# EIDER BREEDING POPULATION SURVEY ARCTIC COASTAL PLAIN, ALASKA 2006

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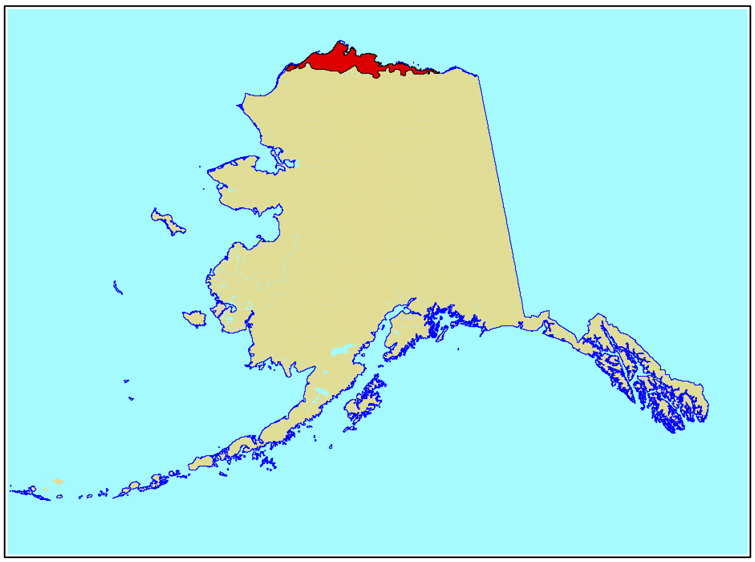

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**Abstract.** The North Slope Eider Survey has been conducted for 15 consecutive years, 1992 to 2006. Primary survey objectives include monitoring abundance, trends and distribution of spectacled eiders on the Arctic Coastal Plain of Alaska in accordance with recovery tasks B1.1 and B1.4 of the Spectacled Eider Recovery Plan (U. S. Fish and Wildlife Service 1996). Secondary objectives include providing similar information for other waterbirds breeding on the Coastal Plain. Survey techniques have remained constant, except for minor technological improvements in electronic data logging and transcribing. The survey pilot/port side observer was the same person for all years, while six 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 reduced the variance of some estimates and facilitated area-wise comparisons. Spring arrived slightly early on the Arctic Coastal Plain in 2006. We completed the survey from 10 to 16 June, with 1 day lost due to fog. Sampling intensity was doubled within three strata in the Teshekpuk Lake region, for the third consecutive year, per request and funding by the Bureau of Land Management. The 2006 population index for spectacled eiders is 6,731 (SE 786), and the average annual growth rate (0.997, n=14 yrs) is not significantly different from 1.0 ($\alpha$=0.10). The king eider index is 12,896 (SE 1,209), with an average annual growth rate of 1.017, which is significantly >1.0 ($\alpha$=0.10). Spatial 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, greater white-fronted goose, black brant, and tundra swan, while a significant negative rate is noted for red-throated loon and shorebirds. Long-term growth rates for other species have not indicated a significant departure from 1.0. However, breeding populations of northern pintails and long-tailed ducks warrant careful monitoring due to short-term downward trends consistent with other independent Alaskan indices. The survey will continue in 2007, modified to incorporate objectives of the "standard" waterfowl breeding population survey of the Alaska Arctic Coastal Plain.

**Key Words:** aerial, survey, Alaska, arctic, waterfowl, breeding, population, *Somateria fischeri*, spectacled eider, *Somateria spectabilis*, king eider,

## 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 2006 eider breeding population survey, and summaries for 1992-2006.

## 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.

Specific objectives:

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

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

3. Develop and implement a detection rate 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, Alaska*

Starboard observer: **David Fronczak,** *Migratory Bird Management, Columbia, Missouri*

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 transects flown in 2006 were duplicates of those flown in 2002. 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 also 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 among 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)). Survey transects flown in 2006 are depicted in Fig. 2. On request from, and using funds provided by, the Bureau of Land Management, we added survey lines midway between the planned transects for strata 9, 15, and 16 (Fig. 1, 2), which doubled the sampling intensity in those areas. The objective was to improve the density estimates and provide more distributional detail within the current focal area for oil and gas leasing. Flight hours required to complete the survey in 2006 totaled 34.7 hours 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 David Fronczak (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"19km@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 viewing angle was determined trigonometrically and strut markers were placed using a clinometer. We actively minimized observations in the "unknown eider" category by leaving the transect centerline when necessary to confirm identification of eiders. Additional birds seen on these departures were not included in the data set, and such deviations typically occur <10 times per annual survey.

<u>Data recording and transcription</u>
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 of which contained a species code, group size, geographic coordinates, date, time, observer code, observer position in aircraft, stratum and transect identifier. Additionally, the system created a track file which is a list of geographic 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 observation data files may be used to produce map, tabular and other products describing population trends and distribution of the various taxa surveyed.

<u>Data Analysis and survey timing</u>
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.

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 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. Indices are typically subject to biases associated with data collection. Bias in this survey comes primarily from three sources: *sampling error* due to the nonrandom spatial distribution of birds within the sampled area, *timing* of the survey relative to bird breeding phenology, and variations in *detection* of birds within 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, when they move offshore for the postnuptial molt (Kistchinski and Flint 1974, Lamothe in Johnson and Herter 1989, for spectacled and king eider, respectively). Variations in timing of arrival and departure between individual spectacled eider males on a study area in the Prudhoe Bay vicinity suggest that there may be few, if any, days when all breeding males are present in the survey area at the same time, especially in years of early spring melt (Troy 1997). Median nest initiation dates for Spectacled eiders at Prudhoe Bay from 1993 to 1996 varied from 7 to 16 June (average 1982-96 = 15 June), and telemetry data suggest that male departure begins within about 3 days of that date, and is more synchronized in the years when it commences later (Troy 1997). Most males depart the tundra for offshore molting areas by 20 to 25 June. Comparable data are not available from other parts of the Arctic Slope, but our aerial observations from this survey since 1992 suggest consistency within about 1 week among areas and years. 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, and timing of spring migration would likely vary somewhat among wintering populations (Lynn Dickson, Canadian Wildlife Service, pers. comm.). 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. We initiated the survey when most eider pairs appeared to be occupying breeding territories, rather than in mixed-sex/species flocks. Our observations from past years on this survey suggest this behavior normally occurs as soon as there is extensive open water in most shallow vegetated wetlands and tundra vegetation is mostly snow-free around pond margins.

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 easier to interpret for most dabbling ducks, which often remain on the breeding grounds after nest initiation to molt in local wetlands, while eider males normally depart the breeding grounds for distant marine molting habitats immediately after nest initiation, rendering them unavailable for observation. Hence, it is expected that the ratio will reach a peak at or slightly beyond the peak of nest initiation, followed by an abrupt drop as males depart the survey area while females are still visible especially during recesses from laying and incubation. This pattern has been observed in the Prudhoe Bay area (Warnock and Troy 1992). Above-noted shortcomings notwithstanding, we consider the average lone drake ratio for the survey period and a plot of daily totals of this ratio helpful when considered in concert 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 97.4km$^2$ irregular polygon plot located within the high density spectacled and king eider habitat about 10km 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, and completed only one replicate in 2006 (10 June). 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. 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 detection study covering a 270km$^2$ subset of our operational transects. The results of this study were not satisfactory in that our fixed-wing count often exceeded the helicopter count, suggesting a serious flaw in design or implementation. Therefore we default to 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

The survey was flown during the period 10-16 June, with all planned transects completed (Table 1). The crew was grounded in Barrow all day on 15 June due to fog.

Habitat conditions and survey timing

Spring breakup at our 9 June arrival in Deadhorse appeared slightly ahead of normal, based on our reconnaissance flight in the area between the Colville River and Deadhorse. Most of the snow was gone from the tundra, shallow wetlands were substantially thawed, and most large deeper lakes had at least narrow thawed margins. Other investigators working in the central arctic coastal plain area concurred with this assessment (B. Anderson, ABR, pers. comm.). Some species (e.g. greater white-fronted geese) in the Colville River Delta area were seen nesting earlier than normal (R. Johnson, ABR, pers. comm.). We found similar conditions during our first survey flight to the southwestern portion of the survey area near Atqasuk on 10 June, and waterfowl and loon distributions seemed normal for appropriate survey initiation. All portions of the arctic slope seemed normal for birds and habitat conditions, except that water levels between Wainwright and Atqasuk were a little higher than usual for this time period.

The overall ratio of lone males to total males during the survey, a rough measure of survey timing in relation to nest initiation, was average for both king and spectacled eiders (Table 2), which is consistent with our impression of a well-timed survey. The daily trend in this measure showed a gentle upward slope in the mid-range for both eider species (Figure 3), suggesting a relatively protracted period of male presence, consistent with an appropriately-timed survey. If the early days of the survey had shown few or no lone males (ratio close to 0.0), or if there was a high ratio during the survey followed by an abrupt drop, we would have suspected the survey was timed too early (some males not arrived yet) or too late (large numbers of males had departed for the postnuptial molt), respectively. The graphs for pintails and long-tailed ducks appear consistent with a well-timed survey (Fig. 3).

Population estimates and breeding distribution for selected species

Table 3 presents totals for sample data (singles, pairs and flocked birds in the sample), as well as indices calculated from these data, for 2006. 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 4-25 include stacked bar graphs, tables and maps describing the size, composition, and spatial distribution of eiders and other waterbirds included in the survey. We report 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 14-15 years of data (depending on species) and for the most recent 7 years. Annual indices and other values are shown for singles, pairs, birds in flocks, and total indicated birds. Please note that only bias resulting from spatial sampling error is accounted for in these calculations, as other sources (e.g. observer effect, survey timing) are unmeasured in this survey. This year rather than producing maps depicting the current year's observations we include maps comparing polygons of average breeding densities calculated from two time periods: 1993-1999 and 2000-2006, for selected species. Annual data sets used in construction of these maps did not include observations from the additional transects in the Teshekpuk Lake area funded by BLM. Following are comments by species.

**Loons**

The Yellow-billed loon index was unchanged from 2005, and slightly above the long-term mean, continuing its erratic pattern and slight, non-significant upward trend (Fig.4). Distribution was similar among the two time periods, but seems to have increased in the most recent period in an area immediately southeast of Teshekpuk Lake (Fig. 5). The Pacific loon index (Fig. 6) was slightly below average. The long-term trend is level, but that of the most recent 7 years is significantly downward at 0.964 (0.944-0.984). The Pacific loon distribution is similar among the two time periods (Fig. 7). The 2005 red-throated loon index was the lowest on record, remaining well below average, with a significantly negative long-term growth rate of 0.934 (0.905-0.965), and a growth rate of 0.902 (0.854-0.953) for the most recent 7 years (Fig. 8). Distribution of the densest breeding concentrations of red throated loons appears to have changed among early and late time periods, as the population declined (Fig. 9).

**Jaegers**

Jaeger species are combined for this survey to help prevent distraction of observer focus from eiders and other higher priority species. The jaeger index fluctuates widely following prey abundance (primarily North American brown lemming, *Lemmus trimucronatus*). Lemming populations spiked this year across much of the arctic coastal plain, and Jaegers responded with the highest index (9,412, Fig. 10) since the survey's inception in 1992. Our subjective impression from aerial and ground observations suggested that pomerine jaegers contributed most of this increase. The extremely variable annual index does not indicate a significant trend in either short or long term (Fig. 10).

**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. 11). This year saw the highest index yet for combined singles and pairs for this survey. Distribution is fairly similar among time periods, but apparent differences may be partly artifacts of the clumped distribution of colonies, and the opportunistic behavior of scavengers/predators (Fig. 12). Sabine's gull annual indices have been erratic, though level in the long term (Fig. 13). The trend for the Arctic tern index increased steadily through 2000, but has declined significantly over the most recent 7 years (Fig. 14). The 2006 index (10,350) is very close to the long-term average (Fig. 14). The relative distribution appears similar among the two time periods, but increased densities in most of the dense breeding concentrations suggest expansion in place over time (Fig. 15).

**Eiders**

The spectacled eider index of 6,731 is below both last year's index of 7,821 and the long-term average of 6,903 (Fig. 16). The 14-year trend remains essentially level, but that of the last 7 years shows a slight insignificant increase (growth rate 1.016, Fig. 16). The gross distribution patterns of the two time periods appear similar, but note the apparent increase in density in the Teshekpuk Lake to Cape Halkett area (Fig. 17). The King eider index of 12,896 is below the long-term average (13,070), and is below the barely-significant positive trend line (growth rate 1.017, Fig. 18). The distribution depicted in Fig. 19 is similar between the two time periods, but increased densities are evident in the more recent period, especially in the core breeding area southeast of Teshekpuk Lake. The difference in distributions between spectacled and king eider distributions is striking, particularly in the central portion of the survey area. 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 2006). There are so few Steller's eiders detected during this survey that it is of little value for detecting a useful trend. This year was a "breeding year" in the Barrow area, with several nests and broods observed by ground observers (N. Rojek, USFWS, pers. comm.., R. Richie, ABR, pers. comm.), and our index of 300 was above the long-term mean of 166 (Fig. 20). We observed 4 single males and 3 pairs in our sample this year (Table 3).

**Other ducks**

Other duck species that occur on the Arctic Coastal Plain in significant numbers are red-breasted merganser, northern pintail, greater scaup, and long-tailed duck. The 2006 red-breasted merganser index is well below that of 2005 (518, 942 respectively), but the long term trend has a significant positive slope (growth rate 1.123, Fig. 21). Mergansers are widely scattered in the central coastal plain, mostly well inland from the coast. Though relatively abundant on the Arctic Coastal Plain, pintail production is low, and the area is thought to be most important for molting males from other parts of the breeding range and as a reservoir for drought-displaced prairie birds (Derksen and Eldridge 1980). Though this survey is timed early relative to breakup and nesting cover availability, we normally record a low percentage of paired pintails (Fig. 23), which is consistent with the molting area hypothesis. Our 2006 index (29,153) was the second of two consecutive years that were well below the long-term average of 49,577, though the 0.980 population growth rate is not significantly less than 1.0 at p=0.10 (Fig. 23). The distribution of pintail concentrations is very similar among the two time periods, though densities appear to be lower in the most recent period, especially in the area north and east of Teshekpuk Lake (Fig. 24). The 2006 greater scaup index (6,739) was the second highest for the 15 years since the survey began, and well above the mean and the significantly positive trend line (growth rate 1.052, Fig. 25). Note that flocked birds made up an unusually high proportion of the total observed scaup during the three years (2002, 2005, 2006) with the highest population indices, suggesting an early influx of molting birds, possibly failed breeders (Fig. 25). While the gross distribution pattern for scaup is similar between the two time periods, it appears that breeding densities have increased substantially in the central portion of the arctic slope, especially in the Fish Creek and Colville River drainages (Fig. 26). The 2006 long-tailed duck index (27,418) is unchanged from 2005, slightly below the 15-year average (31,115), and lies on the insignificantly negative trend line (growth rate 0.982, Fig. 27). This trend agrees closely with that derived from data from the late June Arctic Coastal Plain standard breeding population survey (Mallek et al. 2005), so we recommend close monitoring of the status of this species. The distribution of this species appears relatively consistent since 1993 (Fig. 28).

Mallard, American wigeon (Fig. 22), Am. Green-winged teal, shoveler, and black scoter occur at very low densities on the arctic coastal plain (Table 4), hence the Arctic Coastal Plain of Alaska is not considered important for continental or flyway populations of these species at this time. Most observations of White-winged scoters across all years have been recorded in the southern portion of stratum 8, southeast of Teshekpuk Lake (Fig. 1). Though erratic in the early years of the survey, white-winged scoter indices indicate a positive growth rate, which is significant in both 7 and 15-year time scales (Fig. 29).

**Geese and swans**

The 2006 greater white-fronted goose index (111,468) is the highest so far recorded during this survey, and 47 percent above the long-term mean. The "pairs" component comprises most of the increase this year (Fig. 30). The average growth rate for this species (1.030) indicates a significant increasing trend (Fig. 30). The erratic nature of the annual index is driven mostly by the variable flocked bird component, which is likely to be more sensitive to survey timing than are singles and pairs. The density polygon maps reflect the overall increase in densities through time, but show finer scale inconsistency. Most of the survey area east of Wainwright increased in density, while the southwestern portion decreased. This survey does not adequately sample snow geese, which occur mainly in isolated breeding colonies, 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., ABR Inc. (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 systematic transect survey design. Our data suggest a significant positive growth rate over the survey's 15-year history and the most recent 7 years (Fig. 32), 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), hence the high proportion of flocked birds in our sample most years (Fig. 32). Ritchie et al. (2002) did not detect a significant upward trend in breeding black brant on the North Slope, and Mallek et al. (2005) could not detect a trend due to high sampling error. Canada geese are clustered on the North Slope, and most that we see are in large flocks and therefore likely early failed breeders or non-breeders from other breeding areas. Most observations are near the coast east of Dease Inlet, especially north of Teshekpuk Lake. The 2006 index of 5,340 is below the long-term mean (7,394) and both long-term and 7-year trend lines, which are essentially level (Fig. 33). The 2006 tundra swan index (7,600) was slightly above the long-term mean and on the trend line, which shows a slight but significant positive slope (Growth rate 1.023, Fig. 34). Our temporal distribution comparison suggests a very consistent pattern of nesting distribution.

**Raptors, Ravens, other birds**

Owl populations are extremely variable on the North Slope, following primarily the lemming cycles. This year brown lemmings were in widespread abundance (pers. comm. numerous Alaska Natives and biologists, personal observations), and so were owls. The Short-eared owl index was the third highest since 1992, while that of the snowy owl was second highest (Fig. 36). Most of the snowy owl observations were west of the Colville River and within 30km of the coast. 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. 37). However, the likelihood of our detecting ravens among industrial and residential facilities is low, as they normally spend a large part of their time on or near such structures, which we intentionally avoid during our surveys due to regulatory and safety considerations. In addition we expect detection of dark birds associated with structures would be poor. We see very few sandhill cranes during this survey (2006 index = 75, 1992-2006 mean = 124). The long-term growth rate (1.056) is not significantly greater than 1.0 at P=0.10 (Table 4). 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. Some shorebird species are difficult to distinguish on aerial surveys, and of low priority for this survey. Accordingly, prior to this year we split them into 2 categories: “small”(*Charadrius spp., Pluvialis spp., Calidris spp., Arenaria spp*.) and "large” (*Numenius spp., Limosa spp*.). This year, in recognition of inconsistencies among observers in this classification, we pooled all shorebird observations. The shorebird index growth rate (0.959) is significantly less than 1.0 (Table 4, Fig. 38).

## RECOMMENDATIONS

Work is underway to redesign this survey for the 2007 field season to incorporate the objectives of the "standard" waterfowl breeding population survey of the Alaska Arctic Coastal Plain (Mallek et al. 2005), and eliminate the latter survey. This will include expansion of the survey area, some changes in stratification and sampling intensity, but survey timing protocol for core eider habitats will remain unchanged from the current eider survey.

## ACKNOWLEDGMENTS

The authors would like to thank Dave Fronczak for the excellent job during his first season as observer on this survey, and his supervisor, Ken Gamble, for generously supporting Dave's participation. 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, 1992-2006.

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Recon. Dates (June) | NA | 8 | 10-12 | 8 | 6 | 5-10 | 6 | 8 | 11 | 9-10 | 8 | 8 | 9 | 9-10 | 9 |
| 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 | 10-16 |
| Total transect length (km) | 2784 | 3146 | 3193 | 3248 | 3199 | 3232 | 3527 | 3478 | 2905 | 3200 | 3145 | 3160 | 3343 | 3590 | 3321 |
| Sample area ($km^2$) | 1113 | 1253 | 1277 | 1300 | 1279 | 1292 | 1410 | 1391 | 1162 | 1280 | 1258 | 1264 | 1337 | 1436 | 1329 |
| Survey area ($km^2$) | 30755 | 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 | 4.3 |
| Pilot/observer[1] | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL | WL |
| Starboard observer[2] | GB | GB | GB | GB | GB | TT | TT | TT | JF | JF | AB | AB | AB | TM | DF |
| 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 | 33.7 |

1. WL:William Larned 2. GB:Gregory Balogh, TT:Tim Tiplady, JF:Julian Fischer, AB:Alan Brackney, TM: Tina Moran, DF:David Fronczak

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, 1992-2006 North Slope Eider Survey, Alaska. We suggest that higher numbers indicate more advanced breeding chronology relative to survey timing. Data from 1992 are not included in long-term average calculations due to known late survey timing that year.

| | **1992** | **1993** | **1994** | **1995** | **1996** | **1997** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **1993-2006 Avg.** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| King eider | 0.54 | 0.21 | 0.31 | 0.33 | 0.58 | 0.27 | 0.48 | 0.25 | 0.32 | 0.14 | 0.34 | 0.38 | 0.41 | 0.28 | 0.34 | 0.33 |
| Spectacled eider | 0.52 | 0.52 | 0.44 | 0.42 | 0.55 | 0.53 | 0.56 | 0.29 | 0.55 | 0.37 | 0.53 | 0.59 | 0.53 | 0.42 | 0.48 | 0.48 |

Table 3. Combined observations of birds by pilot and right-hand observer on aerial survey transects sampling tundra habitats, Arctic Coastal Plain, Alaska, June, 2006 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 | Index | Std. Error | %CV |
|---|---|---|---|---|---|---|---|---|
| Yellow-billed loon | 15 | 19 | 0 | 53[1] | 0.041 | 1,268 | 372 | 29 |
| Pacific loon | 166 | 284 | 16 | 750[1] | 0.566 | 17,393 | 1,528 | 9 |
| Red-throated loon | 18 | 19 | 0 | 56[1] | 0.038 | 1,176 | 227 | 19 |
| Jaeger spp. | 346 | 49 | 6 | 450[1] | 0.306 | 9,412 | 574 | 6 |
| Glaucous gull | 245 | 128 | 146 | 647[1] | 0.487 | 14,983 | 2,041 | 14 |
| Sabine's gull | 114 | 80 | 119 | 393[1] | 0.295 | 9,063 | 1,530 | 17 |
| Arctic tern | 164 | 125 | 21 | 435[1] | 0.337 | 10,350 | 875 | 9 |
| Red-breasted merganser | 4 | 7 | 0 | 22[2] | 0.017 | 518 | 162 | 31 |
| Mallard | 2 | 0 | 0 | 4[2] | 0.003 | 103 | 67 | 65 |
| American wigeon | 3 | 4 | 6 | 20[2] | 0.015 | 457 | 281 | 62 |
| Am. green-winged teal | 0 | 4 | 0 | 8[2] | 0.007 | 200 | 97 | 48 |
| Northern pintail | 460 | 55 | 359 | 1,389[2] | 0.948 | 29,153 | 2,164 | 7 |
| Northern shoveler | 0 | 1 | 0 | 2[2] | 0.002 | 50 | 53 | 106 |
| Greater scaup | 46 | 62 | 100 | 270[1] | 0.219 | 6,739 | 1,546 | 23 |
| Long-tailed duck | 255 | 299 | 40 | 1,148[2] | 0.891 | 27,418 | 2,069 | 8 |
| Spectacled eider | 76 | 82 | 0 | 316[2] | 0.219 | 6,731 | 786 | 12 |
| Common eider | 3 | 8 | 0 | 22[2] | 0.019 | 583 | 414 | 71 |
| King eider | 100 | 188 | 0 | 576[2] | 0.419 | 12,896 | 1,209 | 9 |
| Steller's eider | 4 | 3 | 0 | 14[2] | 0.01 | 300 | 141 | 47 |
| Black scoter | 2 | 0 | 0 | 4[2] | 0.003 | 107 | 63 | 59 |
| White-winged scoter | 1 | 5 | 0 | 12[2] | 0.014 | 427 | 318 | 75 |
| Snow goose | 3 | 3 | 8 | 17[1] | 0.043 | 270 | 105 | 39 |
| Gr. white-fronted goose | 288 | 1,222 | 2,287 | 5,307[2] | 3.624 | 111,468 | 9,990 | 9 |
| Canada goose | 15 | 39 | 189 | 297[2] | 0.174 | 5,340 | 1,062 | 20 |
| Black brant | 66 | 114 | 193 | 553[2] | 0.334 | 10,276 | 2,169 | 21 |
| Tundra swan | 136 | 91 | 17 | 335[1] | 0.247 | 7,600 | 671 | 9 |
| Sandhill crane | 1 | 1 | 0 | 3[1] | 0.043 | 62 | 48 | 77 |
| Unid. shorebird[3] | 475 | 419 | 625 | 2,413[2] | 1.299 | 39,938 | 3,669 | 9 |
| Common raven | 2 | 0 | 0 | 2[1] | 0.001 | 38 | 26 | 70 |
| Short-eared owl | 5 | 0 | 0 | 5[1] | 0.005 | 166 | 56 | 34 |
| Snowy owl | 92 | 6 | 0 | 104[1] | 0.073 | 2,256 | 259 | 12 |

1. singles+(2*pairs)+flocked birds 2. 2*(singles+pairs)+flocked birds 3. *Charadrius sp., Pluvialis spp., Calidris spp., Arenaria sp. Numenius sp., Limosa sp., Limnodromus sp. et a.l*

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 1992-2006 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 pop. growth rate | Mean pop. 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 | 1992-2006 | 15 | 1,102 | 0.010 | 1.010 | 0.989 - 1.032 | 0.22 | 14 |
| Pacific loon | S + 2*Pr+FL | 1992-2006 | 15 | 20,643 | -0.001 | 0.999 | 0.981 - 1.018 | 0.07 | 7 |
| **Red-throated loon** | S + 2*Pr+FL | 1992-2006 | 15 | 2,558 | -0.068 | **0.934** | **0.905 - 0.965** | 0.16 | 12 |
| Jaeger spp. | S + 2*Pr+FL | 1992-2006 | 15 | 4,146 | 0.004 | 1.004 | 0.956 - 1.053 | 0.11 | 9 |
| Glaucous gull | S + 2*Pr+FL | 1992-2006 | 15 | 11,870 | 0.005 | 1.005 | 0.980 - 1.030 | 0.14 | 11 |
| Sabine's gull | S + 2*Pr+FL | 1992-2006 | 15 | 6,745 | 0.007 | 1.007 | 0.975 - 1.040 | 0.14 | 11 |
| **Arctic tern** | S + 2*Pr+FL | 1992-2006 | 15 | 10,321 | 0.039 | **1.040** | **1.023 - 1.057** | 0.11 | 9 |
| **Red-breasted merganser** | 2*(S+Pr)+Fl | 1992-2006 | 15 | 440 | 0.116 | **1.123** | **1.058 - 1.191** | 0.43 | 23 |
| Mallard | 2*(S+Pr)+Fl | 1992-2006 | 15 | 209 | -0.100 | 0.905 | 0.809 - 1.012 | 0.58 | 28 |
| American wigeon | 2*(S+Pr)+Fl | 1992-2006 | 15 | 378 | 0.012 | 1.012 | 0.923 - 1.108 | 0.66 | 30 |
| Northern shoveler | 2*(S+Pr)+Fl | 1992-2006 | 15 | 242 | -0.001 | 0.999 | 0.865 - 1.155 | 0.39 | 21 |
| Northern pintail | 2*(S+Pr)+Fl | 1992-2006 | 15 | 49,577 | -0.020 | 0.980 | 0.939 - 1.023 | 0.09 | 8 |
| **Greater scaup** | S + 2*Pr+FL | 1992-2006 | 15 | 4,257 | 0.050 | **1.052** | **1.023 - 1.081** | 0.19 | 13 |
| Long-tailed duck | 2*(S+Pr)+Fl | 1992-2006 | 15 | 31,115 | -0.019 | 0.982 | 0.961 - 1.002 | 0.07 | 7 |
| Spectacled eider | 2*(S+Pr)+Fl | 1993-2006 | 14 | 6,903 | -0.003 | 0.997 | 0.978 - 1.016 | 0.10 | 9 |
| **King eider** | 2*(S+Pr)+Fl | 1993-2006 | 14 | 13,070 | 0.017 | **1.017** | **1.003 - 1.031** | 0.10 | 9 |
| Steller's eider | 2*(S+Pr)+Fl | 1992-2006 | 15 | 166 | 0.034 | 1.035 | 0.910 - 1.177 | 0.48 | 25 |
| **White-winged scoter** | 2*(S+Pr)+Fl | 1992-2006 | 15 | 336 | 0.100 | **1.105** | **1.017 - 1.201** | 0.61 | 29 |
| **Snow goose** | S + 2*Pr+FL | 1992-2006 | 15 | 2,934 | 0.120 | **1.128** | **1.003 - 1.267** | 0.56 | 27 |
| **Gr. White-fronted goose** | S + 2*Pr+FL | 1992-2006 | 15 | 75,784 | 0.029 | **1.030** | **1.002 - 1.058** | 0.08 | 8 |
| Canada goose | S + 2*Pr+FL | 1993-2006 | 14 | 7,394 | -0.018 | 0.983 | 0.943 - 1.024 | 0.27 | 17 |
| **Black brant** | S + 2*Pr+FL | 1992-2006 | 15 | 6,533 | 0.120 | **1.127** | **1.086 - 1.170** | 0.28 | 17 |
| **Tundra swan** | S + 2*Pr+FL | 1992-2006 | 15 | 6,163 | 0.023 | **1.023** | **1.007 - 1.038** | 0.11 | 9 |
| Sandhill crane | S + 2*Pr+FL | 1992-2006 | 15 | 124 | 0.055 | 1.056 | 0.986 - 1.131 | 0.62 | 29 |
| **Unident. shorebird** | 2*(S+Pr)+Fl | 1997-2006 | 10 | 57,581 | -0.042 | **0.959** | **0.925 - 0.995** | 0.07 | 7 |
| Common raven | S + 2*Pr+FL | 1992-2006 | 15 | 63 | -0.029 | 0.971 | 0.911 - 1.036 | 0.71 | 32 |
| Short-eared owl | S + 2*Pr+FL | 1992-2006 | 15 | 88 | 0.044 | 1.045 | 0.947 - 1.152 | 0.33 | 19 |
| Snowy owl | S + 2*Pr+FL | 1992-2006 | 15 | 848 | -0.045 | 0.956 | 0.844 - 1.083 | 0.35 | 20 |

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

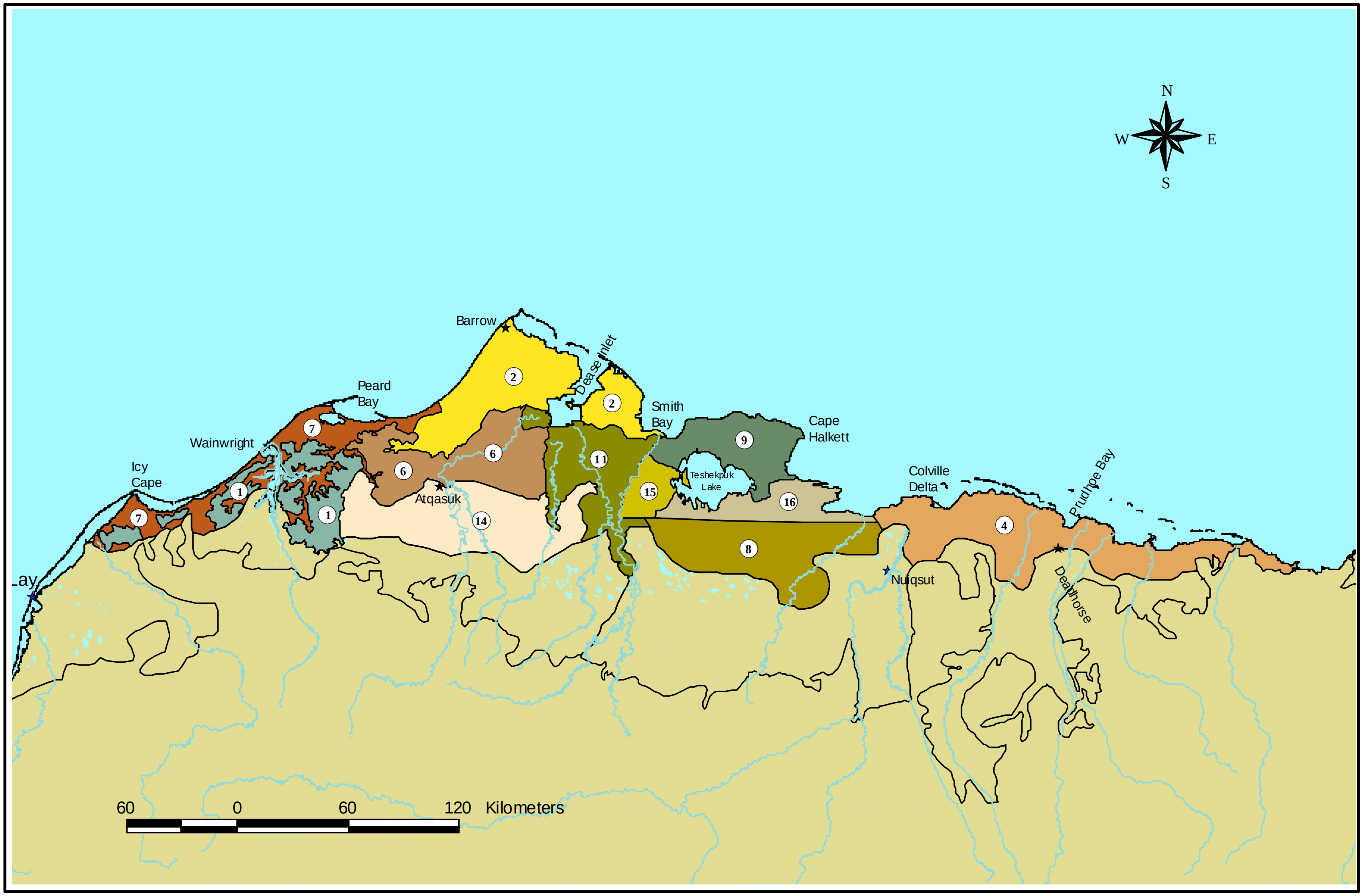



Figure 1. Survey strata for the Eider Breeding Population Survey, Srctic Coastal Plain, Alaska, with major hydrographic and cultural features. Unshaded units south of the eider survey area are strata surveyed only during the Standard waterfowl breeding population survey conducted in late June – early July.

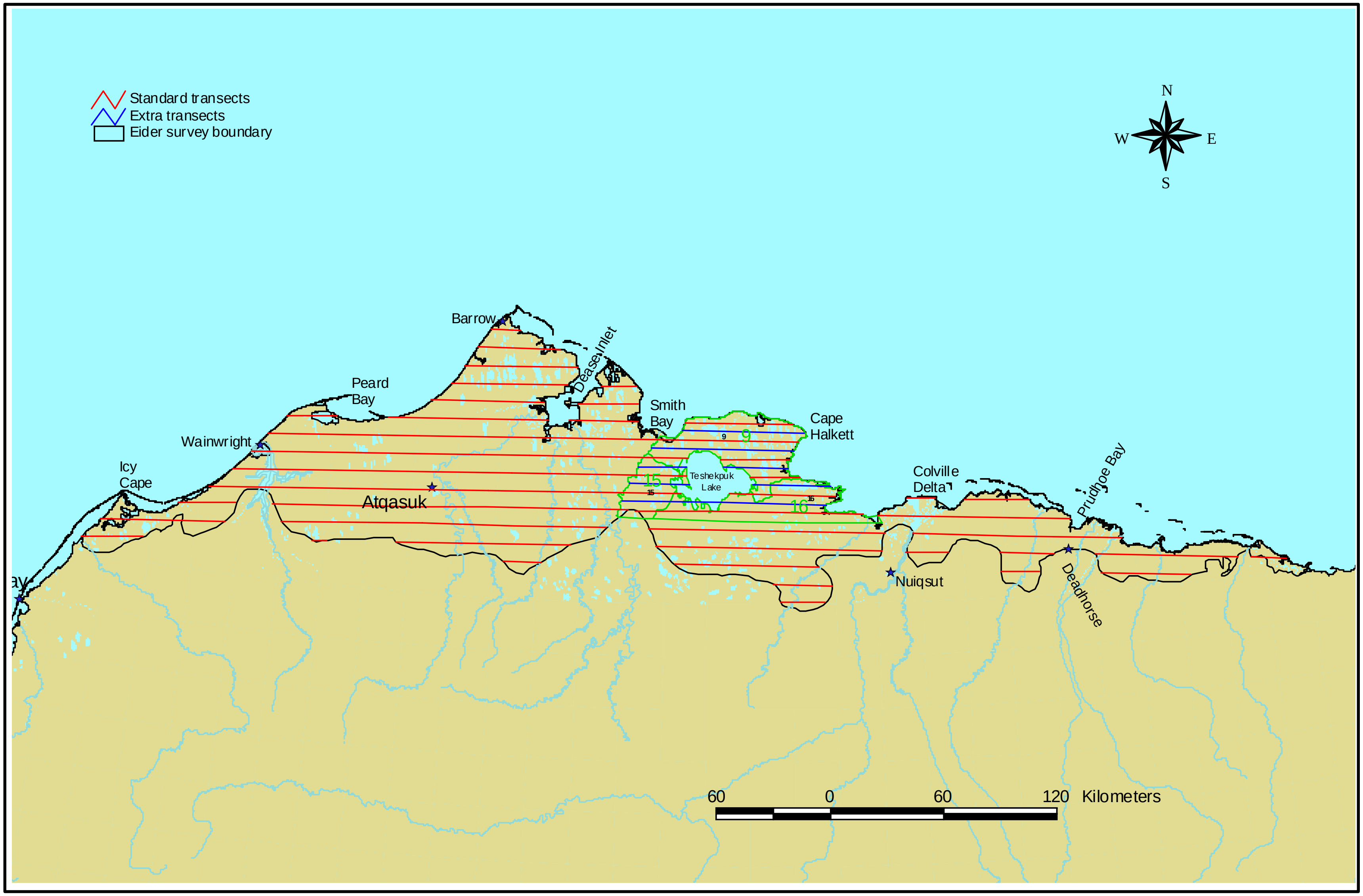



Figure 2. Aerial transects flown during the Eider Breeding Population Survey, Actic Coastal Plain, Alaska, June 2006. Blue lines are extra transects added to increase sampling intensity and distribution resolution in the NPRA Northeast Planning Unit.

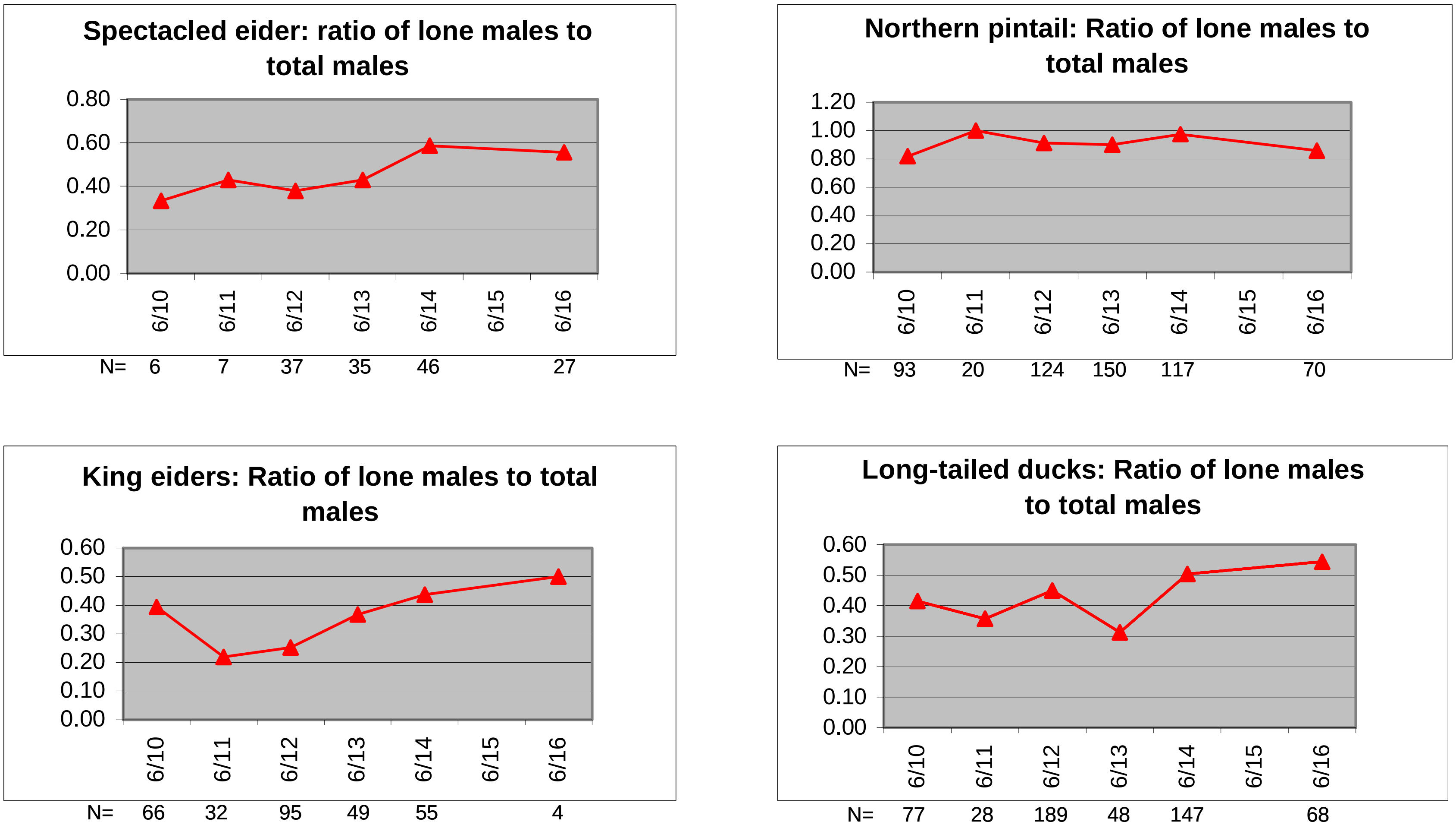
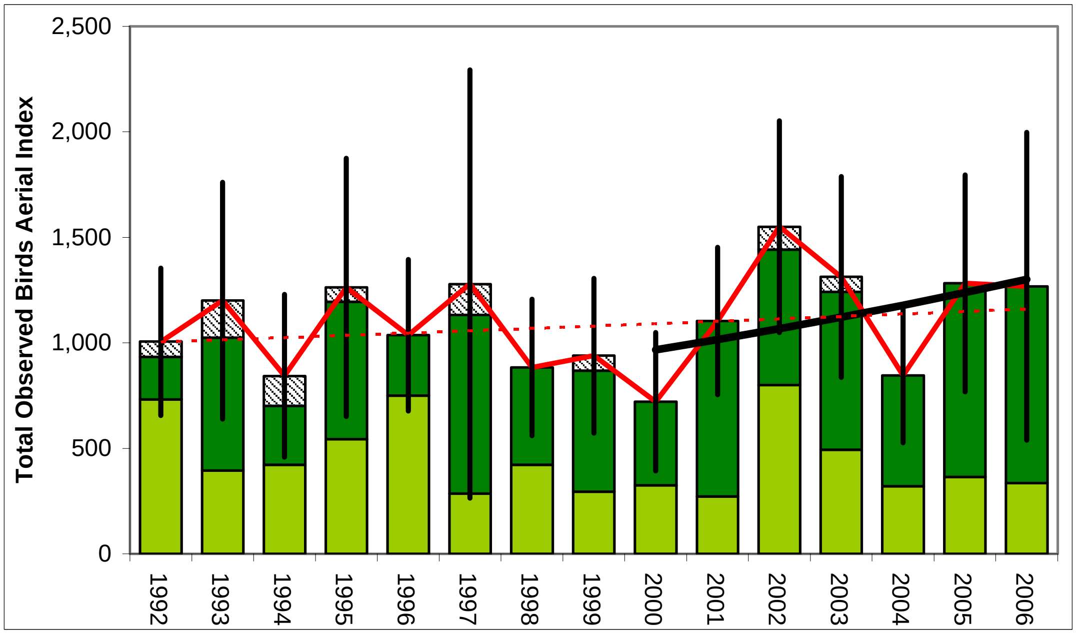



Figure 3. Daily ratios of lone males to total males (lone males plus males in pairs) of selected duck species observed during the Eider Breeding Population Survey, Arctic Coastal Plain, Alaska, June 2006. Sample size (N) refers to total observations (lone males plus males in pairs).




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 |
| 2006 | 336 | 932 | 0 | **1268** | 372 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **1102** |
| std dev = | 230 |
| ln linear slope = | 0.0104 |
| SE slope = | 0.0129 |
| Growth Rate = | **1.010** |
| low 90%ci GR = | 0.989 |
| high 90%ci GR = | 1.032 |
| regression resid CV = | 0.216 |
| avg sampling err CV = | 0.220 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 14.4 |
| w/ sample error CV = | 14.5 |
| most recent 7 years : | |
| Growth Rate = | **1.051** |
| low 90%ci GR = | 0.966 |
| high 90%ci GR = | 1.143 |

Figure 4. 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.

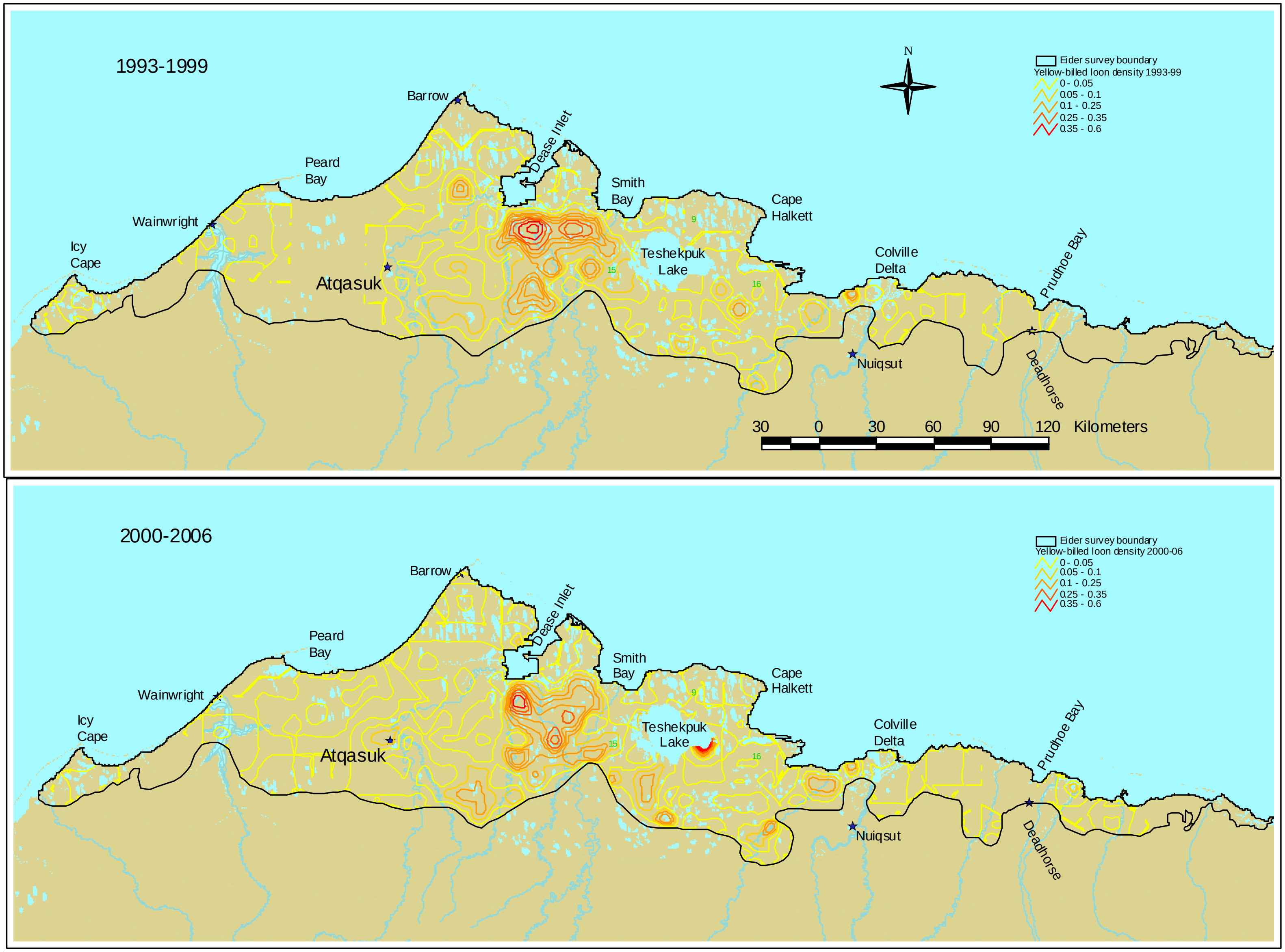
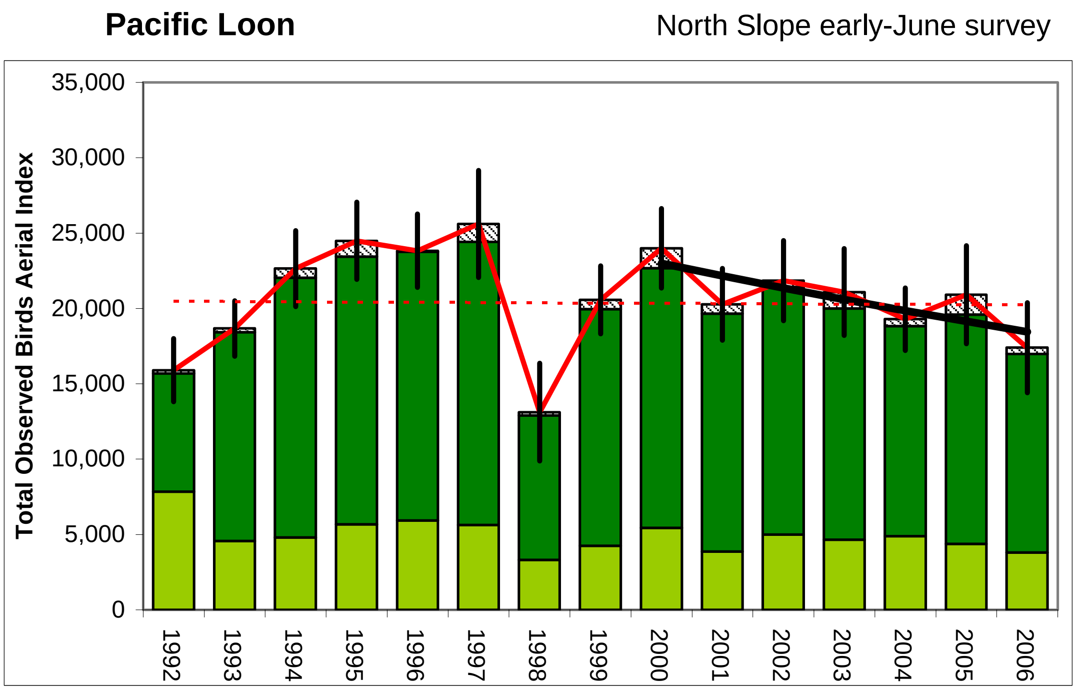



Fig. 5. Mean yellow-billed loon breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).




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** | 1662 |
| 2006 | 3797 | 13182 | 415 | **17393** | 1528 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **20643** |
| std dev = | 3402 |
| ln linear slope = | -0.0008 |
| SE slope = | 0.0111 |
| Growth Rate = | **0.999** |
| low 90%ci GR = | 0.981 |
| high 90%ci GR = | 1.018 |
| regression resid CV = | 0.185 |
| avg sampling err CV = | 0.067 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 13.0 |
| w/ sample error CV = | 6.6 |
| most recent 7 years : | |
| Growth Rate = | **0.964** |
| low 90%ci GR = | 0.944 |
| high 90%ci GR = | 0.984 |

Figure 6. 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.

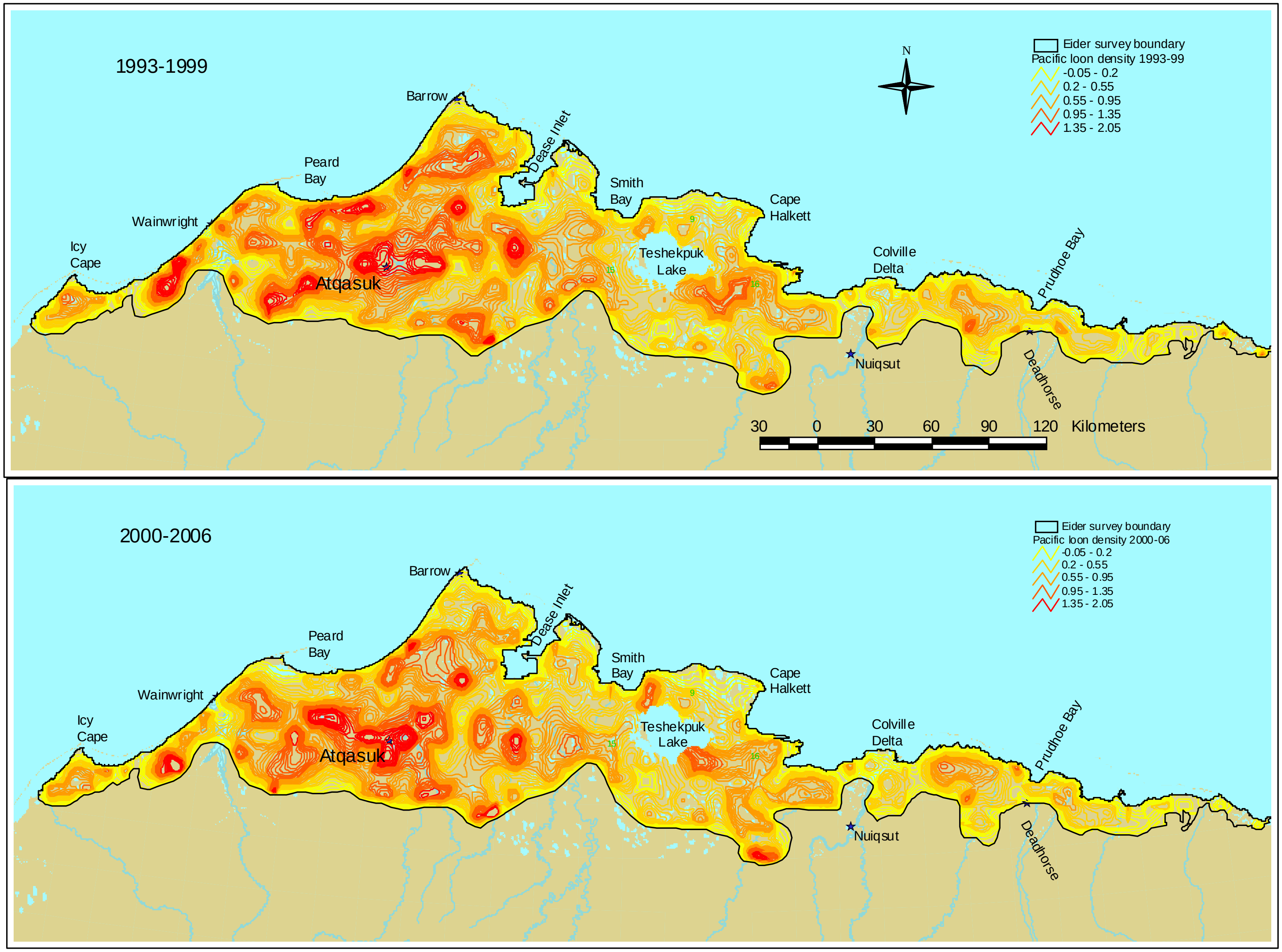
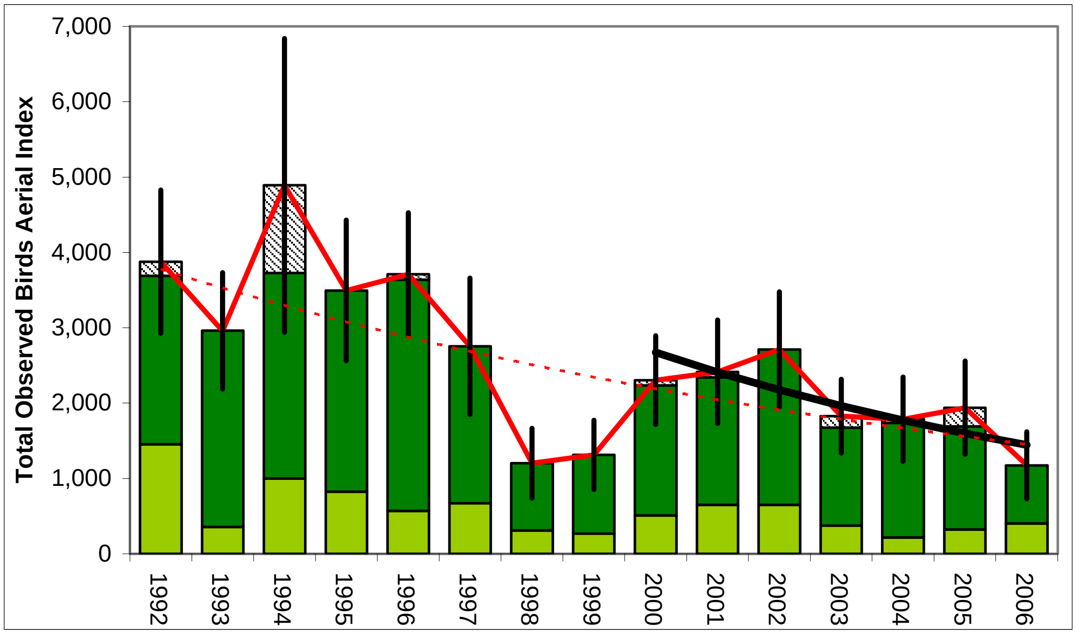



Figure 7. Mean Pacific loon breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).

**Red-throated Loon** North Slope early-June survey




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

| 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 | 248 | **1940** | 316 |
| 2006 | 405 | 770 | 0 | **1176** | 227 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **2558** |
| std dev = | 1086 |
| ln linear slope = | -0.0681 |
| SE slope = | 0.0196 |
| Growth Rate = | **0.934** |
| low 90%ci GR = | 0.905 |
| high 90%ci GR = | 0.965 |
| regression resid CV = | 0.328 |
| avg sampling err CV = | 0.155 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 19.0 |
| w/ sample error CV = | 11.5 |
| most recent 7 years : | |
| Growth Rate = | **0.902** |
| low 90%ci GR = | 0.854 |
| high 90%ci GR = | 0.953 |

Figure 8. 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.

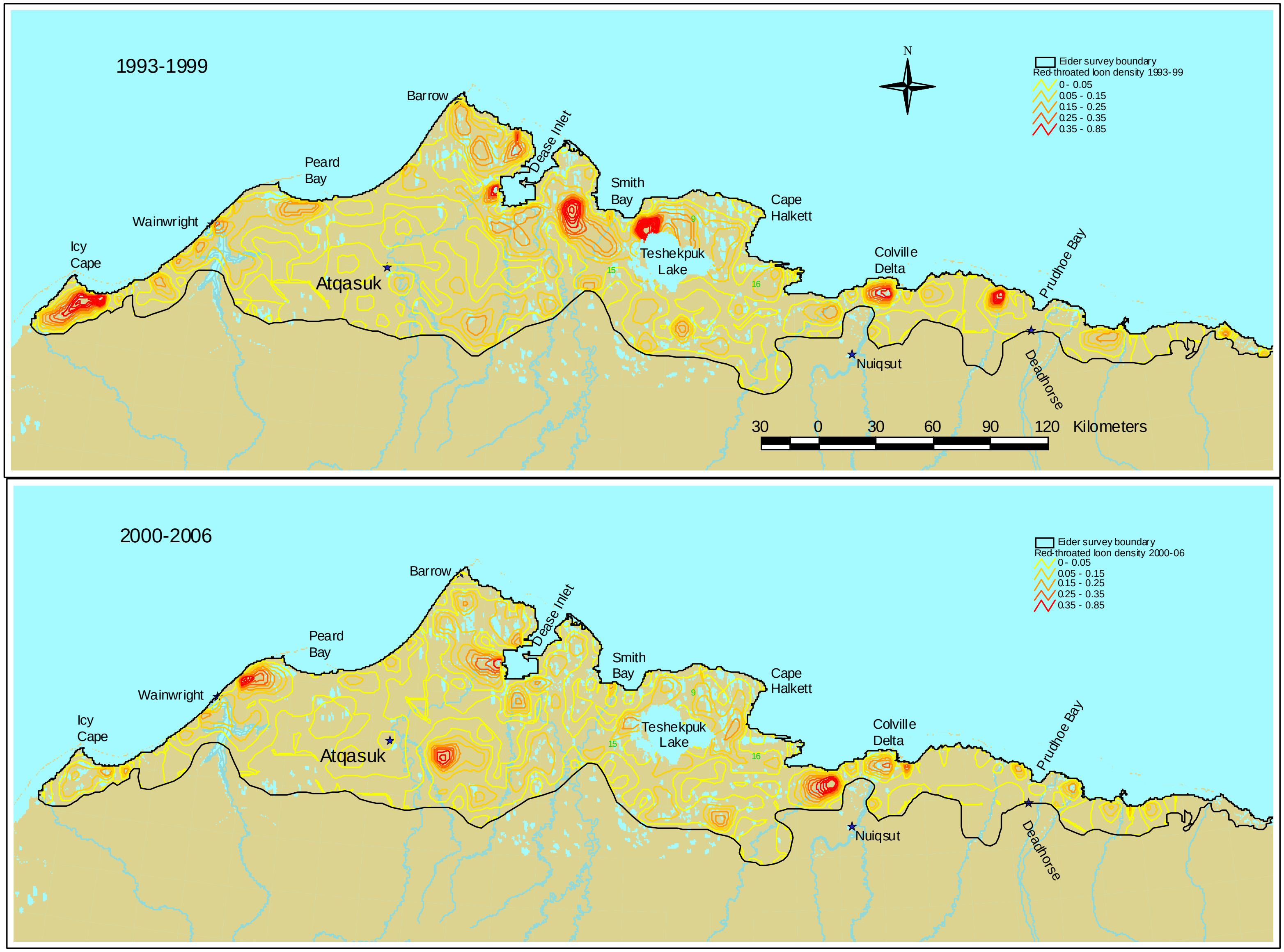
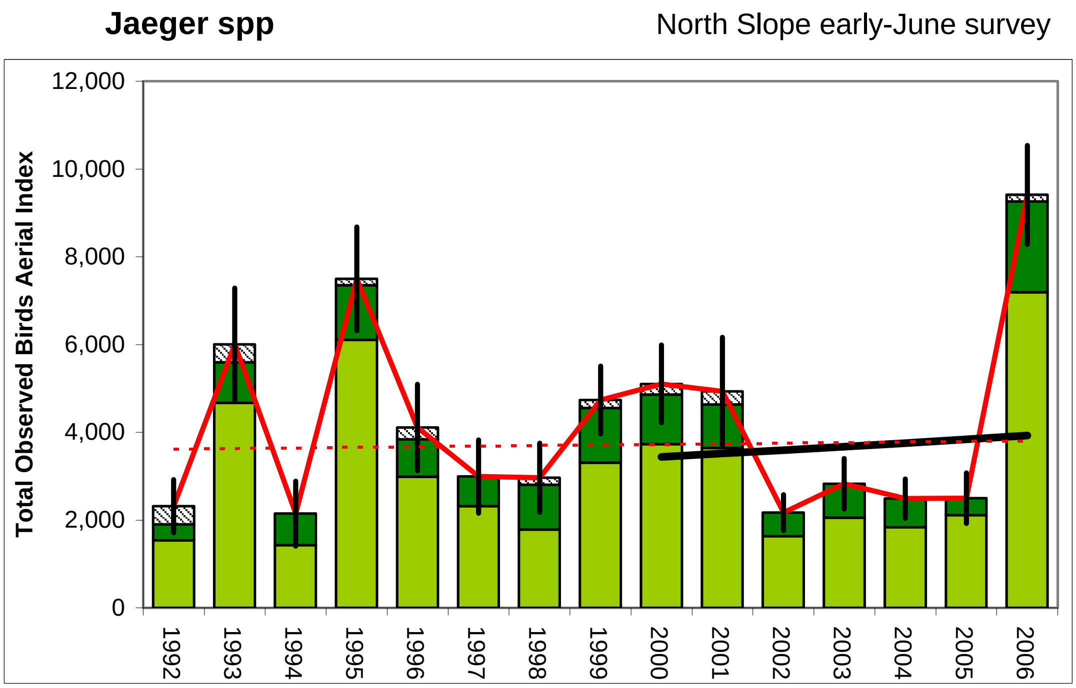



Figure 9. Mean red-throated loon breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).



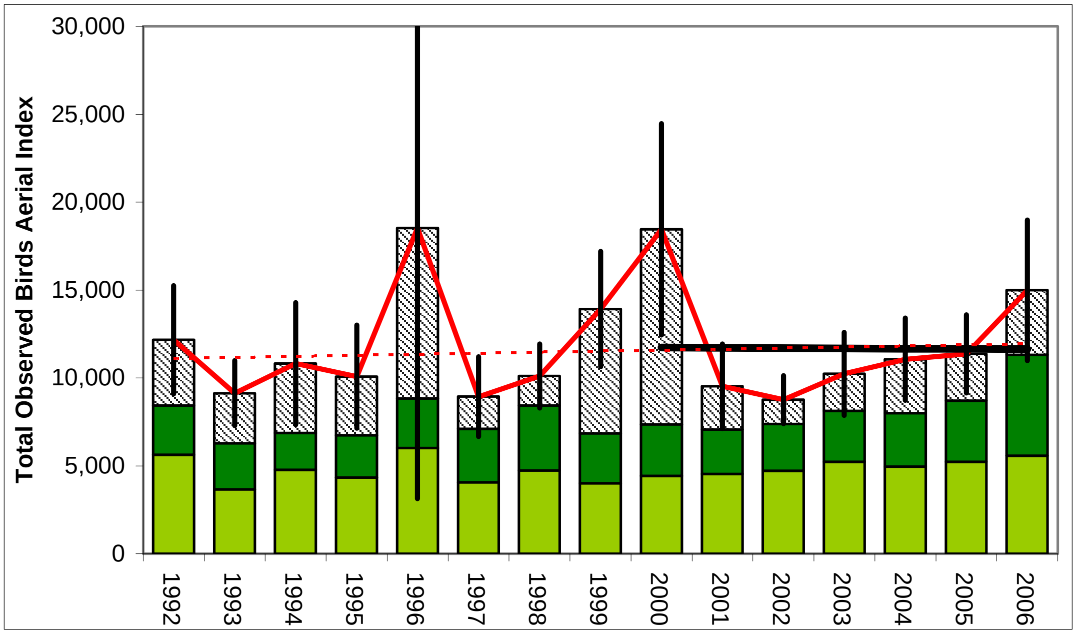

Aerial index: Total birds observed S6d strata (n=11) JAEG

| 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 |
| 2006 | 7193 | 2070 | 148 | **9412** | 574 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **4146** |
| std dev = | 2163 |
| ln linear slope = | 0.0036 |
| SE slope = | 0.0294 |
| Growth Rate = | **1.004** |
| low 90%ci GR = | 0.956 |
| high 90%ci GR = | 1.053 |
| regression resid CV = | 0.491 |
| avg sampling err CV = | 0.111 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 24.8 |
| w/ sample error CV = | 9.2 |
| most recent 7 years : | |
| Growth Rate = | **1.022** |
| low 90%ci GR = | 0.852 |
| high 90%ci GR = | 1.226 |

Figure 10. 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) GLGU

| 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 |
| 2006 | 5573 | 5732 | 3679 | **14983** | 2041 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **11870** |
| std dev = | 3206 |
| ln linear slope = | 0.0051 |
| SE slope = | 0.0151 |
| Growth Rate = | **1.005** |
| low 90%ci GR = | 0.980 |
| high 90%ci GR = | 1.030 |
| regression resid CV = | 0.253 |
| avg sampling err CV = | 0.143 |
| <u>min yrs to detect -50%/20yr rate :</u> | |
| w/ regression resid CV = | 16.0 |
| w/ sample error CV = | 10.9 |
| <u>most recent 7 years :</u> | |
| Growth Rate = | **0.999** |
| low 90%ci GR = | 0.913 |
| high 90%ci GR = | 1.093 |

Figure 11. 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.

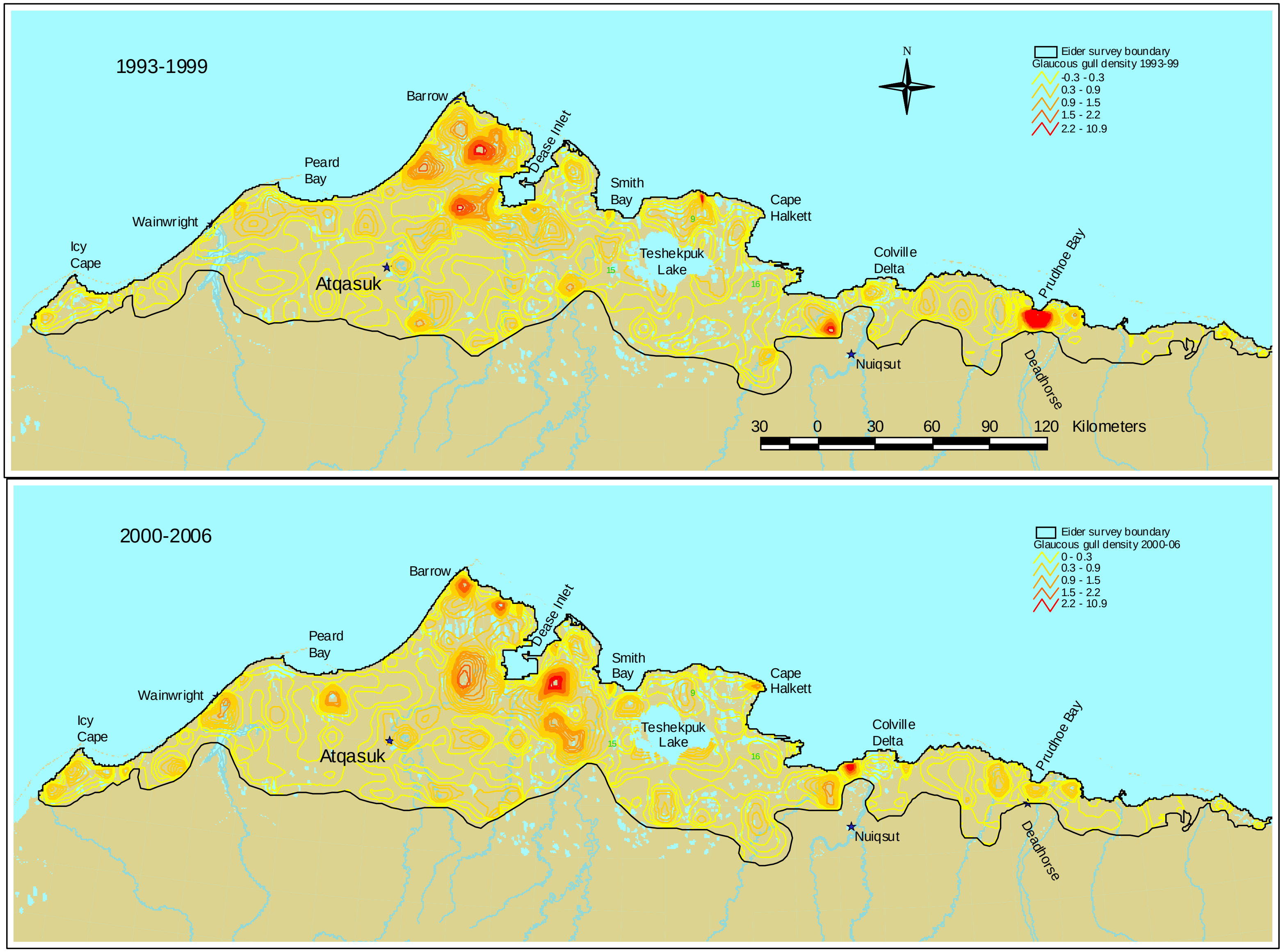
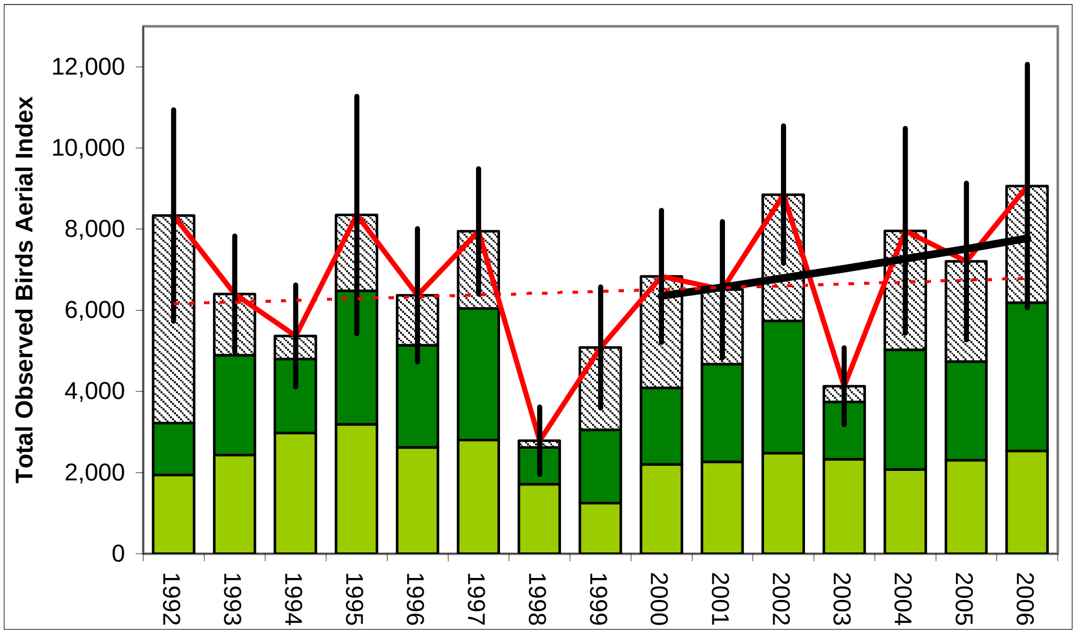



Figure 12. Mean glaucous gull breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).

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



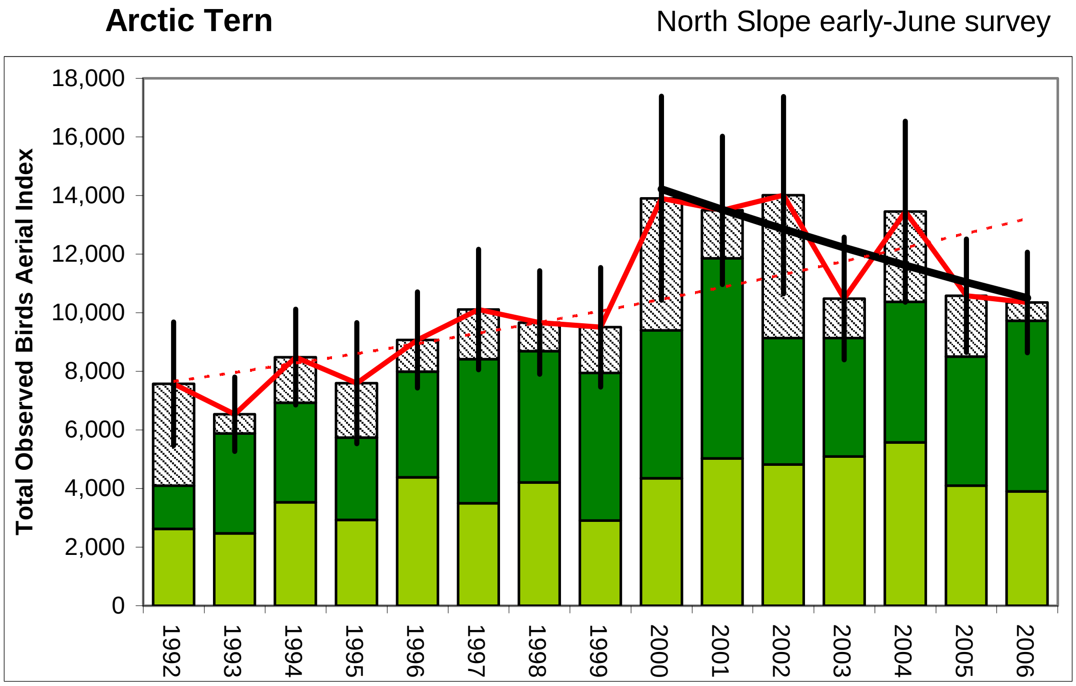

Aerial index: Total birds observed S6d strata (n=11)

| 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 |
| 2006 | 2536 | 3656 | 2871 | **9063** | 1530 |

SAGU

| | |
|---|---|
| n yrs = | 15 |
| mean = | **6745** |
| std dev = | 1804 |
| ln linear slope = | 0.0069 |
| SE slope = | 0.0198 |
| Growth Rate = | **1.007** |
| low 90%ci GR = | 0.975 |
| high 90%ci GR = | 1.040 |
| regression resid CV = | 0.332 |
| avg sampling err CV = | 0.136 |
| <u>min yrs to detect -50%/20yr rate :</u> | |
| w/ regression resid CV = | 19.1 |
| w/ sample error CV = | 10.5 |
| <u>most recent 7 years :</u> | |
| Growth Rate = | **1.034** |
| low 90%ci GR = | 0.948 |
| high 90%ci GR = | 1.128 |

Figure 13. 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.




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 | 4098 | 4408 | 2072 | **10578** | 987 |
| 2006 | 3900 | 5824 | 627 | **10350** | 875 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **10321** |
| std dev = | 2418 |
| ln linear slope = | 0.0390 |
| SE slope = | 0.0099 |
| Growth Rate = | **1.040** |
| low 90%ci GR = | 1.023 |
| high 90%ci GR = | 1.057 |
| regression resid CV = | 0.165 |
| avg sampling err CV = | 0.108 |
| <u>min yrs to detect -50%/20yr rate :</u> | |
| w/ regression resid CV = | 12.0 |
| w/ sample error CV = | 9.0 |
| <u>most recent 7 years :</u> | |
| Growth Rate = | **0.951** |
| low 90%ci GR = | 0.920 |
| high 90%ci GR = | 0.982 |

Figure 14. 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.

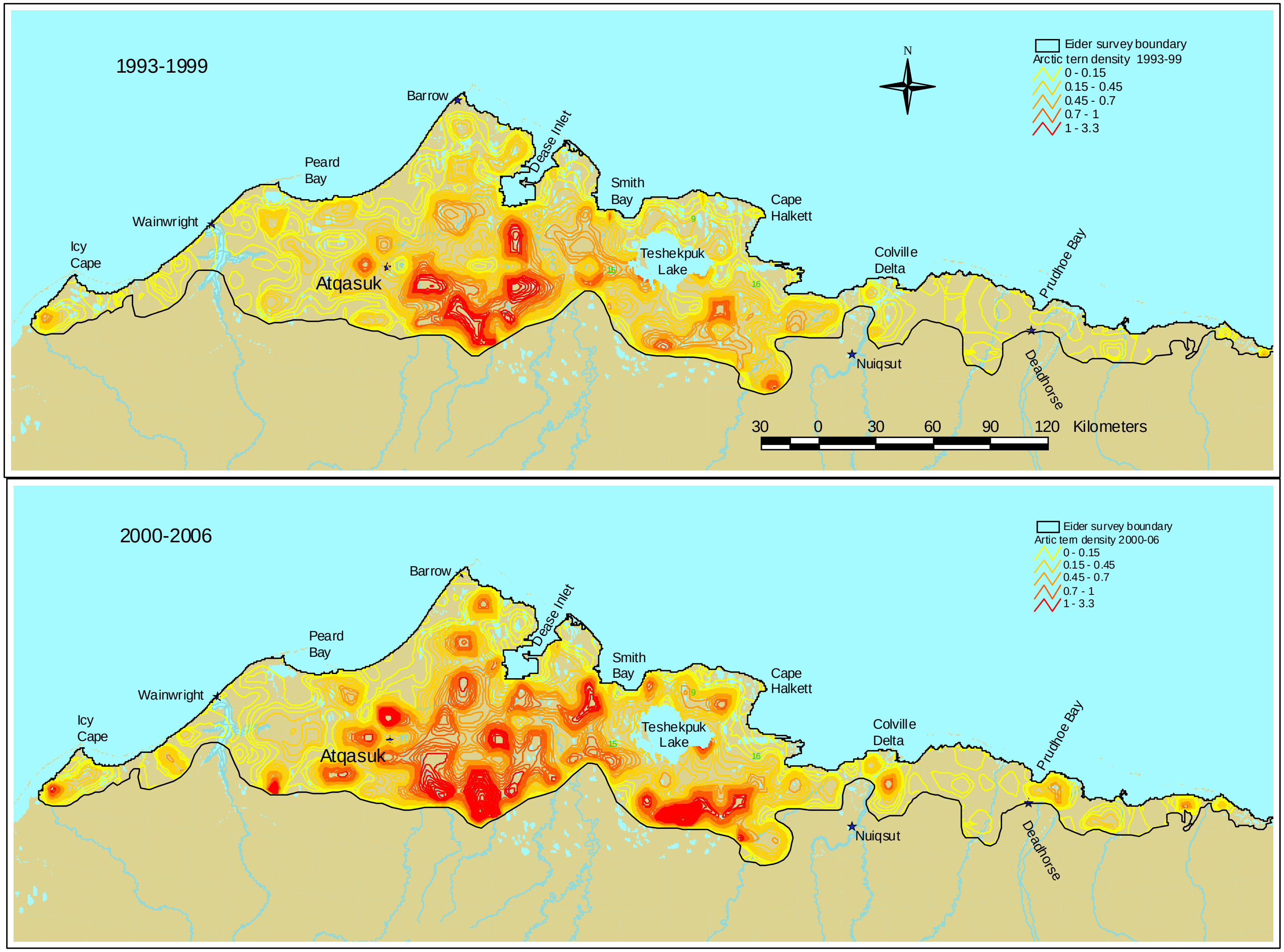
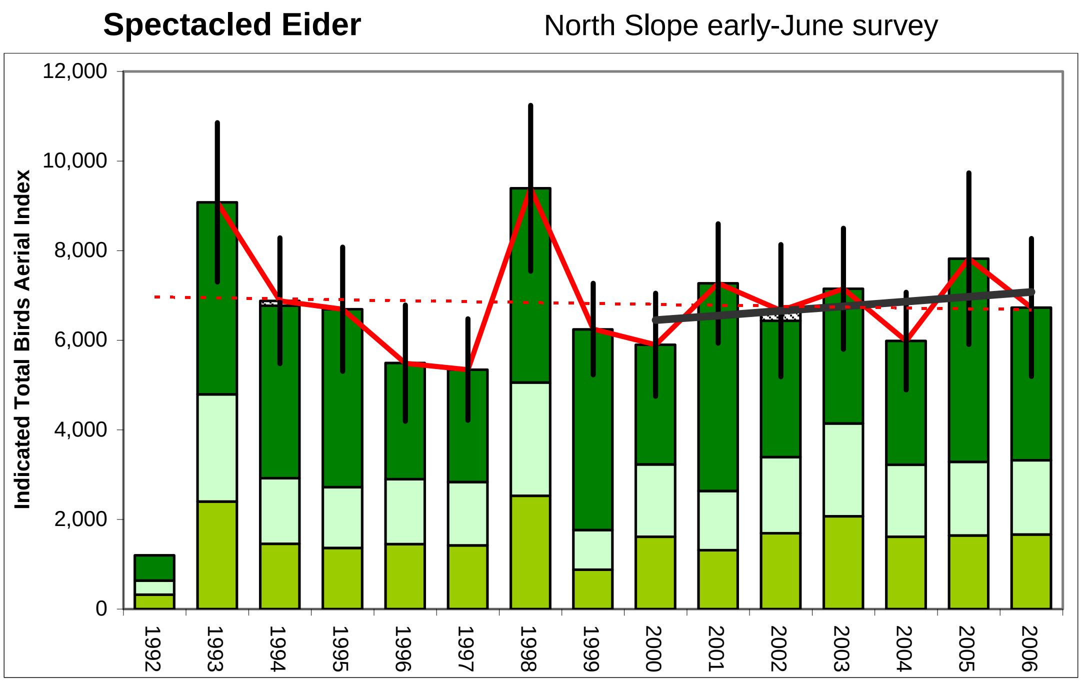



Figure 15. Mean arctic tern breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).




| Aerial index: Indicated total birds | | | | S6d strata (n=11) | | | SPEI |
|---|---|---|---|---|---|---|---|
| year | 2*sg | 2*pr | flocks | Index | Std Err | | |
| 1992 | 638 | 564 | 0 | | | n yrs = | 14 |
| 1993 | 4796 | 4284 | 0 | **9079** | 909 | mean = | **6903** |
| 1994 | 2920 | 3848 | 113 | **6882** | 717 | std dev = | 1203 |
| 1995 | 2722 | 3970 | 0 | **6693** | 707 | ln linear slope = | -0.0030 |
| 1996 | 2902 | 2588 | 0 | **5489** | 663 | SE slope = | 0.0115 |
| 1997 | 2838 | 2506 | 0 | **5345** | 577 | Growth Rate = | **0.997** |
| 1998 | 5060 | 4332 | 0 | **9392** | 944 | low 90%ci GR = | 0.978 |
| 1999 | 1764 | 4482 | 0 | **6247** | 521 | high 90%ci GR = | 1.016 |
| 2000 | 3228 | 2672 | 0 | **5900** | 585 | | |
| 2001 | 2634 | 4636 | 0 | **7270** | 679 | regression resid CV = | 0.173 |
| 2002 | 3390 | 3048 | 224 | **6662** | 752 | avg sampling err CV = | 0.104 |
| 2003 | 4144 | 3006 | 0 | **7149** | 690 | | |
| 2004 | 3222 | 2762 | 0 | **5985** | 556 | min yrs to detect -50%/20yr rate : | |
| 2005 | 3284 | 4538 | 0 | **7821** | 978 | w/ regression resid CV = | 12.4 |
| 2006 | 3324 | 3408 | 0 | **6731** | 786 | w/ sample error CV = | 8.8 |
| | | | | | | most recent 7 years : | |
| | | | | | | Growth Rate = | **1.016** |
| | | | | | | low 90%ci GR = | 0.983 |
| | | | | | | high 90%ci GR = | 1.050 |

Figure 16. 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.

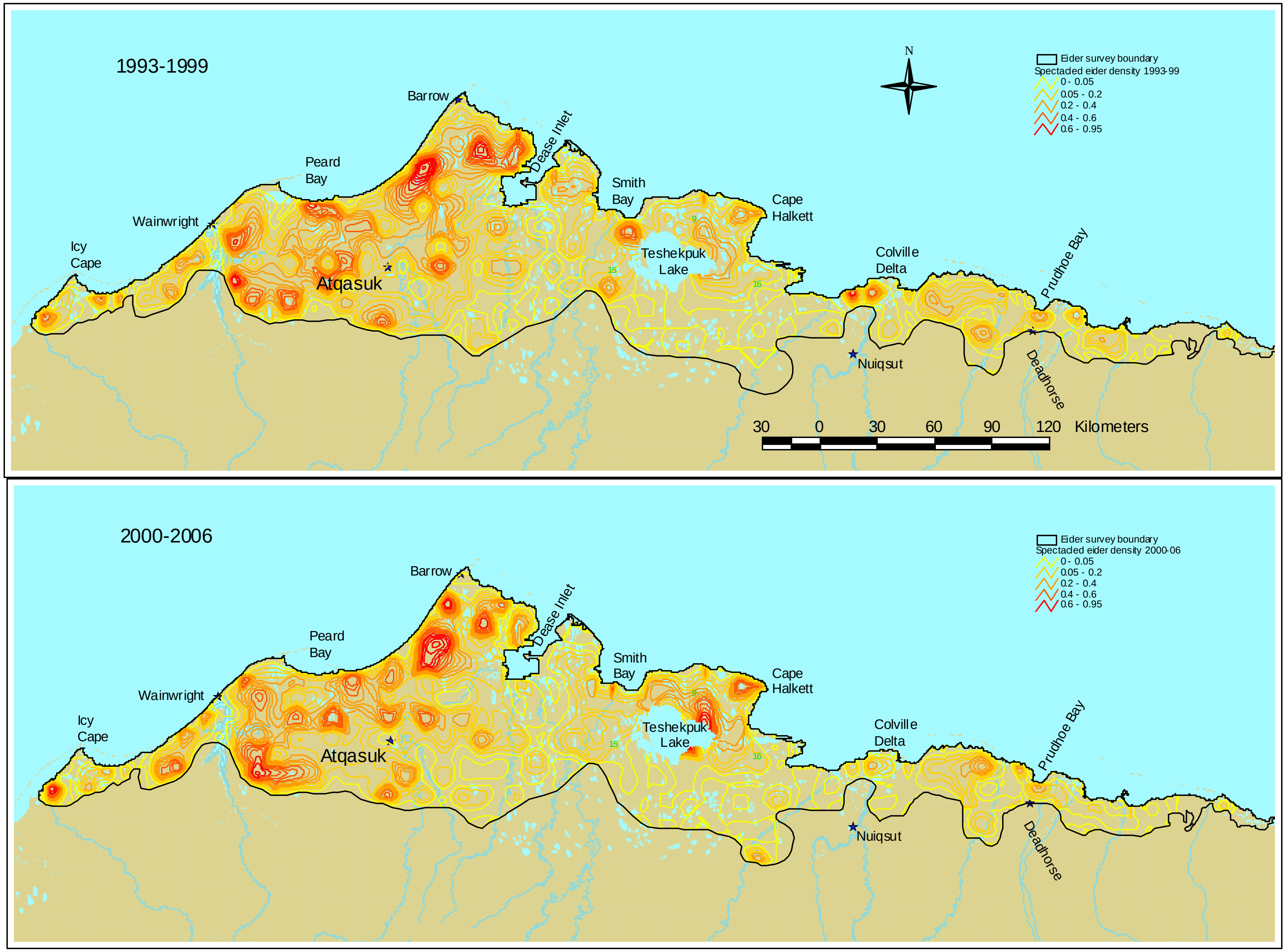
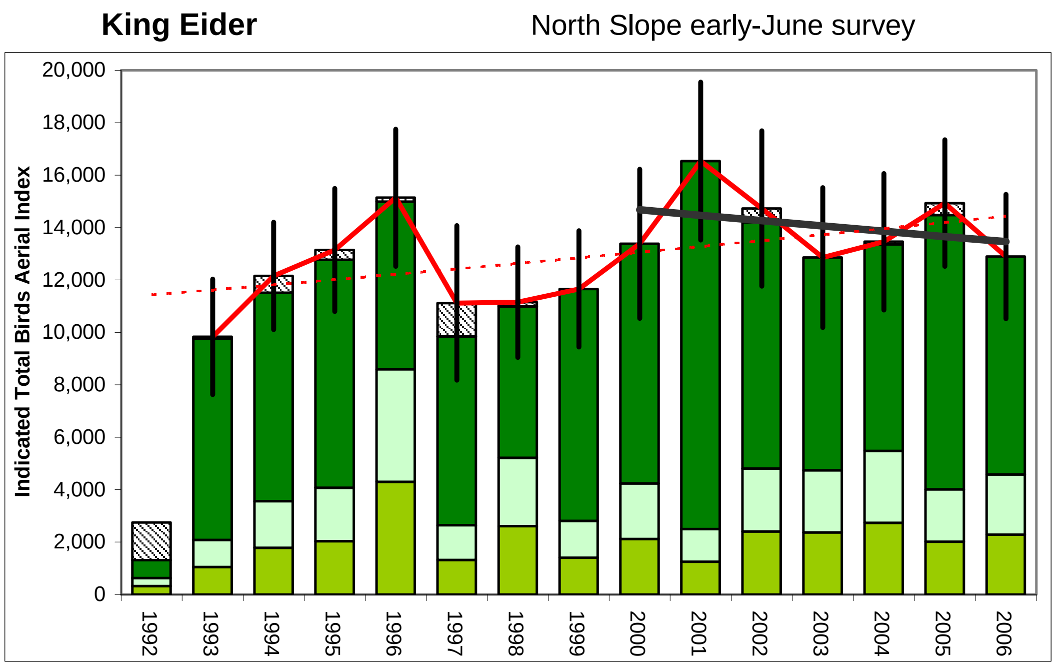



Figure 17. Mean spectacled eider breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).




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 |
| 2006 | 4578 | 8318 | 0 | **12896** | 1209 |

| | KIEI |
|---|---|
| n yrs = | 14 |
| mean = | **13070** |
| std dev = | 1832 |
| ln linear slope = | 0.0167 |
| SE slope = | 0.0085 |
| Growth Rate = | **1.017** |
| low 90%ci GR = | 1.003 |
| high 90%ci GR = | 1.031 |
| 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 = | **0.986** |
| low 90%ci GR = | 0.957 |
| high 90%ci GR = | 1.016 |

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.

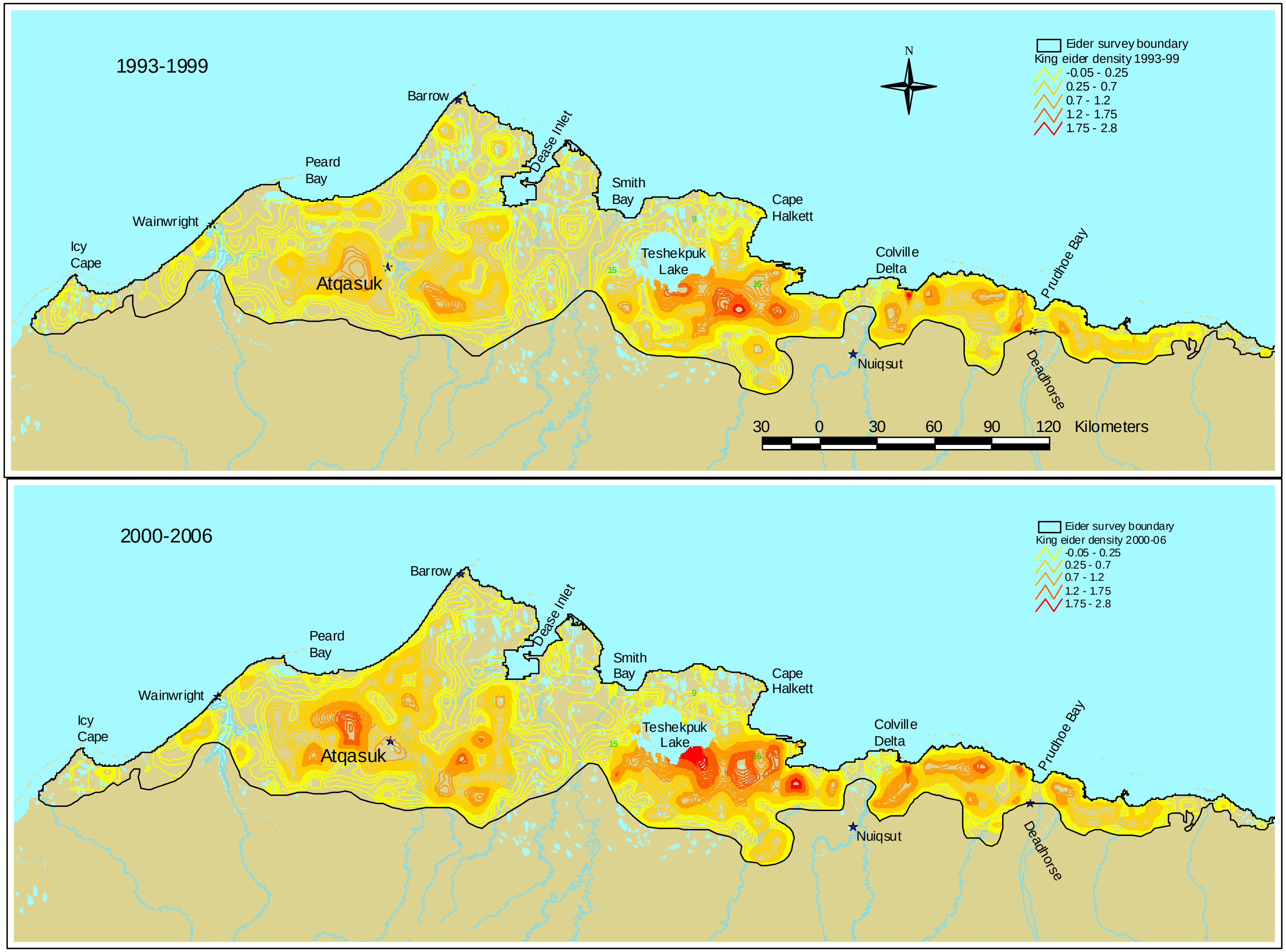
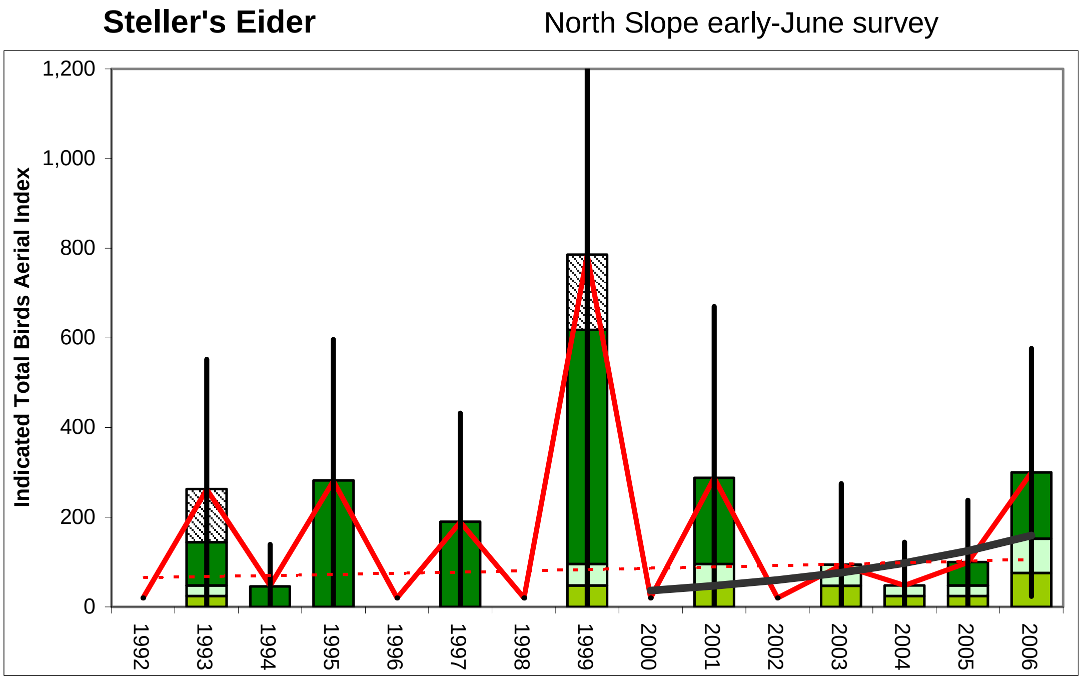



Figure 19. Mean king eider breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).

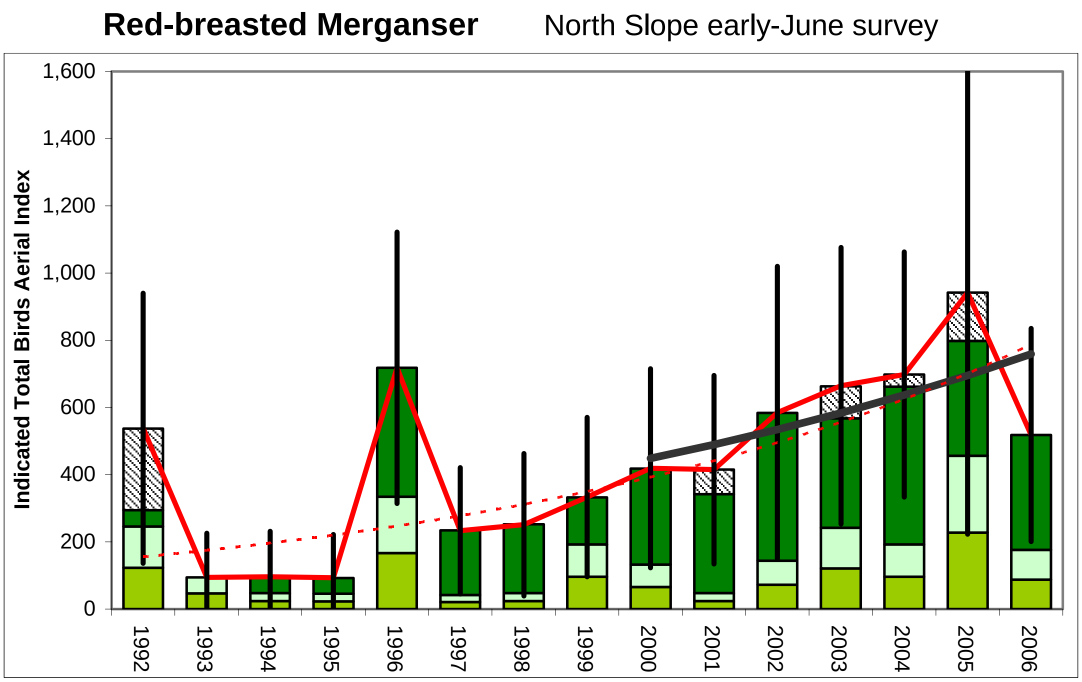



Aerial index: Indicated total birds — S6d strata (n=11) — STEI

| 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 |
| 2006 | 152 | 148 | 0 | **300** | 141 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **166** |
| std dev = | 204 |
| ln linear slope = | 0.0344 |
| SE slope = | 0.0781 |
| Growth Rate = | **1.035** |
| low 90%ci GR = | 0.910 |
| high 90%ci GR = | 1.177 |
| regression resid CV = | 1.310 |
| avg sampling err CV = | 0.484 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 47.7 |
| w/ sample error CV = | 24.6 |
| most recent 7 years : | |
| Growth Rate = | **1.278** |
| low 90%ci GR = | 0.913 |
| high 90%ci GR = | 1.789 |

Figure 20. 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.



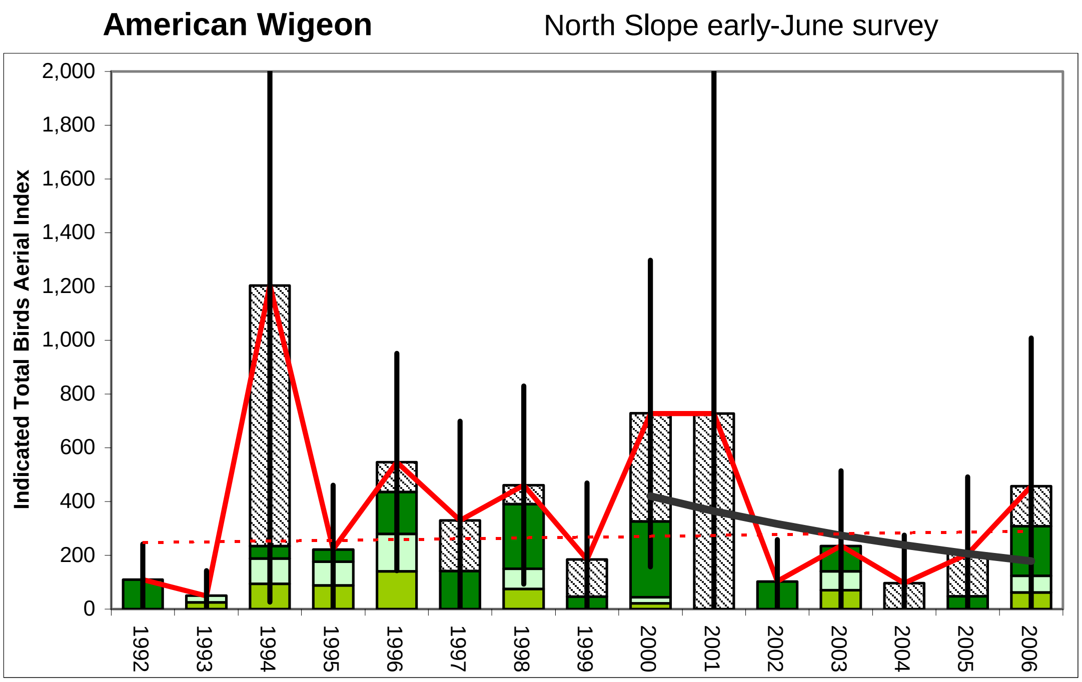

Aerial index: Indicated total birds — S6d strata (n=11)

| 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 |
| 2006 | 176 | 342 | 0 | **518** | 162 |

RBME

| | |
|---|---|
| n yrs = | 15 |
| mean = | **440** |
| std dev = | 258 |
| ln linear slope = | 0.1157 |
| SE slope = | 0.0361 |
| Growth Rate = | **1.123** |
| low 90%ci GR = | 1.058 |
| high 90%ci GR = | 1.191 |
| | |
| regression resid CV = | 0.604 |
| avg sampling err CV = | 0.426 |
| | |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 28.5 |
| w/ sample error CV = | 22.6 |
| most recent 7 years : | |
| Growth Rate = | **1.092** |
| low 90%ci GR = | 1.011 |
| high 90%ci GR = | 1.178 |

Figure 21. Population trend for Red-breasted Meganser (*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.



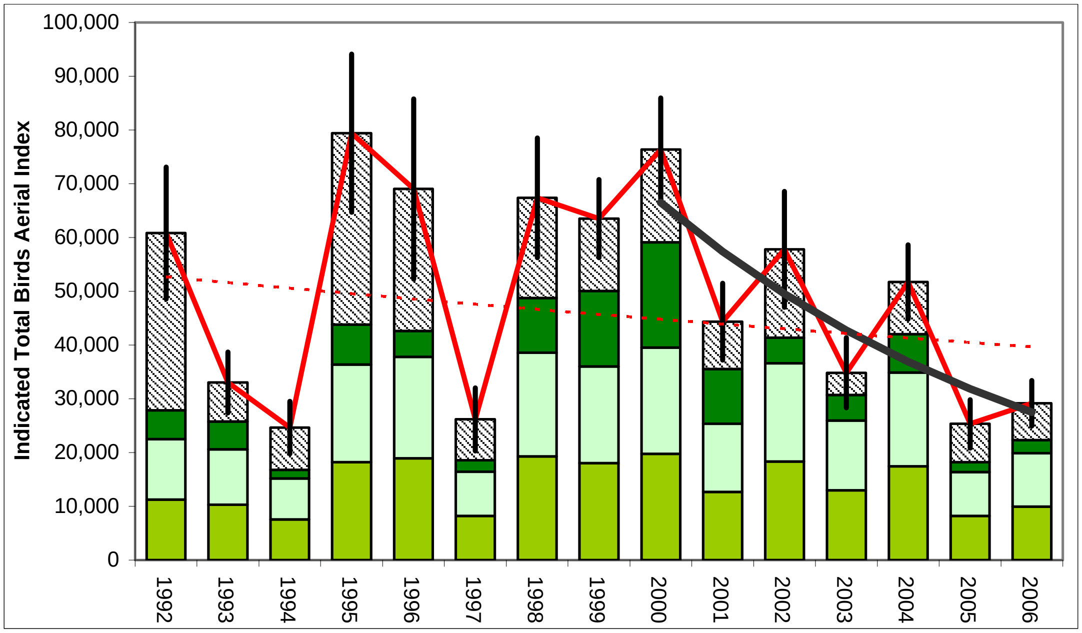

Aerial index: Indicated total birds S6d strata (n=11) AMWI

| 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 |
| 2006 | 124 | 184 | 149 | **457** | 281 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **378** |
| std dev = | 318 |
| ln linear slope = | 0.0115 |
| SE slope = | 0.0556 |
| Growth Rate = | **1.012** |
| low 90%ci GR = | 0.923 |
| high 90%ci GR = | 1.108 |
| regression resid CV = | 0.931 |
| avg sampling err CV = | 0.660 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 38.0 |
| w/ sample error CV = | 30.2 |
| most recent 7 years : | |
| Growth Rate = | **0.867** |
| low 90%ci GR = | 0.663 |
| high 90%ci GR = | 1.135 |

Figure 22. 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.

**Northern Pintail** North Slope early-June survey




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 | **25347** | 2297 |
| 2006 | 19892 | 2440 | 6822 | **29153** | 2164 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **49577** |
| std dev = | 19616 |
| ln linear slope = | -0.0203 |
| SE slope = | 0.0260 |
| Growth Rate = | **0.980** |
| low 90%ci GR = | 0.939 |
| high 90%ci GR = | 1.023 |
| regression resid CV = | 0.435 |
| avg sampling err CV = | 0.089 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 22.9 |
| w/ sample error CV = | 8.0 |
| most recent 7 years : | |
| Growth Rate = | **0.863** |
| low 90%ci GR = | 0.798 |
| high 90%ci GR = | 0.934 |

Figure 23. 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.

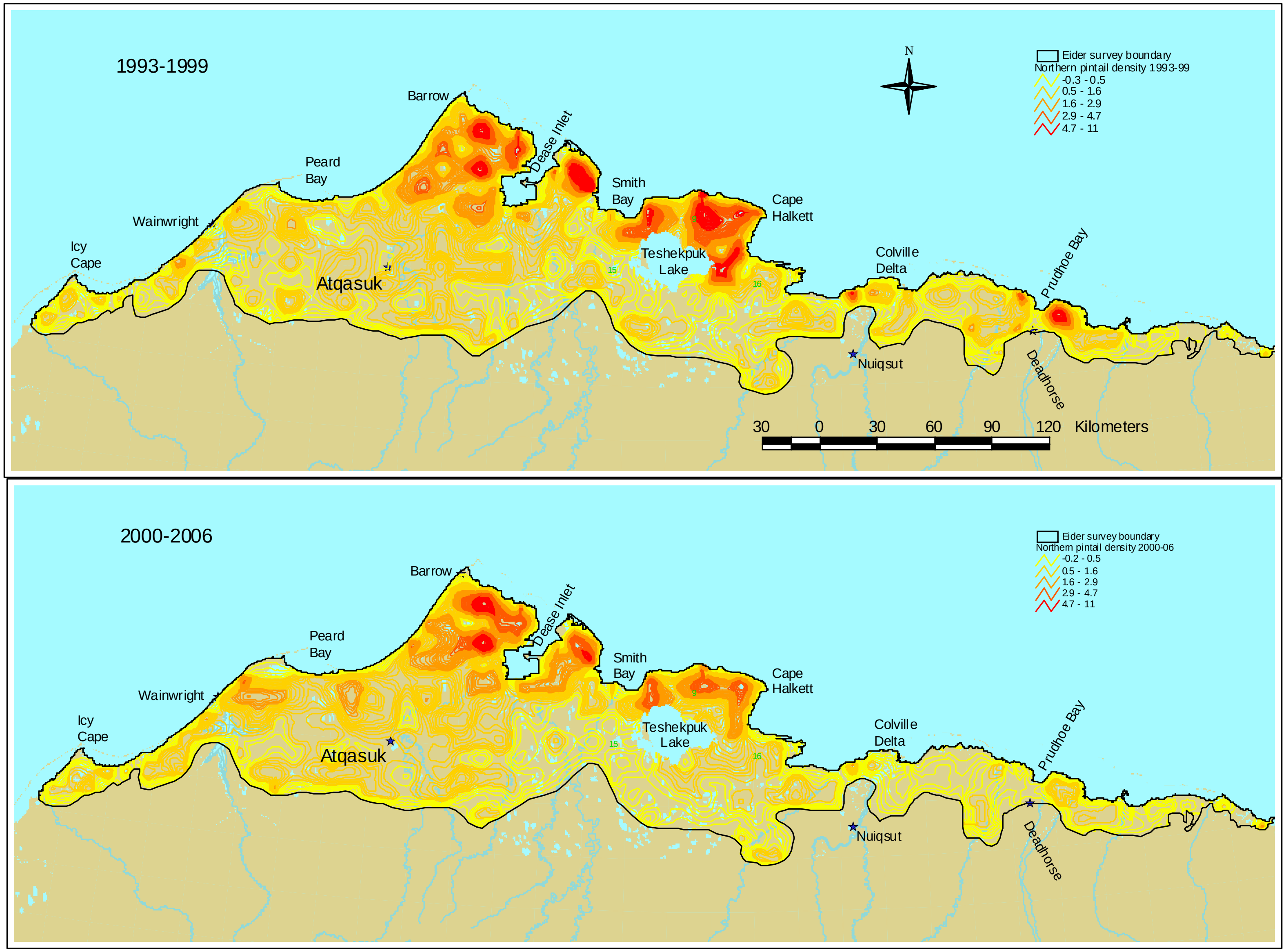
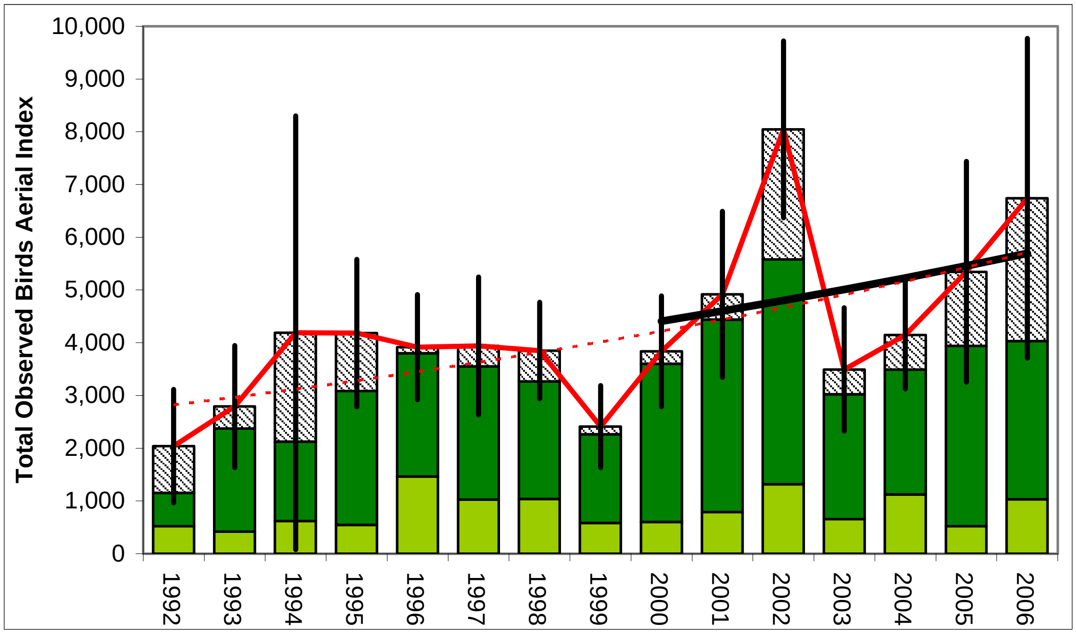



Figure 24. Mean northern pintail breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).




| Aerial index: Total birds observed | | | | S6d strata (n=11) | | SCAU | |
|---|---|---|---|---|---|---|---|
| year | sg | 2*pr | flocks | Index | Std Err | | |
| 1992 | 525 | 630 | 884 | **2039** | 549 | n yrs = | 15 |
| 1993 | 417 | 1954 | 420 | **2791** | 590 | mean = | **4257** |
| 1994 | 617 | 1510 | 2065 | **4192** | 2097 | std dev = | 1553 |
| 1995 | 547 | 2540 | 1096 | **4182** | 713 | ln linear slope = | 0.0504 |
| 1996 | 1462 | 2340 | 116 | **3917** | 508 | SE slope = | 0.0169 |
| 1997 | 1029 | 2520 | 392 | **3940** | 665 | Growth Rate = | **1.052** |
| 1998 | 1039 | 2230 | 581 | **3851** | 466 | low 90%ci GR = | 1.023 |
| 1999 | 581 | 1684 | 144 | **2410** | 396 | high 90%ci GR = | 1.081 |
| 2000 | 601 | 2998 | 240 | **3838** | 535 | | |
| 2001 | 787 | 3652 | 479 | **4918** | 803 | regression resid CV = | 0.284 |
| 2002 | 1319 | 4260 | 2467 | **8046** | 855 | avg sampling err CV = | 0.191 |
| 2003 | 658 | 2368 | 468 | **3494** | 597 | | |
| 2004 | 1121 | 2372 | 655 | **4149** | 523 | min yrs to detect -50%/20yr rate : | |
| 2005 | 524 | 3418 | 1404 | **5347** | 1068 | w/ regression resid CV = | 17.2 |
| 2006 | 1033 | 3000 | 2707 | **6739** | 1546 | w/ sample error CV = | 13.2 |
| | | | | | | most recent 7 years : | |
| | | | | | | Growth Rate = | **1.044** |
| | | | | | | low 90%ci GR = | 0.946 |
| | | | | | | high 90%ci GR = | 1.152 |

Figure 25. 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.

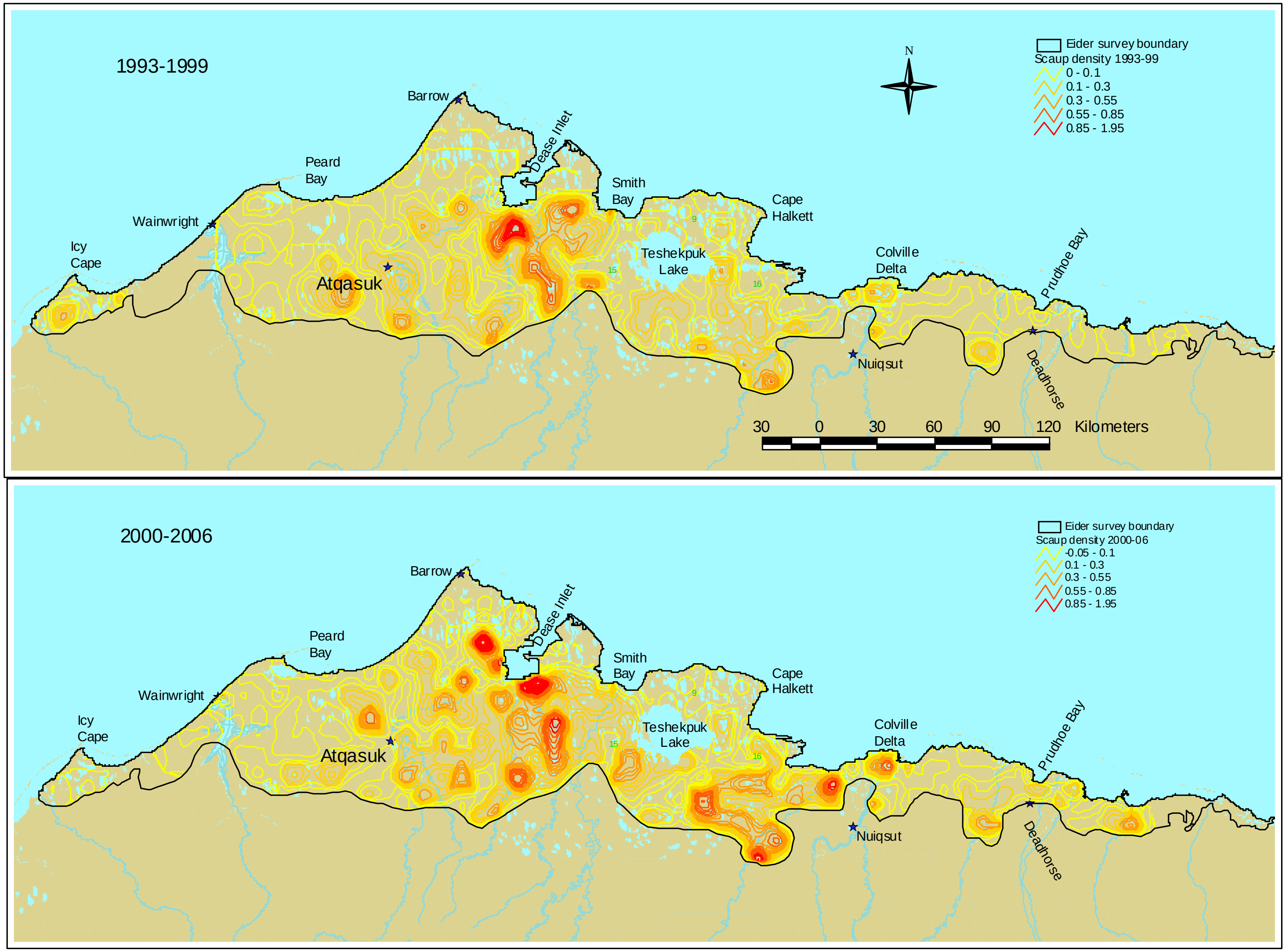
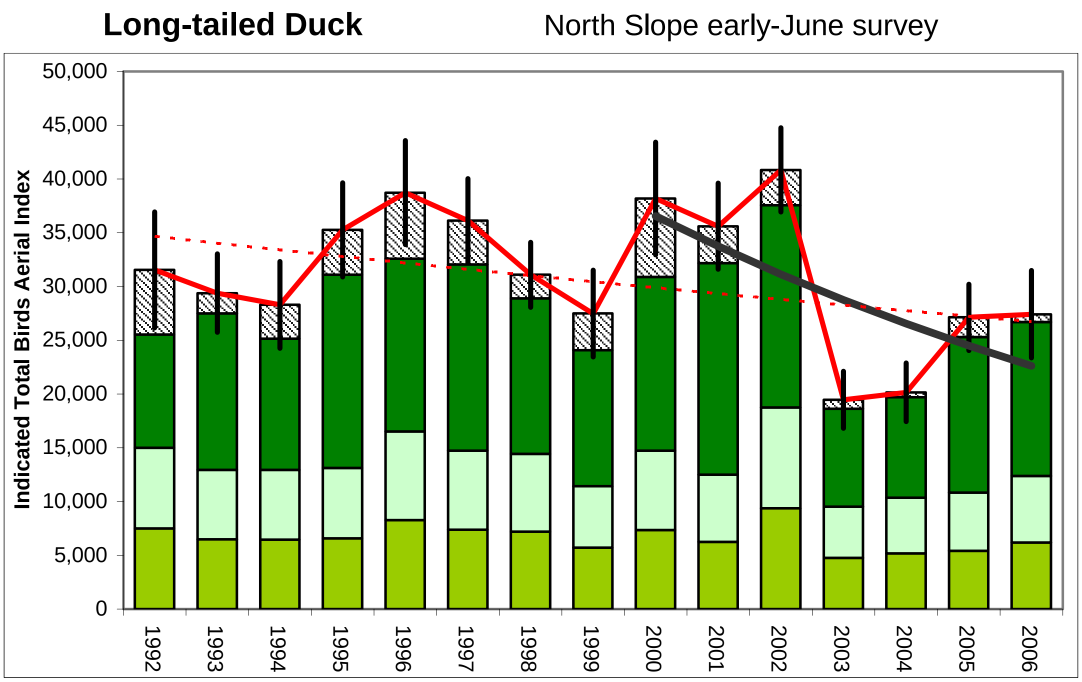



Figure 26. Mean greater scaup breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).




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 |
| 2006 | 12390 | 14292 | 736 | **27418** | 2069 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **31115** |
| std dev = | 6405 |
| ln linear slope = | -0.0185 |
| SE slope = | 0.0127 |
| Growth Rate = | **0.982** |
| low 90%ci GR = | 0.961 |
| high 90%ci GR = | 1.002 |
| regression resid CV = | 0.213 |
| avg sampling err CV = | 0.065 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 14.2 |
| w/ sample error CV = | 6.5 |
| most recent 7 years : | |
| Growth Rate = | **0.923** |
| low 90%ci GR = | 0.850 |
| high 90%ci GR = | 1.003 |

Figure 27. 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.

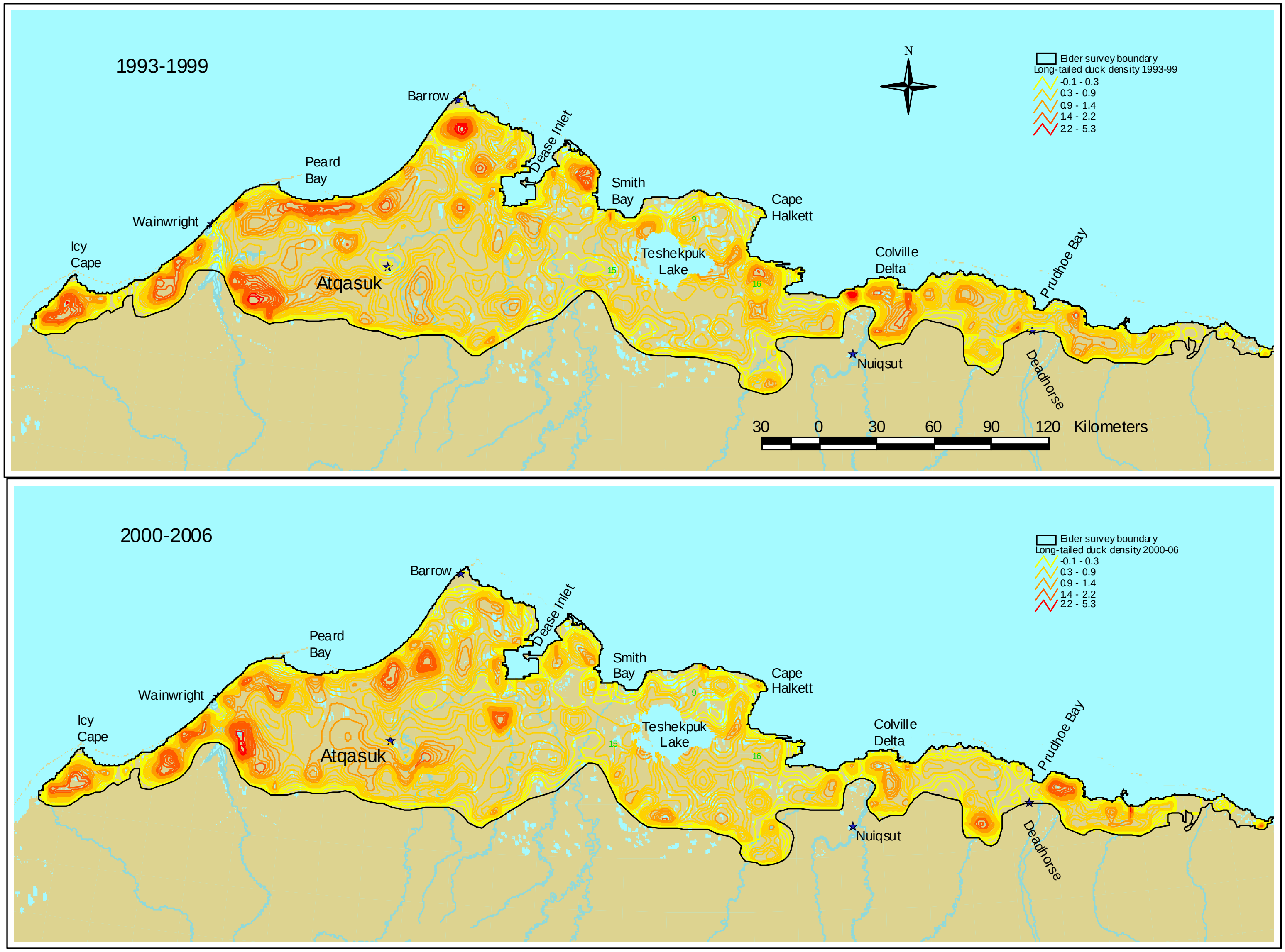
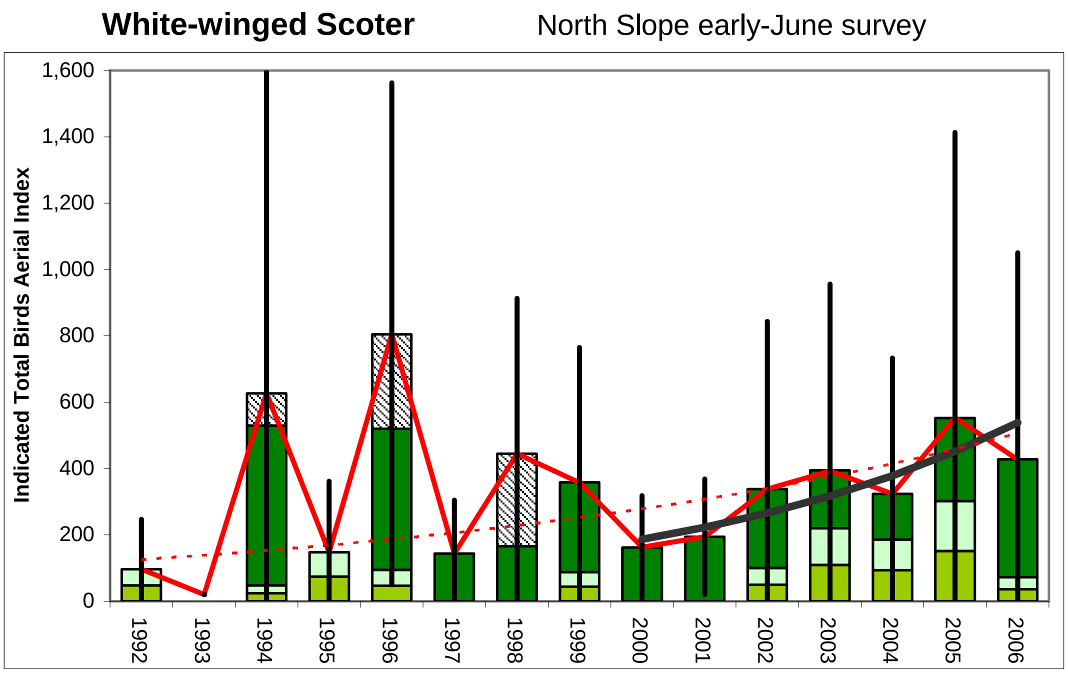



Figure 28. Mean long-tailed duck breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).

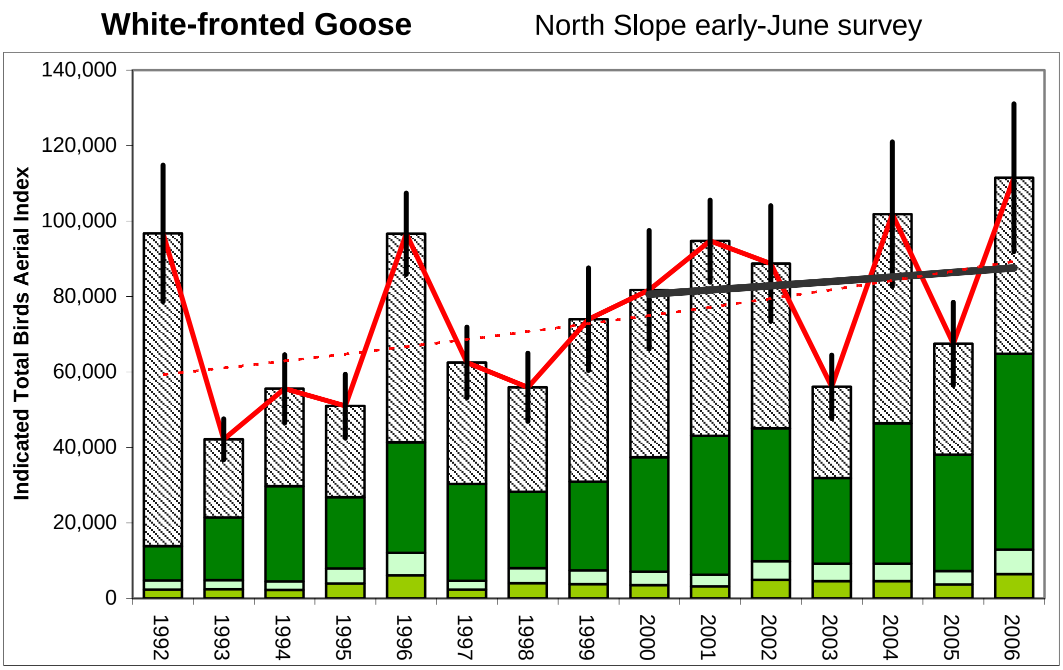



Aerial index: Indicated total birds S6d strata (n=11) WWSC

| 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 |
| 2006 | 72 | 356 | 0 | **427** | 318 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **336** |
| std dev = | 217 |
| ln linear slope = | 0.0998 |
| SE slope = | 0.0505 |
| Growth Rate = | **1.105** |
| low 90%ci GR = | 1.017 |
| high 90%ci GR = | 1.201 |
| regression resid CV = | 0.846 |
| avg sampling err CV = | 0.611 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 35.6 |
| w/ sample error CV = | 28.7 |
| most recent 7 years : | |
| Growth Rate = | **1.193** |
| low 90%ci GR = | 1.111 |
| high 90%ci GR = | 1.281 |

Figure 29. 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.




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 |
| 2006 | 12904 | 51904 | 46660 | **111468** | 9990 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **75784** |
| std dev = | 21675 |
| ln linear slope = | 0.0292 |
| SE slope = | 0.0166 |
| Growth Rate = | **1.030** |
| low 90%ci GR = | 1.002 |
| high 90%ci GR = | 1.058 |
| regression resid CV = | 0.278 |
| avg sampling err CV = | 0.082 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 17.0 |
| w/ sample error CV = | 7.5 |
| most recent 7 years : | |
| Growth Rate = | **1.014** |
| low 90%ci GR = | 0.935 |
| high 90%ci GR = | 1.100 |

Figure 30. 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.

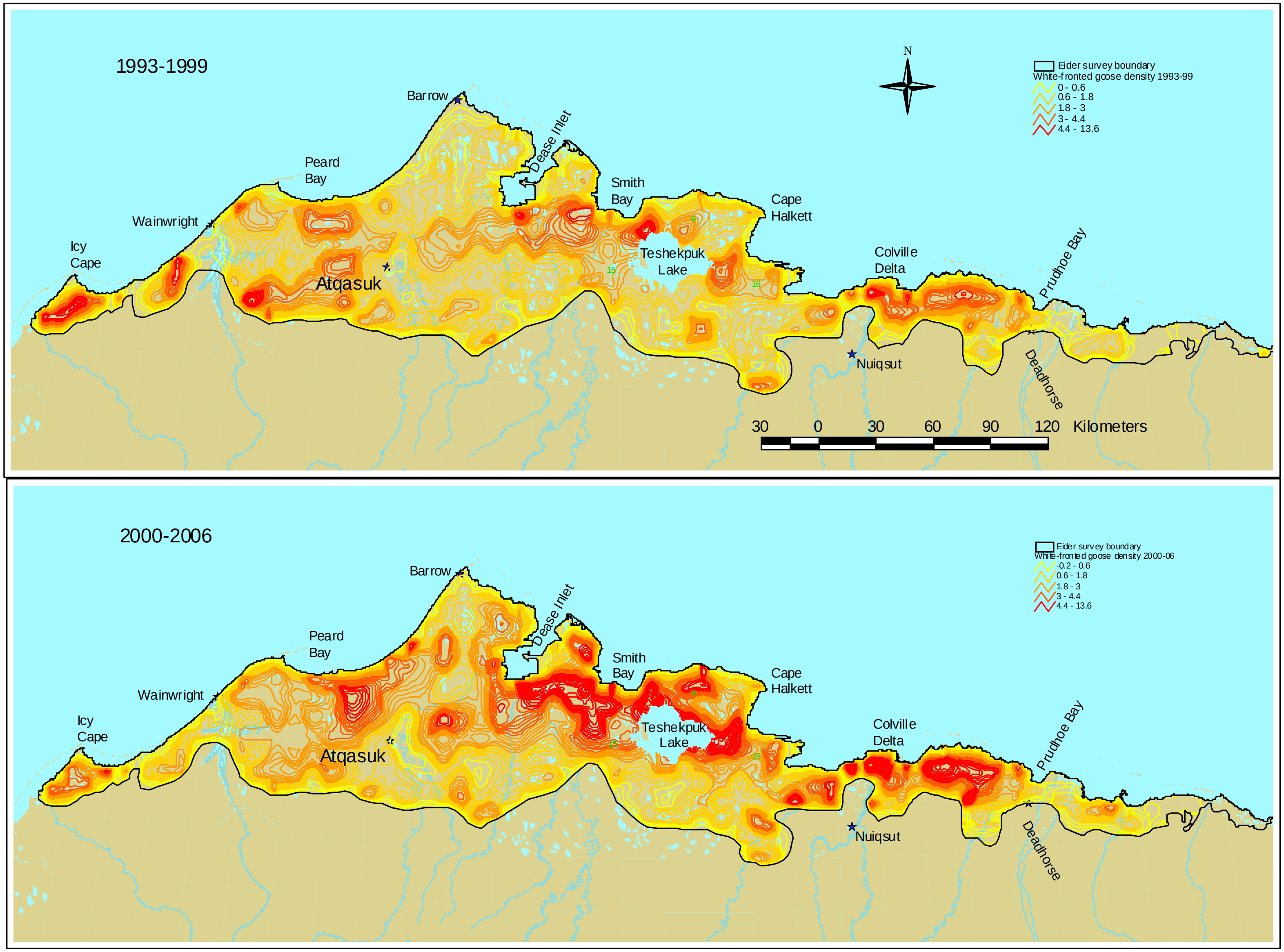
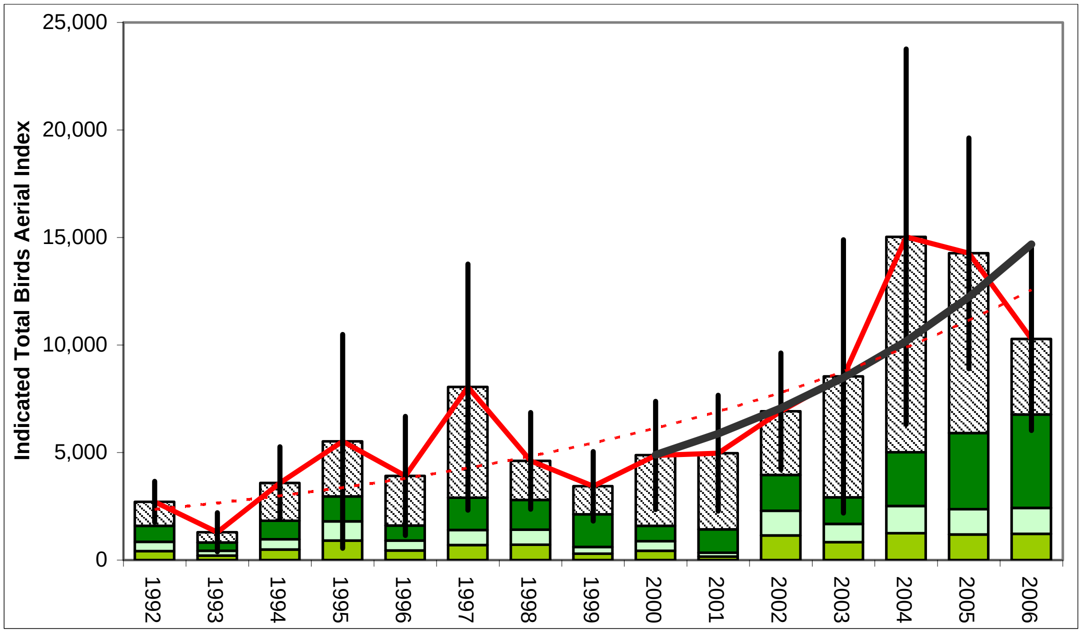



Figure 31. Mean white-fronted goose breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).



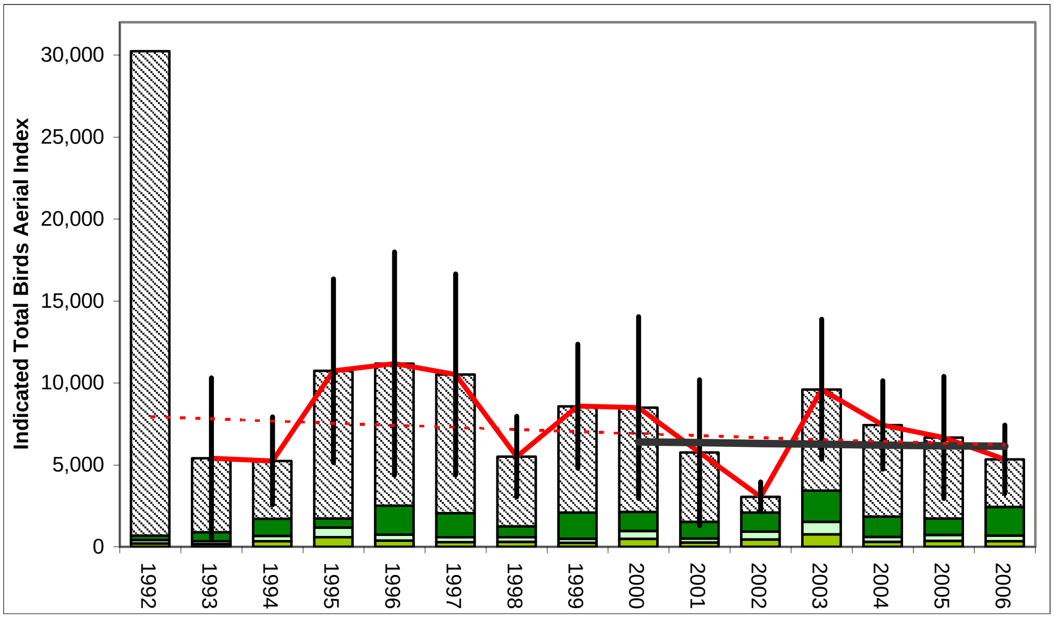

Aerial index: Indicated total birds S6d strata (n=11) BRAN

| 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 |
| 2006 | 2426 | 4340 | 3511 | **10276** | 2169 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **6532** |
| std dev = | 4050 |
| ln linear slope = | 0.1195 |
| SE slope = | 0.0227 |
| Growth Rate = | **1.127** |
| low 90%ci GR = | 1.086 |
| high 90%ci GR = | 1.170 |
| regression resid CV = | 0.380 |
| avg sampling err CV = | 0.284 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 20.9 |
| w/ sample error CV = | 17.2 |
| most recent 7 years : | |
| Growth Rate = | **1.201** |
| low 90%ci GR = | 1.108 |
| high 90%ci GR = | 1.301 |

Figure 32. 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.

**Canada Goose** North Slope early-June survey

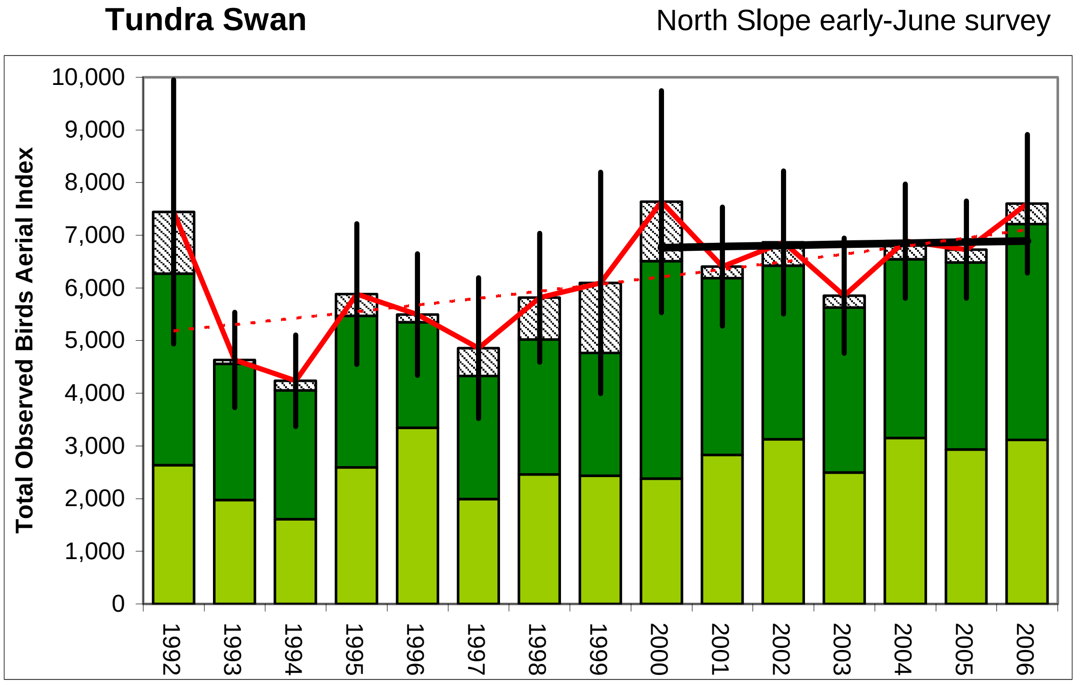



Aerial index: Indicated total birds — S6d strata (n=11) — CAGO

| 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 | 4932 | **6673** | 1902 |
| 2006 | 690 | 1744 | 2907 | **5340** | 1062 |

| | |
|---|---|
| n yrs = | 14 |
| mean = | **7394** |
| std dev = | 2502 |
| ln linear slope = | -0.0176 |
| SE slope = | 0.0249 |
| Growth Rate = | **0.983** |
| low 90%ci GR = | 0.943 |
| high 90%ci GR = | 1.024 |
| regression resid CV = | 0.376 |
| avg sampling err CV = | 0.273 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 20.8 |
| w/ sample error CV = | 16.8 |
| most recent 7 years : | |
| Growth Rate = | **0.993** |
| low 90%ci GR = | 0.873 |
| high 90%ci GR = | 1.129 |

Figure 33. 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.




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

| 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 |
| 2006 | 3112 | 4102 | 385 | **7600** | 671 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **6163** |
| std dev = | 1062 |
| ln linear slope = | 0.0225 |
| SE slope = | 0.0093 |
| Growth Rate = | **1.023** |
| low 90%ci GR = | 1.007 |
| high 90%ci GR = | 1.038 |
| regression resid CV = | 0.156 |
| avg sampling err CV = | 0.112 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 11.5 |
| w/ sample error CV = | 9.3 |
| most recent 7 years : | |
| Growth Rate = | **1.003** |
| low 90%ci GR = | 0.972 |
| high 90%ci GR = | 1.035 |

Figure 34. 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.

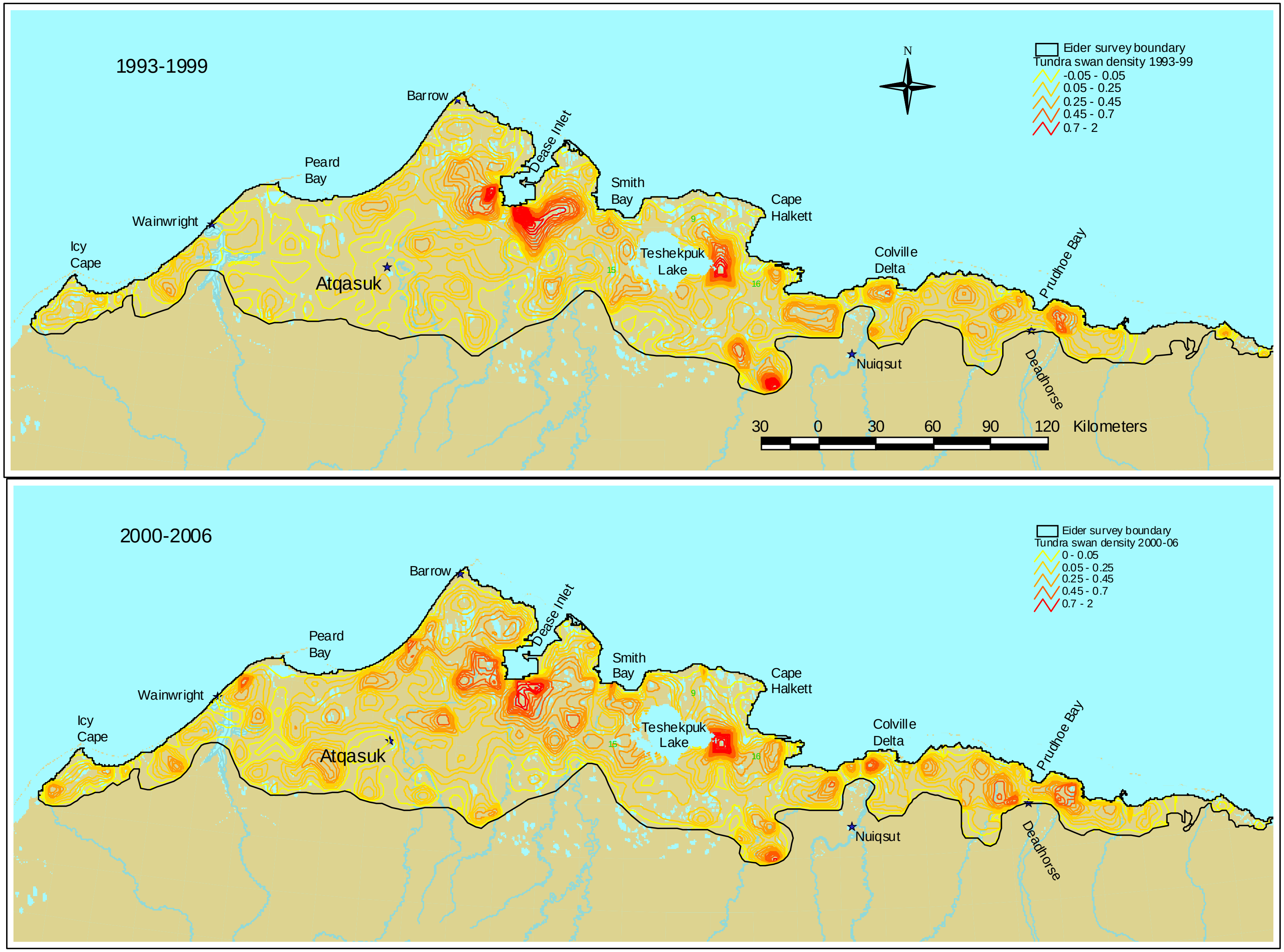
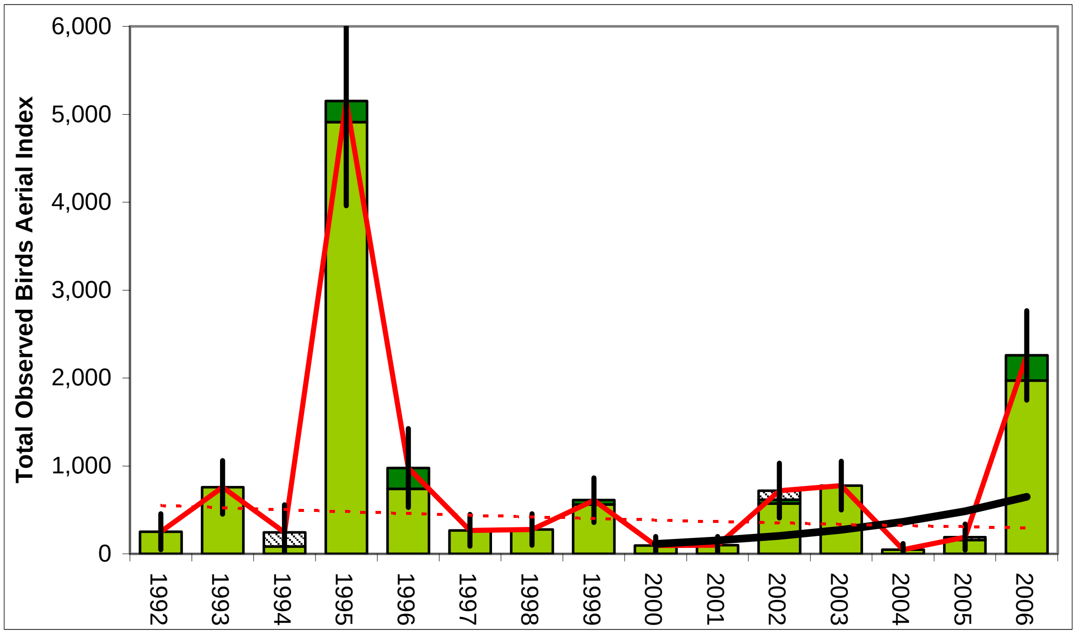



Figure 35. Mean tundra swan breeding densities, Alaska Arctic Coastal Plain, 1993-99 (above) and 2000-06 (below).

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



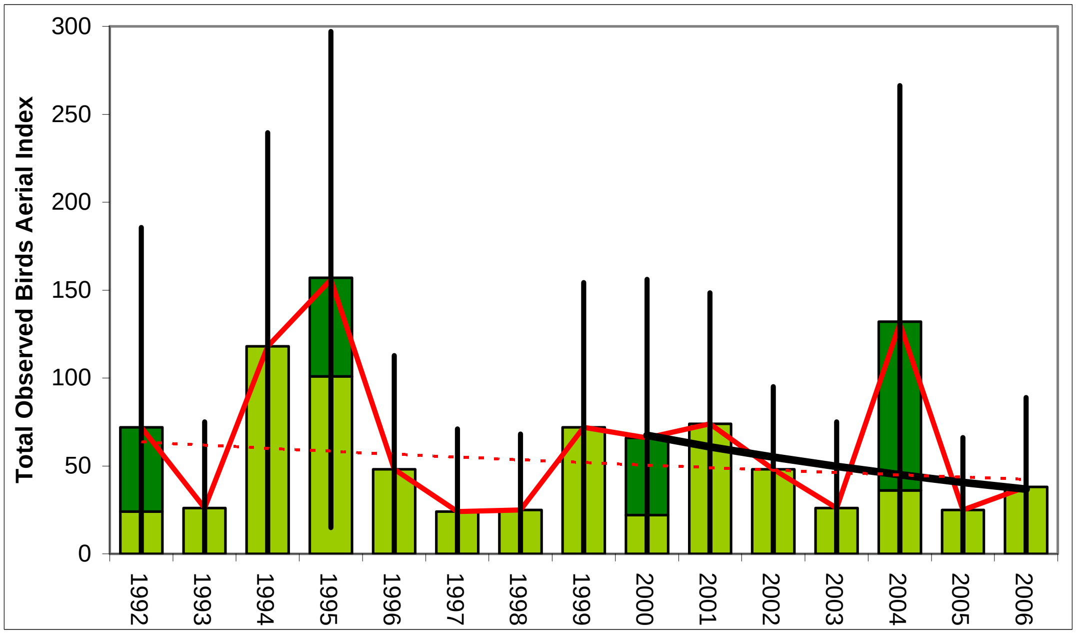

Aerial index: Total birds observed S6d strata (n=11) SNOW

| 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 |
| 2006 | 1971 | 286 | 0 | **2256** | 259 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **848** |
| std dev = | 1314 |
| ln linear slope = | -0.0446 |
| SE slope = | 0.0757 |
| Growth Rate = | **0.956** |
| low 90%ci GR = | 0.844 |
| high 90%ci GR = | 1.083 |
| regression resid CV = | 1.271 |
| avg sampling err CV = | 0.347 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 46.7 |
| w/ sample error CV = | 19.7 |
| most recent 7 years : | |
| Growth Rate = | **1.337** |
| low 90%ci GR = | 0.874 |
| high 90%ci GR = | 2.046 |

Figure 36. 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.

**Common Raven** North Slope early-June survey

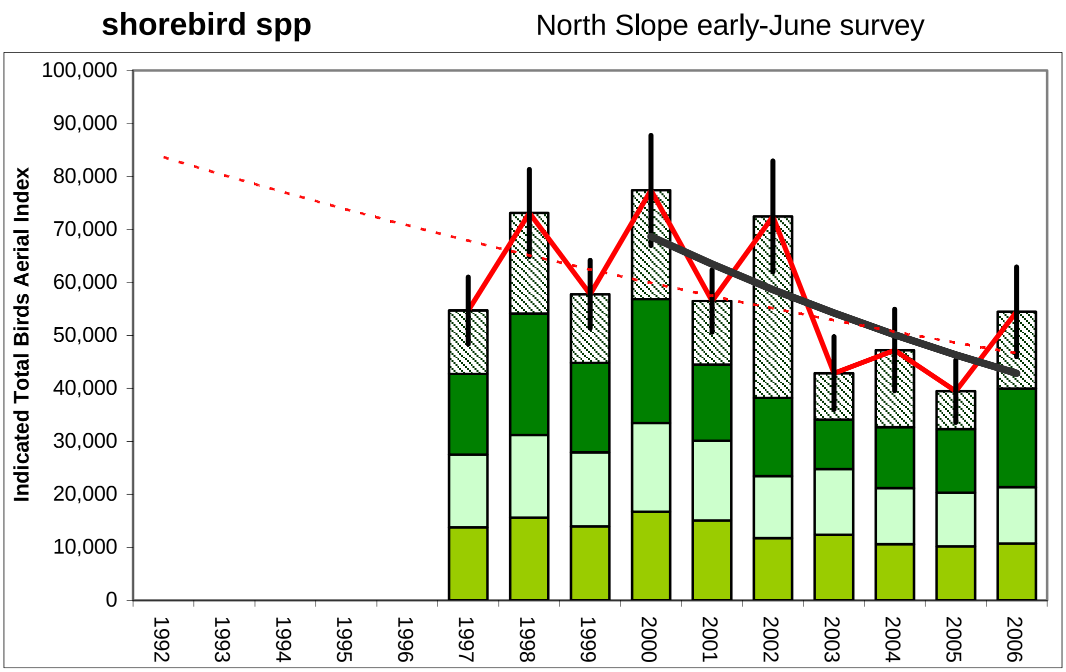



Aerial index: Total birds observed — S6d strata (n=11) — CORA

| 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 |
| 2006 | 38 | 0 | 0 | **38** | 26 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **63** |
| std dev = | 42 |
| ln linear slope = | -0.0290 |
| SE slope = | 0.0393 |
| Growth Rate = | **0.971** |
| low 90%ci GR = | 0.911 |
| high 90%ci GR = | 1.036 |
| regression resid CV = | 0.659 |
| avg sampling err CV = | 0.709 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 30.2 |
| w/ sample error CV = | 31.7 |
| most recent 7 years : | |
| Growth Rate = | **0.904** |
| low 90%ci GR = | 0.748 |
| high 90%ci GR = | 1.093 |

Figure 37. 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 | | | | | |
| 1993 | | | | | |
| 1994 | | | | | |
| 1995 | | | | | |
| 1996 | | | | | |
| 1997 | 27506 | 15240 | 11938 | **54684** | 3226.2 |
| 1998 | 31170 | 22922 | 18990 | **73082** | 4186.5 |
| 1999 | 27912 | 16890 | 12950 | **57753** | 3270.6 |
| 2000 | 33470 | 23394 | 20507 | **77369** | 5294.1 |
| 2001 | 30096 | 14380 | 12009 | **56483** | 3003.4 |
| 2002 | 23432 | 14806 | 34207 | **72445** | 5338.7 |
| 2003 | 24782 | 9326 | 8771 | **42879** | 3517.4 |
| 2004 | 21192 | 11504 | 14517 | **47212** | 3930.8 |
| 2005 | 20300 | 12016 | 7144 | **39460** | 2997 |
| 2006 | 21396 | 18562 | 14483 | **54440** | 4316 |

ULUS

| | |
|---|---|
| n yrs = | 10 |
| mean = | **57581** |
| std dev = | 13014 |
| ln linear slope = | -0.0417 |
| SE slope = | 0.0221 |
| Growth Rate = | **0.959** |
| low 90%ci GR = | 0.925 |
| high 90%ci GR = | 0.995 |
| regression resid CV = | 0.201 |
| avg sampling err CV = | 0.069 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 13.7 |
| w/ sample error CV = | 6.7 |
| most recent 7 years : | |
| Growth Rate = | **0.924** |
| low 90%ci GR = | 0.867 |
| high 90%ci GR = | 0.986 |

Figure 38. Population trend for combined shorebird species (sandpipers, phalaropes, plovers, whimbrel, godwit, dowitcher, snipe) 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.