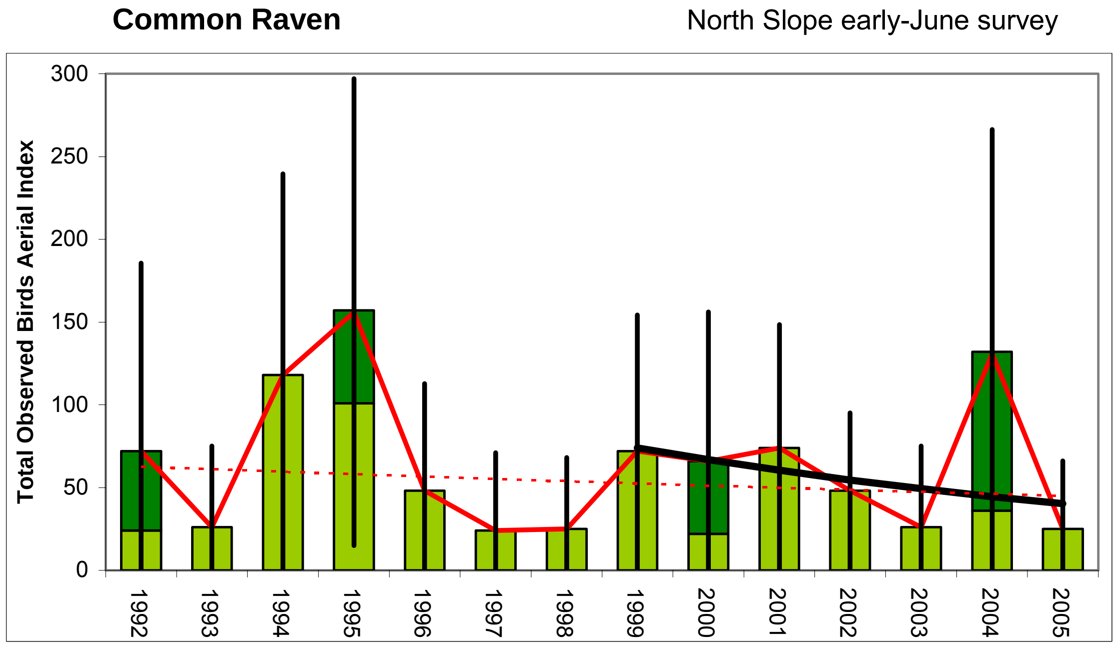


Aerial index: Total birds observed S6d strata (n=11) SNOW

year	sg	2*pr	flocks	Index	Std Err
1992	251	0	0	**251**	104
1993	756	0	0	**756**	156
1994	84	0	161	**245**	160
1995	4910	240	0	**5150**	608
1996	741	236	0	**976**	228
1997	266	0	0	**266**	92
1998	276	0	0	**276**	91
1999	561	50	0	**610**	130
2000	96	0	0	**96**	51
2001	97	0	0	**97**	51
2002	571	46	100	**718**	159
2003	776	0	0	**776**	141
2004	49	0	0	**49**	35
2005	155	0	36	**191**	76

n yrs =	14
mean =	**747**
std dev =	1302
ln linear slope =	-0.1118
SE slope =	0.0751
Growth Rate =	**0.894**
low 90%ci GR =	0.790
high 90%ci GR =	1.012
regression resid CV =	1.136
avg sampling err CV =	0.363
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	43.4
w/ sample error CV =	20.3
most recent 7 years :	
Growth Rate =	**0.906**
low 90%ci GR =	0.621
high 90%ci GR =	1.323

Figure 31. Population trend for Snowy Owls (*Bubo scandiacus*) observed on aerial survey transects sampling 30,755 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 11 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.

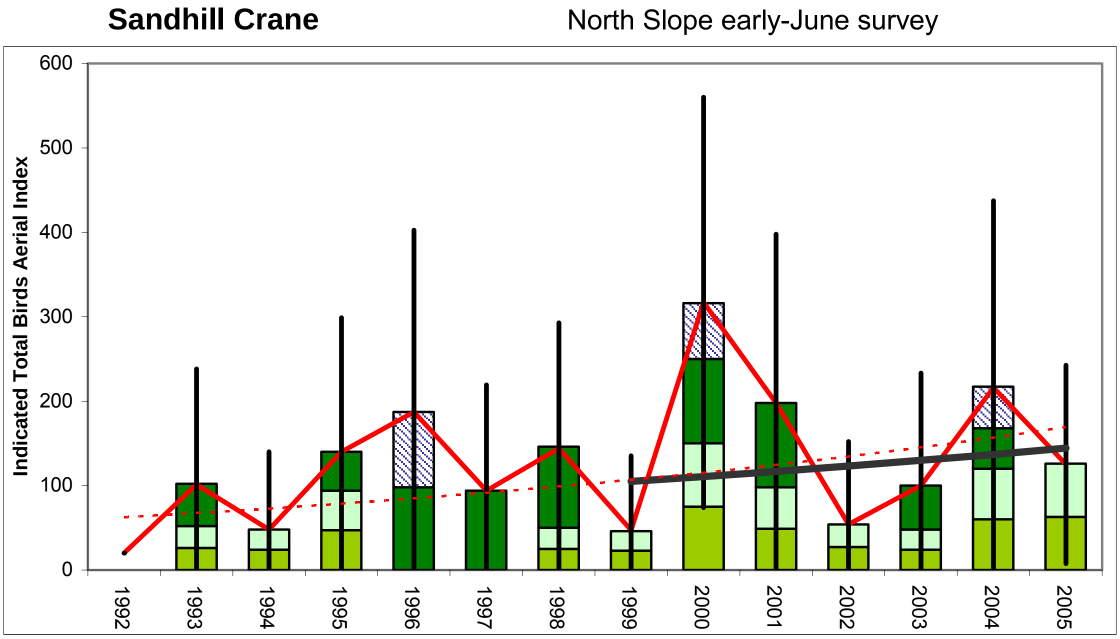


Aerial index: Total birds observed S6d strata (n=11)

year	sg	2*pr	flocks	Index	Std Err
1992	24	48	0	**72**	58
1993	26	0	0	**26**	25
1994	118	0	0	**118**	62
1995	101	56	0	**156**	72
1996	48	0	0	**48**	33
1997	24	0	0	**24**	24
1998	25	0	0	**25**	22
1999	72	0	0	**72**	42
2000	22	44	0	**66**	46
2001	74	0	0	**74**	38
2002	48	0	0	**48**	24
2003	26	0	0	**26**	25
2004	36	96	0	**131**	69
2005	25	0	0	**25**	21

	CORA
n yrs =	14
mean =	**65**
std dev =	43
ln linear slope =	-0.0254
SE slope =	0.0454
Growth Rate =	**0.975**
low 90%ci GR =	0.905
high 90%ci GR =	1.050
regression resid CV =	0.685
avg sampling err CV =	0.710
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	31.0
w/ sample error CV =	31.7
most recent 7 years :	
Growth Rate =	**0.903**
low 90%ci GR =	0.747
high 90%ci GR =	1.092

Figure 32. Population trend for Common Ravens *(Corvus corax)* observed on aerial survey transects sampling 30,755 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 11 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.



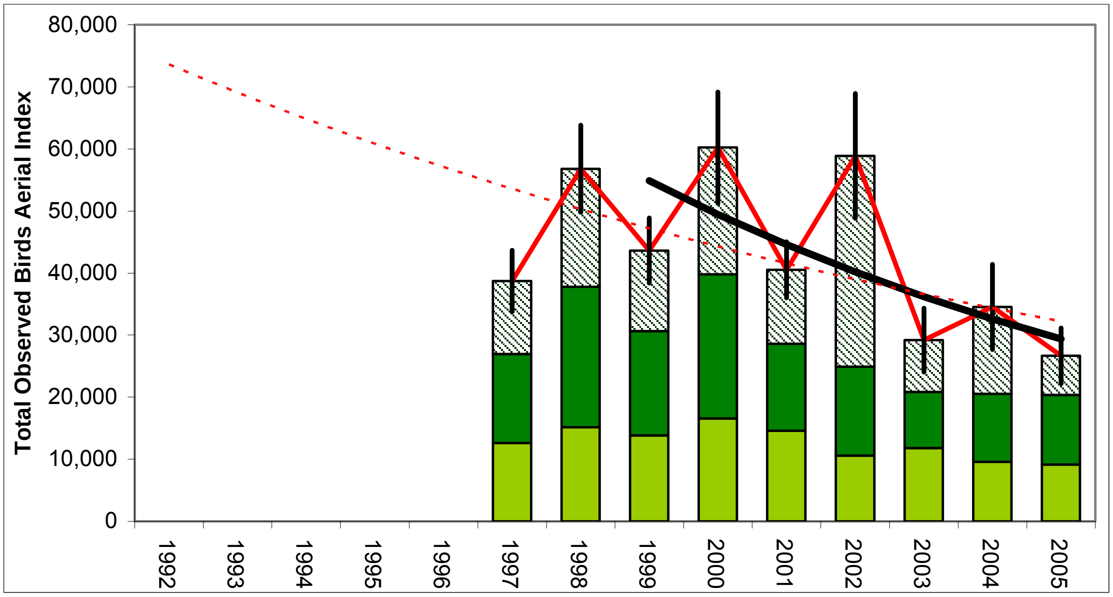
Aerial index: Indicated total birds — S6d strata (n=11)

year	2*sg	2*pr	flocks	Index	Std Err
1992	0	0	0	**20**	0
1993	52	50	0	**101**	70
1994	48	0	0	**48**	47
1995	94	46	0	**140**	81
1996	0	98	89	**187**	110
1997	0	94	0	**94**	64
1998	50	96	0	**144**	76
1999	46	0	0	**47**	45
2000	150	100	66	**317**	124
2001	98	100	0	**198**	102
2002	54	0	0	**54**	50
2003	48	52	0	**100**	68
2004	120	48	49	**216**	113
2005	126	0	0	**125**	60

	SACR
n yrs =	14
mean =	**128**
std dev =	81
ln linear slope =	0.0768
SE slope =	0.0461
Growth Rate =	**1.080**
low 90%ci GR =	1.001
high 90%ci GR =	1.165
regression resid CV =	0.696
avg sampling err CV =	0.609
min yrs to detect -50%/20yr rate :	
w/ regression resid CV =	31.3
w/ sample error CV =	28.6
most recent 7 years :	
Growth Rate =	**1.054**
low 90%ci GR =	0.829
high 90%ci GR =	1.342

Figure 33. Population trend for Sandhill Cranes (*Grus canadensis*) observed on aerial survey transects sampling 30,755 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 11 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.

small shorebird spp North Slope early-June survey



Aerial index: Total birds observed S6d strata (n=11)

year	sg	2*pr	flocks	Index	Std Err
1992					
1993					
1994					
1995					
1996					
1997	12642	14292	11771	**38705**	2524
1998	15166	22638	18990	**56794**	3578
1999	13822	16840	12950	**43612**	2681
2000	16565	23238	20411	**60213**	4568
2001	14565	14024	11935	**40523**	2301
2002	10568	14330	33989	**58887**	5129
2003	11804	9032	8372	**29209**	2623
2004	9560	10990	13975	**34524**	3499
2005	9142	11230	6280	**26653**	2277

	USSB
n yrs =	9
mean =	**43236**
std dev =	12712
ln linear slope =	-0.0635
SE slope =	0.0338
Growth Rate =	**0.938**
low 90%ci GR =	0.888
high 90%ci GR =	0.992
regression resid CV =	0.262
avg sampling err CV =	0.076
<u>min yrs to detect -50%/20yr rate :</u>	
w/ regression resid CV =	16.3
w/ sample error CV =	7.2
<u>most recent 7 years :</u>	
Growth Rate =	**0.901**
low 90%ci GR =	0.834
high 90%ci GR =	0.973

Figure 34. Population trend for small shorebid species (*Caladris* spp.) observed on aerial survey transects sampling 30,755 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 11 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.