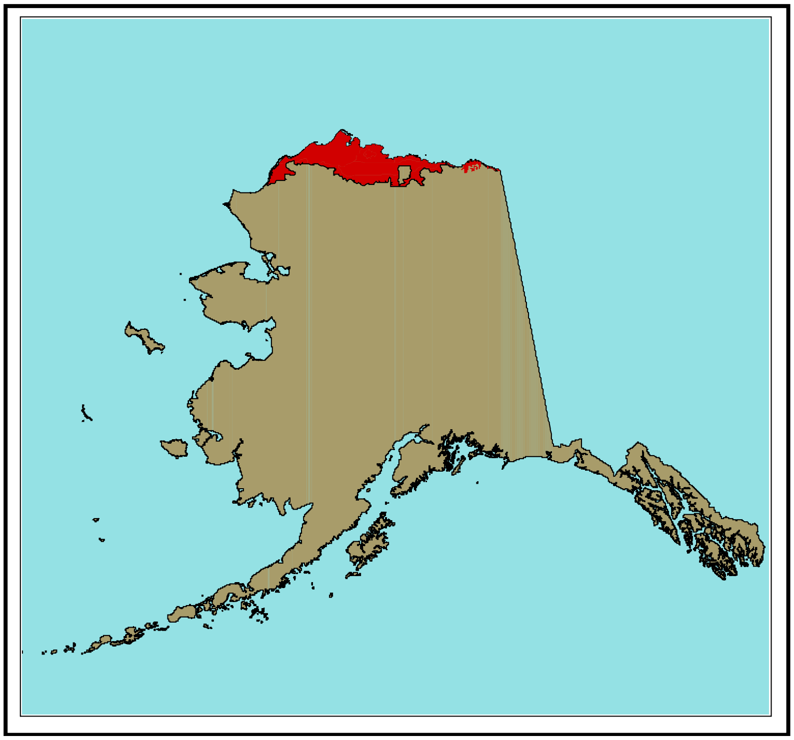
WATERFOWL BREEDING POPULATION SURVEY
ARCTIC COASTAL PLAIN, ALASKA
2010



William Larned[1]
Robert Stehn[2]
Robert Platte[2]

U.S. Fish and Wildlife Service
Division of Migratory Bird Management
[1]Waterfowl Mgt. Branch, 43655 KBeach Rd., Soldotna, AK 99669
[2]Waterfowl Mgt. Branch, 1011 E. Tudor Rd., Anchorage, AK 99503
November 23, 2011

Waterfowl breeding population survey, Arctic Coastal Plain, Alaska 2010

WILLIAM W. LARNED, *U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, 43655 Kalifornsky Beach Rd., Soldotna, Alaska 99669*

ROBERT S. STEHN, **ROBERT M. PLATTE,** *U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, 1011 E. Tudor Rd., Anchorage, Alaska 99503.*

ABSTRACT. Waterfowl breeding population surveys have been completed annually on the Arctic Coastal Plain of Alaska since 1986. Methods for the 2010 Arctic Coastal Plain Waterfowl Breeding Population Survey (ACP survey) were similar to those employed since 2007, when a single survey was implemented to address objectives of two pre-existing surveys: the geographically comprehensive 1986 ACP survey conducted in mid-June to early July, and the geographically limited 1992-2006 North Slope Eider Survey, conducted in early to mid June to target the early phenology and breeding range of eiders. The current redesigned ACP survey utilizes a 57,336 km^2 spatial coverage roughly equivalent to the previous ACP survey, but its timing is similar to the previous North Slope Eider Survey. The current design also incorporates an annually-shifting transect grid, completed and repeated on a 4-year rotational basis. The survey flown in 2010 completed the first 4-year set of the redesigned ACP survey. Due to a crewmember family emergency the last one-half of the 2010 survey was delayed, which we suspect resulted in decreased precision of our estimates for some species. Airborne data collection methods followed the Standard Operating Standards (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987) utilized for breeding pair surveys by natural resource agencies throughout North America. In this report we present spatial distribution, breeding densities and comparisons with Standard population size using the entire new ACP survey area (57,336 km^2). We restrict trend analyses to data from the northern coastal region that corresponds to the former North Slope Eider Survey area (30,465 km^2) because of the similarity in phenological timing of the current survey and the former North Slope Eider Survey. We tested for population growth rates significantly greater or less than 1.0 (with significance probability <0.10) for all survey years (1992-2010) and for the most recent 10 years (2001-2010). Of these, the 1992-2010 growth rates for red-throated loon, and spectacled eider were <1.0, while those for yellow-billed loon, scaup, king eider, greater white-fronted goose and tundra swan were >1.0. During the most recent 10 years, spectacled eider had growth rates <1.0, while growth rates of scaup, greater white-fronted goose and tundra swan were >1.0. Indices for greater white-fronted geese and tundra swans have been well above Standard levels for 4 consecutive years. The 2010 spectacled eider index (6,286) was below the 18-year mean (6,526). Based on our results through 2010 we recommend a review of long-term viability for the ACP breeding populations of spectacled eiders and red-throated loons. We include maps showing breeding density isopleths for most species from composite 4-year survey data.

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

INTRODUCTION

From 1992 to 2006, two aerial waterfowl breeding pair surveys were conducted on the Arctic Coastal Plain (ACP) annually. The first was a comprehensive aerial waterfowl breeding population survey initiated in 1986, and continued annually to 2006. That survey (herein referred to as the "Standard ACP Survey"), was conducted from late June through early July. This timing was selected based both to target what was believed by the survey crew to be the optimal window to assess the abundance and breeding distribution of the majority of waterfowl species considered high priority at the time, and to avoid scheduling conflict with other spring surveys. It soon became evident that late June missed the optimal timing for eiders, the males of which depart the breeding grounds for the post-nuptial molt soon after nest initiation, typically about 20 June ± one week, but at that time there was relatively little management interest in those species. However, in response to a 1990 petition to list spectacled and Steller's eiders under the Endangered Species Act, the North Slope Eider Survey was initiated in 1992, timed in early to mid June to coincide with the peak presence of adult males on the breeding grounds, and designed to assess and monitor the abundance and distribution of spectacled and Steller's eiders. The latter Survey consistently provided precise data for spectacled eiders and king eiders, while those for Steller's eiders had relatively low power to detect trends due to mismatch between the latter's very low breeding densities and survey design.

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

The present survey is titled the "Waterfowl Breeding Population Survey, Arctic Coastal Plain, Alaska", and referred to in this report as the "ACP Survey". The survey design consists of four sets of equally-spaced parallel transects which are surveyed on a four-year rotational basis. This report describes the methods and results of the 2010 ACP survey and the first completed four-year rotation of the current design. For trend analysis we combined the 1992-2006 North Slope Eider Survey data set with a geographically identical subset of the ACP survey 2007-2010 (hereafter referred to as the "northern coastal strata"). We believe this subset provides the most spatially and phenologically consistent data set available for trend, while the total ACP survey area is more spatially comprehensive to describe spatial distribution. We have also included long-term means from the Standard ACP Survey (1986-2006) for comparison with current ACP indices for comprehensive coastal plain geographic context.

OBJECTIVES

Objectives for the 2010 ACP Survey relate to the Spectacled Eider Recovery Plan (U. S. Fish and Wildlife Service 1996), evaluation of the potential impacts of extractive resource development to migratory birds, and USDOI obligations for annual assessment of harvested waterfowl populations under the Migratory Bird Treaty Act of 1918, as follows:

Spectacled Eider Recovery Plan

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

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

<u>Specific objectives:</u>

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

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

Evaluation of potential impacts of oil and gas development on waterbird resources

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

Migratory Bird Treaty Act obligations

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

STUDY AREA AND METHODS

Aerial crew for 2010:

William Larned, *US Fish and Wildlife Service, Migratory Bird Management, Soldotna, Alaska*

Karen Bollinger, *Migratory Bird Management, Fairbanks, Alaska*

Wade Schock, *University of Alaska, Anchorage, Alaska*

Study area, survey design, navigation, and observation

The geographic extent of the ACP Survey area (Fig. 1) has been consistent subsequent to survey redesign in 2007, and consists of a 57,336 km^2 portion of the 61,645 km^2 Standard ACP Survey area (1986-2006). Small areas (total 4,309 km^2) of relatively poor upland waterfowl habitat were deleted from the Standard ACP survey in 2007 to increase overall efficiency. Procedures followed the standard protocol described in the "Standard Operating Procedures for Aerial Waterfowl Breeding Ground Population and Habitat Surveys in North America" (U. S. Fish and Wildlife Service and Canadian Wildlife Service 1987). A series of transects, oriented in an east-west direction (Fig. 1), were flown in a Cessna model 206 amphibious aircraft, at 38 m altitude and 176±19km/hr ground speed. Both the pilot and the starboard observer recorded all waterbirds, and avian predators observed within 200m either side of the flight path. To estimate the outer transect boundary we determined the required viewing angle trigonometrically and marked a reference point on the wing strut for each observer using a clinometer and marking tape.

Transects consisted of computer-generated great circle segments, for compatibility with Global Positioning System (GPS) navigation. Transects were spaced systematically in each of 20 geographic strata (Fig. 1, Table 1) from a randomly-selected starting point. Distance between transects varied by stratum, in 4 categories of sampling intensity: Low (7.2 km), Medium (4.8 km), High (2.4 km) and Very High (1.2 km). Stratification and spacing assignments were based on a combination of physiographic (mostly hydrographic) characteristics, Standard waterfowl breeding density data (from previous North Slope Eider and ACP surveys), and boundaries of different management units, such as planning areas for current and proposed oil and gas leases. In each stratum every fourth transect was flown in a given year; the sampling frame shifted incrementally the following year. Four years were required for coverage of all transects, after which the cycle will be repeated; thus transects flown in 2010 will be flown again in 2014. Stratification facilitated comparisons among geographic areas and provided a framework for more efficient sample allocation to decrease the magnitude of total sample variance. Transects flown in 2010 are depicted in Fig. 1.

Flight time required to complete the 2010 ACP Survey was 60.1 hours, not including ferry time to and from the survey area.

Data recording and transcription

Each observer had a notebook computer, into which bird observations were entered vocally via a remote microphone. Each computer received position data concurrently from a GPS receiver mounted in the aircraft instrument panel, and was supplied with power via a DC to AC power inverter connected to the aircraft's electrical system. The vocal and GPS inputs resulted in a sound file (.wav format) with voice recording, and a linked position file containing location, date and time. After the flight, the observer played back the sound file on the computer and entered the species name and group size for each observation using a custom transcribing program. The transcription program produced an ASCII text file, each line of which contained a species code, group size, geographic coordinates, date, time, observer code, observer position in aircraft, stratum and transect identifier. The system also recorded a "track file" consisting of a list of the aircraft's geographic coordinates every five seconds during flight. These data files were used to produce the maps, tables and other data products for this report. 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.

Data Analysis

We provide an index to the number of individuals of each waterfowl species and other selected bird species present within the survey area. The term index as used here is defined as a number that represents an unknown proportion of the population of birds occupying the survey area during the nesting season and detected by the observers. While unknown, the proportion is assumed to be consistent enough among years to provide trend information sufficient to inform management decisions relative to spectacled eiders and others of the more abundant waterbird species.

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

We present population estimates where applicable in tables 3, 4 and 6. The term population estimate as used here is based on index estimates expanded using visibility correction factors derived during a three-year helicopter/fixed wing study conducted in tundra habitat on the Yukon-Kuskokwim Delta (Conant et al. 1991). This is designed to convert population indices to population estimates by accounting for birds present but not detected by observers in fixed wing aircraft. Untested assumptions were: 1. the helicopter crew recorded all birds present, 2. observers are equal in performance, and 3. detection rates of ducks in the Yukon-Kuskokwim Delta are similar to those in the ACP. Eiders were not included in the YK delta study, so no VCF is applied for eiders.

Bias

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

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

Our procedure for determining 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 a reconnaissance survey to determine whether or not waterfowl, spectacled eiders in particular appeared to be occupying breeding territories as pairs, rather than in mixed-sex/species flocks. Our observations from past years in this area suggest this behavior normally occurs as soon as there is ice-free water in most shallow vegetated wetlands, and tundra vegetation is mostly snow-free around pond margins.

To determine retrospectively the accuracy of our survey timing for spectacled and king eiders, long-tailed ducks and northern pintails, we used a ratio of males unaccompanied by females to total males (with and without females), averaged over the entire survey. Our sample for this statistic included all unaccompanied males in groups of 1to 4 only. This ratio, called the lone-drake index (LDI), was used for many years in the northern prairies of Canada and the U. S. (U.S. Fish and Wildlife Service and Canadian Wildlife Service 1987). The assumption inherent in this index is that the proportion of lone or grouped males in the surveyed population will increase as the season progresses because males remain visible on breeding ponds, while females spend more time with nesting activities. The index is easy to interpret for many dabbling ducks that normally remain on the breeding grounds after nest initiation to molt in local wetlands, whereas male eiders and other sea ducks depart the breeding grounds for distant, mostly marine molting habitats soon after nest initiation, making them unavailable for observation. Hence, it is expected that the ratio will reach a peak at or slightly beyond the peak of nest initiation, followed by an abrupt drop as post-breeding males depart the survey area, while birds still visible may be mostly unsuccessful inexperienced pairs that stay on the breeding grounds beyond peak departure of successful males. This pattern has been observed in the Prudhoe Bay area (Warnock and Troy 1992). We consider the average lone drake ratio for the survey period and a plot of daily totals of this ratio helpful when considered in combination with other indicators of phenology, especially in determining the beginning of the survey window.

Detection bias is unaccounted for in the current survey analysis, though as noted above we have presented some duck indices adjusted using standard tundra Visibility Correction Factors developed on the YK Delta primarily to enable readers to more easily compare ACP populations with those from other parts of North America. This survey is designed to track the populations of large waterbirds that breed in the ACP. 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 such as fatigue, experience level, visual acuity, distractions, sunlight conditions, presence or absence of snow and ice, bird behavior, and work load (density of survey subjects and other objects competing for the observer's attention). As previously noted, we have attempted to minimize the effects of numbers 1 and 2 by adjusting 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 Eider Survey we conducted a fixed-wing/helicopter detection study covering a 270 km^2 subset of our operational transects. The results of this study were unsatisfactory in that our fixed-wing count often exceeded the helicopter count, suggesting a flaw in design or implementation. Therefore we resorted to an unadjusted annual index of abundance, for which we strive to minimize effects of observer bias by using the same observers (or those thoroughly trained to a common standard) and methods.

RESULTS

Habitat conditions, survey schedule

Mid-May, 2010 brought the promise of an early spring breakup on the ACP, but a heavy snow in late May changed that prognosis significantly. Imagery from the NASA MODIS satellite indicated most lakes and tundra on the coastal plain remained snow and ice covered until the second week of June, with the Barrow area the last to thaw (Fig. 2). This was nearly two weeks later than 2009, but still within the normal range with about average snow remaining by 10 June compared to the previous 10 years. The MODIS images also revealed extensive open water along the Chukchi coast from Point Hope to Barrow, but continuous ice persisted along the Beaufort coast east of Barrow until at least mid-June, which may have delayed passage of some east-bound sea ducks and other waterbirds.

The survey was initiated on 11 June, and generally favorable survey conditions prevailed through 14 June, at which time pilot/observer Bill Larned departed due to a family emergency. Karen Bollinger arrived to take over flying duties, and the rest of the survey was completed from 19-22 June without interruption.

The effect of the mid-survey crew change and resultant timing gap and relatively late coverage of the latter half of the survey made survey timing difficult to evaluate. Of the four species selected as timing indicators, spectacled eiders exhibited a high Lone-drake Index (LDI, the overall ratio of lone males to total males during the survey, a rough measure of survey timing in relation to nest initiation in ducks, Table 2.), The spectacled eider daily LDI showed an increasing trend, followed by a decline in the last survey days (Fig. 3). This pattern is consistent with synchronized nest initiation followed closely by male exodus which typically occurs about 20 June, leaving a small presence of late pairs which briefly reverses the ratio trend. The overall LDIs for king eiders and long tailed ducks were both average (Table 2). Daily LDI trend looked normal for long-tails, but that for king eiders was very erratic, reflecting a flocked bird component unusually high for this survey, and an obvious departure of males near the end of the survey. The flocked king eider component may have been transient birds unable to continue eastward migration due to the persistent Beaufort Sea ice. We suspect the low composite pintail LDI (Table 2) as well as the LDI decline during the final days of the survey (Fig. 3) resulted from many of the post-breeding males joining coastal molting flocks, again due to the lateness of the latter half of the survey. In general, we feel that the crew change and resultant delay in completion of the survey, coupled with the unusual spring weather and sea ice conditions resulted in less than optimal survey timing for most species in 2010. We found evidence for less than optimal survey timing in observations of loons, gulls, arctic terns, and scaup. For these species we do not double observed singles in analysis, thus we expect to see mostly pairs early in the breeding cycle, each of which contributes two birds to the index, while each observed single is one. If the survey is conducted after initiation of nests and especially incubation, the available sample will be reduced by approximately the number of birds on nests at any given time, thereby reducing the index. This year most nests were probably initiated prior to completion of the survey.

The late completion of the survey probably also slightly reduced the indices for eiders whose males tend to depart the breeding grounds shortly after nest initiation. There was a decrease in king eiders this year, along with an unusually large flocked component, suggesting pre-departure flocked males or early failed breeders.

Population indices for selected species

Totals for 2010 sample data (singles, pairs and flocked birds in the sample), as well as indices calculated from these data, are presented in Table 3 for northern coastal strata (strata 3-6, 9, 11, 15, 18-20), and Table 4 for all strata. Table 5 presents long-term population index trend slopes, growth rates, and the power of the survey to detect trends (expressed as the minimum number of years required to detect a growth rate equivalent to a population growth or decline of 50 percent in 20 years), using data from the northern coastal strata only. Table 6 provides a comparison of 2010 indices from the entire survey area with averages from 2007-2010 (current design) and 1986-2006 means from the Standard ACP Survey (Mallek et al. 2007). Figures 4-32 include breeding density polygon maps for most species summarizing distribution of 2007-2010 observations for all 20 strata, and stacked bar graphs describing the size and composition of the 2010 and Standard population indices for selected species for the 10 northern coastal strata. Column divisions in the latter graphs separate the sample into singles, assumed mates of singles, and birds in pairs, small flocks (≤5 birds) medium flocks (6-30 birds), and large flocks (>30 birds). Population growth rates are given for the full 19 years of data (fewer in some cases -- see Table 5) and the most recent 10 years. The variance of mean density is calculated using a ratio estimator accounting for the unequal length transects within each stratum. Total variance is the sum of the strata variances. The variance reflects the sampling error associated with geographic variation in density among transects and other differences such as variation in observation conditions during the day or days of observation within each stratum. Differences between strata, phenological timing, years, observer effects, and detection rates are not included in the measured variance.

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

Loons

The 2010 yellow-billed loon index (1,223) is 28% below the survey record of 2009, but 6% above the long-term mean, and the population growth rate indicates a significant positive trend over the long term (Tables 3-5, Fig. 4). In contrast, the 2007-2010 average is 11% below that of the 1986-2006 Standard ACP survey (Table 6). We believe the higher estimates attributed to the Standard ACP survey are due to the later timing relative to the current ACP survey (Earnst et al. 2005), whereby an influx of non-breeding yellow-billed loons arrive on the ACP in late June. Distribution was similar to other years, with most of the population in the area between the Meade and Colville rivers, and southward to the southern survey boundary (Fig. 4). The Pacific loon index (15,362) is the second lowest for the survey, 48% below the 2009 record high, and 27% below the long-term average (Tables 3-5, Fig. 5). The Pacific loon index has been very erratic since 2007, after 13 years of relative stability, but still shows a level trend over both long and recent terms (Fig. 5). The 2007-2010 average for all strata is 18% above that of the ACP survey from 1986-2006. Pacific loons are abundant throughout most of the ACP where there are high pond densities (Fig. 5). The 2010 red-throated loon northern coastal strata index (1,578) was one of the lowest on record, contributing to the significant long-term downward trend (Tables 3 & 5, Fig. 6), but the recent 10-year trend is essentially level. On the larger geographic scale, the ACP 2007-2010 mean is 13% below that of the ACP 1986-2006 mean (Table 6), which is a smaller decline than that of the northern coastal strata, but less convincing due to the timing difference. Red-throated loon observations show a predominately coastal breeding distribution, with the exception of the central arctic between Atqasuk and Nuiqsut, where they occur further inland, associated with river flood plains (Fig. 6). As noted earlier, we believe the major delay in the last one-half of the survey in 2010 may have caused part of the noted decrease in indices for all three loon species compared to the 3 prior years.

Jaegers

The three endemic Jaeger species (pomarine, parasitic and long-tailed) are combined for this survey to help reduce diversion of observer focus from eiders and other high priority species. The jaeger index fluctuates widely, probably owing mostly to the dependence of pomarine and long-tailed jaegers on the irruptive cycles of microtine prey (primarily North American brown lemming, *Lemmus trimucronatus;* Wiley and Lee 1999, 2000), forgoing breeding or breeding elsewhere when lemmings are in short supply. The parasitic jaeger, on the other hand, normally breeds every year and depends more on small birds and eggs. The jaeger index spiked across much of the arctic coastal plain in 2006, but has since maintained close to the long-term average (Fig. 7). The 2010 jaeger index (3,690) is 11% below the 1992-2010 mean (Tables 3,5; Fig. 7). The variable annual index does not indicate a significant trend in either short or long term (Table 5, Fig. 7). While erratic from year to year in response to spatial changes in prey abundance, their distribution appears fairly homogeneous throughout the APC over the 2007-2010 period (Fig. 7).

Gulls & terns

Discounting birds in flocks, (strongly influenced by clumped distribution) the glaucous gull long-term trend has remained essentially level and stable, while that for the most recent 10 years is significantly positive (Table 5, Fig. 8). The 2010 total index of 12,064 is 4% below the long-term mean. Not surprisingly, their breeding densities are highest near the coast, especially in and near river mouths and human settlements and industrial activity (Fig. 8).

The 2010 Sabine's gull index (10,338) is down slightly from 2009, but still 38% above the long-term mean and second highest in the survey's history (Table 3 Fig. 9). This species showed a significant positive growth rate over both long-term and previous 10 year period (Table 5). High variability in numbers depicted in Fig. 9 indicates a level trend prior to the 2007 survey transition, followed by a consistently high index, suggesting a positive effect of the slightly later average timing of the new survey (compared to the 1992-2006 Eider Survey). This species is distributed primarily within the low wet central portion of the ACP (Fig. 9). The arctic tern index has increased steadily through 2000, resulting in a significant positive long-term growth rate (Table 5), but the trend has been erratic and overall nearly level since 2000 (Table 5, Fig. 10). The 2010 index (12,188, Table 3) is 12% above the 19-year mean. Arctic terns are common throughout most of the ACP, but most concentrated in the central portion (Fig. 10).

Ducks

Red-breasted merganser indices increased from 1992 to 2002, then leveled off at an average of about 700 (Fig. 11). The 2010 index (554, Table 3) is 12% lower than the long-term average for the northern coastal strata. This species has been recorded mostly in or near river corridors, and primarily away from the coast in the south-central portion of the survey area (Fig. 11). The merganser 2007-2010 all-strata mean (1900) was 19% below the long term average from the 1986-2006 Standard ACP Survey (Table 6). This suggests a relatively late migration pattern, since the Standard ACP survey was conducted earlier than the current one.

Mallard, American wigeon, green-winged teal and northern shoveler are recorded in very low numbers and thus have high sampling errors and low power to detect meaningful trends (Tables 3-5, Figs. 12-14, 16).

The 2010 Northern coastal strata northern pintail index (40,057) is 18% below the long-term average (Table 3, Fig. 15), and the expanded 2007-2010 all-ACP index is 197,936 -- 10% below the average of the 1986-2006 ACP survey. The northern pintail is the most abundant duck species recorded on the ACP survey. The highest densities of pintails were recorded in the central portions of the survey area, within about 60 km of the coast (Fig. 15).

The large inter-annual variation and strongly male-biased observed spring ACP pintail population (Fig. 15) is challenging to explain, though drought displacement has been strongly implicated (Derksen and Eldridge 1980). Intuitively it seems an influx of drought-displaced birds or molt migrants should result in a larger average index with later survey timing, but the average pintail index from the late-timed Standard ACP Survey was only slightly higher than from our 2007-2010 current ACP design average, and the area surveyed on the former was slightly larger than the latter (Table 6). Another factor that could explain part of the observed sex bias and inter-annual variation is the timing and habitat selection relative to nesting on the ACP. We have observed many pintails nesting as soon as there is open water and snow-free tundra, and pairs and nests are frequently found associated with tiny puddles far from large lakes or ponds, where they are extremely cryptic – especially the females. We think it is likely that the observed sex ratio and index is biased strongly by the local phenology, and that much of the observed variation could be happening within the ACP breeding population, without, or in combination with, an influx of foreign molt migrants. These questions provide fertile ground for further study, but so far the long-term trajectory does not warrant concern (Fig. 15).

North Slope scaup, which appear to be entirely or mostly greater scaup based on our long-term aerial observations of flying birds, are found predominately in wetlands associated with river and small stream corridors, often far inland (Fig. 17). Scaup numbers have exhibited a gradual increase over our survey 1992-2010 reference period, and the 2010 index (6,680) is 36% above the long-term average (Table 3, Fig. 17). Our index continues to show a significant positive growth rate over both the long term and most recent 10 year periods (Table 5). The series of years from 2006 to 2010, and 2002 had the highest scaup indices of the northern coastal strata data set (Fig. 17), and, based on thaw-degree-day data averaged from 6 ACP weather stations, all had thaws earlier than average except 2010 (the year when the survey was completed later than usual). Perhaps earlier thaws have resulted in improved survey timing or changed other factors for scaup. The 2007-2010 average expanded total ACP scaup index of 39,450 ranks third highest among ACP ducks, behind northern pintail and long-tailed duck (Table 6).

The 2010 long-tailed duck Northern coastal strata index (24,557) is 19% below the 19-year mean (Table 3, Fig. 18), however neither of the slightly decreasing long-term and recent 10-year growth rates is significant (Table 5, Fig. 18). This species is the second most abundant of the ducks, and the most evenly dispersed throughout most of the ACP (Fig. 18).

The 2010 spectacled eider index (6,286) is 4% lower than the 18-year mean (Table 3, Fig. 19). The index growth rate is significantly negative and nearly identical over both the long term and most recent 10 years (0.987, 0.974 respectively, Table 5, Fig. 19). Only 8 of 321 indicated birds in the all-ACP sample were recorded outside the 10 northern coastal strata (Tables 3, 4), which was similar to other recent years. The distribution of spectacled eider observations from 2007-2010 was similar to most other survey years, with highest densities within about 100 km of the coast primarily in the Prudhoe/Kuparuk area, northeast of Teshekpuk Lake, and along the Chukchi Sea coast (Fig. 19). We cannot compare our recent results fairly with those of the Standard ACP survey for spectacled or king eiders because the earlier survey was conducted past the departure dates for most eider males.

The distinctly coastal, colonial breeding distribution of the common eider renders it a poor fit for our survey design. For instance, the 2010 survey transects happened to cross a large aggregation of 110 flocked birds, which accounted for all but 8 of the observed sample (Tables 3-4, Fig. 20). Accordingly, a coastal arctic Alaska survey was designed specifically for common eiders and has been conducted annually for this since 1999, by C. Dau and others (Dau and Larned 2008).

The 2010 king eider index for the northern coastal strata (15,715) is 13% above the long-term mean, but below the positive long term and recent 10-year trend lines (Table 3, Fig. 21). The lateness of survey coverage in 2010 of some of the most productive habitat may account for the lower number of single and paired birds compared to recent years, as well as the unusual appearance of a large contingent of flocked birds (Fig. 21). Our long term survey indices for this eider have described a significant positive growth rate, while the most recent ten-year trend is similar but not significant (Table 5). Though well distributed across the wet tundra lowlands of the ACP, the breeding density map clearly illustrates this species' concentration between Teshekpuk Lake and the Colville River Delta (Fig. 21).

Steller's eiders occur in very low densities throughout much of the ACP, and are known to nest sporadically in the Barrow area, where they have been studied extensively most years since 1991 (Safine 2011). Intensive (25-50% coverage) aerial surveys for Steller's eiders were conducted annually from 1999 to 2010 in the Barrow area by ABR Inc., using a technique similar to our own (ibid.). Indicated pair density estimates from our north coastal strata during the 1992-2006 North Slope Eider and 2007-2010 ACP surveys averaged 0.0025 (Table 5, Fig. 22), whereas the pair density estimated by ABR in a roughly 2,800 km^2 survey area south of Barrow averaged 0.016, suggesting a Steller's eider density in the Barrow area approximately 6 times higher than that in the entire north coastal strata. We observed no Steller's eiders during our 2010 survey.

Observers on this survey have recorded a few black scoters each year. However, sedentary white-winged and black scoters appear similar at the marginal observation distance of this survey, and likely some white-winged scoters have been misidentified as black. In any case, black scoters appear in our sample in very small numbers (Tables 3- 4, Fig. 23).

The ACP survey crew recorded an index of 5,090 white-winged scoters in the northern coastal strata in 2010; nearly nine times the long-term average of 584 (Table 3, Fig. 24). Most of the observations have been recorded in the central arctic well south of Teshekpuk Lake – in fact 65% of the total ACP observations were recorded south of the 10 northern coastal strata (Fig. 24). The 2010 estimate for the all-ACP strata is 17,686, which dwarfs the long-term Standard ACP Survey average of 247 birds – however, note that the Standard ACP survey all-scoter average, which was likely mostly white-wings, was within the range of the 2007-2010 surveys (Table 6). Most of the birds we recorded in 2010 were adult males, and we have observed many large flocks of male white-winged scoters apparently molting along the arctic coast, so it is likely many of the scoters we have recorded during the survey were molt migrants staging in the inland riparian wetlands waiting for arctic coastal sea ice to dissipate.

Geese and swans

This survey does not adequately sample snow geese, which occur mainly in isolated coastal breeding colonies. Our estimates have fluctuated widely in relation to differences in transect placement relative to these colonies (Fig. 25). However, observers on our surveys have also noted a recent increase in scattered observations of small groups of snow geese throughout much of the survey area within about 80 km of the coast. Specific aerial snow goose surveys have been conducted since the early 1990's by ABR Inc. (Ritchie and Rose 2009). These surveys indicate strong positive growth rates since about 2000 for most individual colonies and the overall ACP breeding population (ibid).

2010 was the 4th consecutive year of unusually high estimates of white-fronted geese in the arctic coastal plain (Fig. 26). The 2010 index for the northern coastal strata (146,828) exceeds the 19-year mean index by 61%, while the all-strata index (220,918, Tables 4,6) is 3% greater than the 2007-2010 average, and exceeds the highest index from the 1986-2006 Standard ACP Survey (192,426 in 1999, Mallek et al. 2007). The trends are significantly positive in both the long term and recent 10-year periods. We have no explanation for the sudden apparent jump in the Arctic Slope whitefront population in 2007, after a long gentle increase since 1992 (Fig. 26). The 2007-2010 distribution of observations shows the highest densities along the coast from Dease Inlet to Prudhoe Bay, and areas near Atqasuk and Point Lay (Fig. 26).

The 2010 Taverner's cackling goose (Canada goose) index for the northern coastal strata is 12,676, which is 53% above the long-term mean (Tables 3, 5). The ACP all strata 2007-2010 mean index (17,796) is 3% below the 1986-2006 ACP survey mean (Table 6). In past years Canada geese were most prevalent in large flocks near the coast north of Teshekpuk Lake – probably molt migrants -- but during the last few years we have begun to record more geese in scattered pairs further inland throughout the central portions of the survey area, suggesting the onset of breeding range expansion (Fig. 27).

Most black brant nest in colonies on the Arctic Coastal Plain, so trends are difficult to detect with our systematic survey design. ABR Inc. conducts periodic aerial brant nesting and brood-rearing surveys between Barrow and the Coleville Delta, and found 32 colonies occupied in both 2001 (Ritchie et al. 2002) and 2006 (Ritchie et al. 2007), with active nest counts of 386 and 346, respectively, consistent with a level population (Ritchie et al. 2007). In contrast, results of our survey suggest a significant increase in the brant breeding population, or more precisely an abrupt increase between 2001 and 2004, with subsequent stability through 2010 at the higher level (Table 5, Fig. 28). Since the flocked proportion of the population has increased since 2002 it is possible that the recorded increase is largely an influx of early failed breeders from other breeding areas, or a chance transect alignment through breeding colonies. We have also begun to record pairs and small flocks of brant scattered farther from the coast during that same period, suggesting the beginning of breeding range expansion (Fig. 28), as with Taverner's cackling geese.

The tundra swan index has also jumped to a higher plateau beginning in 2007 (Fig. 29), with the 2010 index (10,012, Table 3), very close to those of the intervening years. This has resulted in a significant positive growth rate for this species in both long-term and recent 10-year periods (Table 5). The 2007-2010 average all-strata index (14,458) is 45% above the ACP survey 1986-2006 mean (Tables 6). Tundra swans are widely distributed on the ACP with notable hot-spots in and near the Colville River delta and the wetlands surrounding Dease Inlet (Fig. 29).

Raptors, Ravens, other birds

We have recorded very few sandhill cranes during the ACP survey (2010 ACP Survey index from 10 northern coastal strata=580, northern coastal strata 1992-2010 mean=167, Tables 3, 5). Nevertheless, the trend at this point is significantly positive, for both the long-term and recent 10 year periods (Table 5).

We have recorded shorebirds, only by the left side pilot/observer, since 1997, primarily to identify important shorebird habitats in general, and to track the ACP long-term population trend for this group (Fig. 30). We pooled all species due to difficulty in identifying shorebirds reliably from the air. Currently, the data suggest a long-term, but non-significant decline that is considerably more erratic prior to 2007, when we began the new survey design.

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

Owl populations are extremely variable on the ACP, with peaks typically associated with spikes in lemming populations. The 2010 northern coastal strata short-eared and snowy owl indices were both extremely low, following much higher 2009 indices (Figs. 31, 32).

CONCLUSIONS

This report describes in detail the scope, precision and summarized results of spatially comprehensive aerial breeding population survey data for all common waterbirds, owls, eagles and ravens on the arctic coastal plain of Alaska, collected by the U. S. Fish and Wildlife Service from 1986 to 2010. In addition to the general information herein, it may be used as a guide to the underlying database for requests for more detailed products or raw data. Primary uses to date have included primarily environmental impact prediction and assessment related to mineral and other natural resource exploration and extraction, baseline data for management planning for large tracts of public lands, and for baseline and monitoring of Endangered Species Act listed and candidate species. Currently our data indicate that three species (red-throated loon, American green-winged teal, and spectacled eider) have statistically significant negative long-term trends, while 12 others have significantly positive growth rates (Table 5). We recommend a review of long-term viability of the ACP breeding populations of spectacled eiders and red-throated loons. Of the remaining species with non-significant rates, 8 have negative mean growth rates and 9 have positive. Our distribution maps illustrate breeding distributions that vary considerably among species, each requiring a unique survey design for optimal precision, but current budget and staffing constraints limit us to a single design that accommodates all reported species but favors a few of highest management priority. During these times of lean budgets, there will be requests to delete or modify the schedules of some assessment and monitoring programs. The sampling frame of this survey is the maximum possible for a single crew to complete within the phenological window of eiders, and power analysis values (Table 5) show that annual frequency is barely adequate to provide the data to confidently manage priority species. We therefore urge support for continuation of this program as currently designed, particularly in view of the anticipated but yet unknown effects of climate change on the arctic environment.

2010 was the 4th year of the current ACP survey design combining the North Slope Eider and the Standard ACP Survey, and represented the first completion of a full 4-year cycle. Unfortunately, as noted in Results (p. 7), the interruption of the survey schedule this year probably compromised the accuracy of estimates for loons, gulls, terns, scaup, king eiders and probably others, to some degree.

ACKNOWLEDGMENTS

The authors would like to thank Wade Schock for his fast learning and excellent performance as first year observer, and Karen Bollinger for stepping in to take over pilot duties when Bill Larned had to leave. Special thanks also to the Bureau of Land Management for once again supporting increased sampling intensity in the Teshekpuk Lake region.

LITERATURE CITED

Ad Hoc Eastern Population Tundra Swan Committee. 2007. Management plan for the eastern population of tundra swans. Report prepared for the Atlantic, Mississippi, Central and Pacific Flyway Councils. 49p.

Cochran, W. G. 1977. Sampling techniques. Third edition. John Wiley and Sons, Inc., New York, N.Y. 428p.

Conant, B., C. P. Dau and W. Larned.. 1991. Yukon Delta Alaska helicopter/fixed wing comparative waterfowl breeding population survey. Progress Report III. Unpubl. Rep. U.S. Fish and Wildl. Serv.

Dau, C. P. and W. W. Larned. 2008. Aerial population survey of common eiders and other waterbirds in near shore waters and along barrier islands of the Arctic Coastal Plain of Alaska, 24-26 June 2008. Unpubl. Rept., U. S. Fish and Wildlife Service. 21p.

Derksen, D. V. and Eldridge, W. D. 1980. Drought-displacement of pintails to the arctic coastal plain, Alaska. J. Wildl. Manage. **44**: 224–229.

Earnst, S. L., R. A. Stehn, R. M. Platte, W. W. Larned, and E. J. Mallek. Population size and trend of yellow-billed loons in northern Alaska. The Condor 107:289-304.

Johnson, S. R., and D. R. Herter. 1989. The birds of the Beaufort Sea. BP Exploration (Alaska) Inc. Anchorage, Alaska. 372p.

Kistchinski, A. A., and V. E. Flint. 1974. On the biology of the spectacled eider. Wildfowl 25:5-15.

Lamothe, P. 1973. Biology of king eider *Somateria spectabilis* in a fresh water breeding area on Bathurst Island, N. W. T. M. Sc. Thesis. U. of Alberta. Edmonton. 125p.

Larned, W. W., R. A. Stehn, and R. M. Platte. 2010. Waterfowl breeding population survey, arctic coastal plain, Alaska, 2009. Unpubl. Rept., U. S. Fish and Wildlife Service. 45 p.

Mallek, E. J., R. M. Platte and R. A. Stehn. 2007. Aerial breeding pair surveys of the Arctic Coastal Plain of Alaska B 2006. Unpubl. rept., U.S. Fish and Wildl. Serv. Mig. Bird Manage. Fairbanks, Alaska. 25p

Obritschkewitsch, T. and R. J. Ritchie. 2011. Steller's eider surveys near Barrow, Alaska, 2010. ABR, Inc. Fairbanks, Alaska. 13 pp

Ritchie, R. J., P. Lovely, and M. J. Knoche. 2002. Aerial surveys for nesting and brood rearing brant and snow geese, Barrow to Fish Creek Delta and snow goose banding near the Ikpikpuk River Delta, Alaska, 2001. Unpubl. rept. submitted to North Slope Borough Department of Wildlife Management. ABR, Inc., Fairbanks, Alaska. 31p.

Ritchie, R. J., T. Obritschkewitsch, J. Shook, R. Burgess and J. Rose. 2007. Surveys for nesting and brood rearing brant and lesser snow geese, Barrow to Fish Creek Delta and lesser snow goose banding near the Ikpikpuk River Delta, Alaska, 2006. Unpubl. rept. submitted to North Slope Borough Department of Wildlife Management. ABR, Inc., Fairbanks, Alaska. 45p.

Ritchie, R. J., and J. Rose. 2009. Results of snow goose surveys and a pilot study to band snow geese near Pt. Lay, Kasegaluk Lagoon, Alaska. Unpubl. rept. Submitted to ConocoPhillips Alaska, Inc., by ABR, Inc., Fairbanks, Alaska. 14p.

Troy, D. 1997. Distribution and abundance of spectacled eiders in the vicinity of Prudhoe Bay, Alaska: 1996 Status Report. Unpubl. Rep. for BP Exploration, Troy Ecological Res. Assoc., Anchorage, Alas. 11p.

U. S. Fish and Wildlife Service. 1996. Spectacled eider recovery plan. Anchorage, Alas. 157p.

U. S. Fish and Wildlife Service, and Canadian Wildlife Service. 1987. Standard Operating procedures for aerial waterfowl breeding ground population and habitat surveys. Unpubl. Manual, U. S. Fish and Wildl. Serv., Migratory Bird Management, Laurel, Maryland. 98p.

Warnock, N. D., and D. M. Troy. 1992. Distribution and abundance of spectacled eiders at Prudhoe Bay, Alaska: 1991. BP Exploration (Alaska) Inc., Anchorage, Alaska. 11p

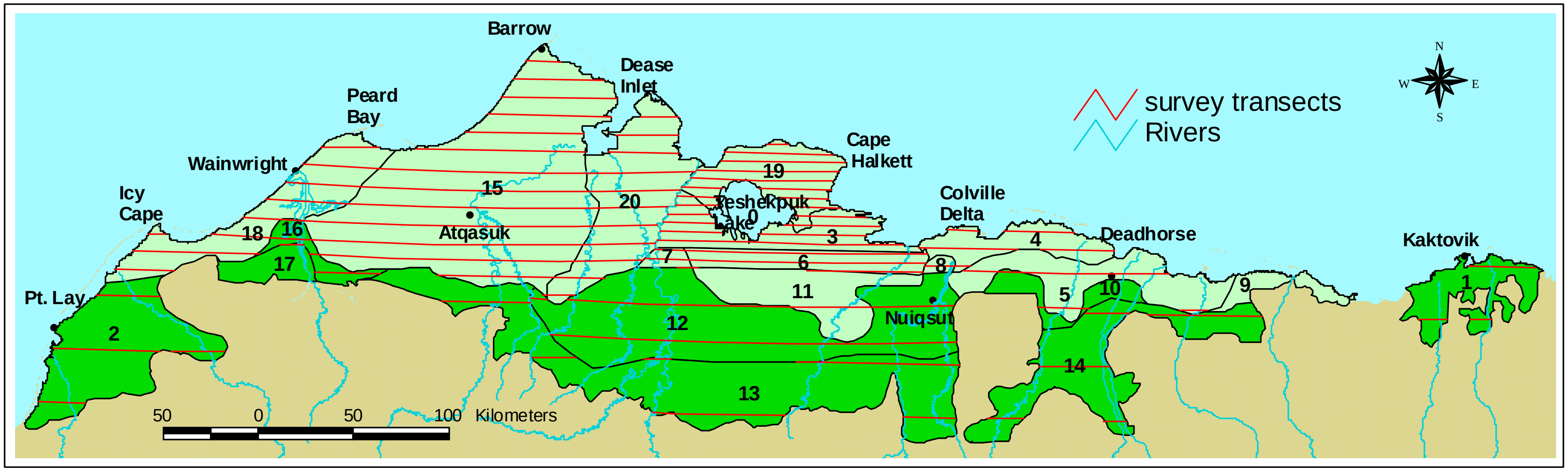


Figure 1. Spatial design of the aerial waterfowl breeding population survey, Arctic Coastal Plain, Alaska, 2010. Northern coastal strata are shown in light green, strata outside the northern coastal strata area are shown in dark green. Red lines show locations of the 2010 design transects. Numbered strata are described in Table 1 below.

Table 1. Sampling design, aerial waterfowl breeding population survey, Arctic Coastal Plain, Alaska, June 2010. ID numbers refer to Fig. 1 above.

ID	Sampling Intensity	Stratum Area km^2	ID	Sampling Intensity	Stratum Area km^2		Stratum Area km^2	Sample Area km^2	Sample % of Stratum Area
0	Non-habitat		11	Medium	2,240	All Low	18,276	248.5	1.4
1	Low	1,812	12	Medium	7,453	All Medium	13,058	246.0	1.9
2	Low	3,916	13	Low	7,652	All High	20,351	852.1	4.2
3	Very High	2,019	14	Low	3,571	All Very High	5,650	456.1	8.1
4	High	1,423	15	High	11,358	N. coastal strata	30,465	1,357.0	4.5
5	Medium	2,581	16	High	582	All Strata	57,335	1,802.7	3.1
6	Very High	1,362	17	Low	748				
7	Very High	226	18	High	3,093				
8	High	128	19	Very High	2,044				
9	Low	577	20	High	3,768				
10	Medium	784							

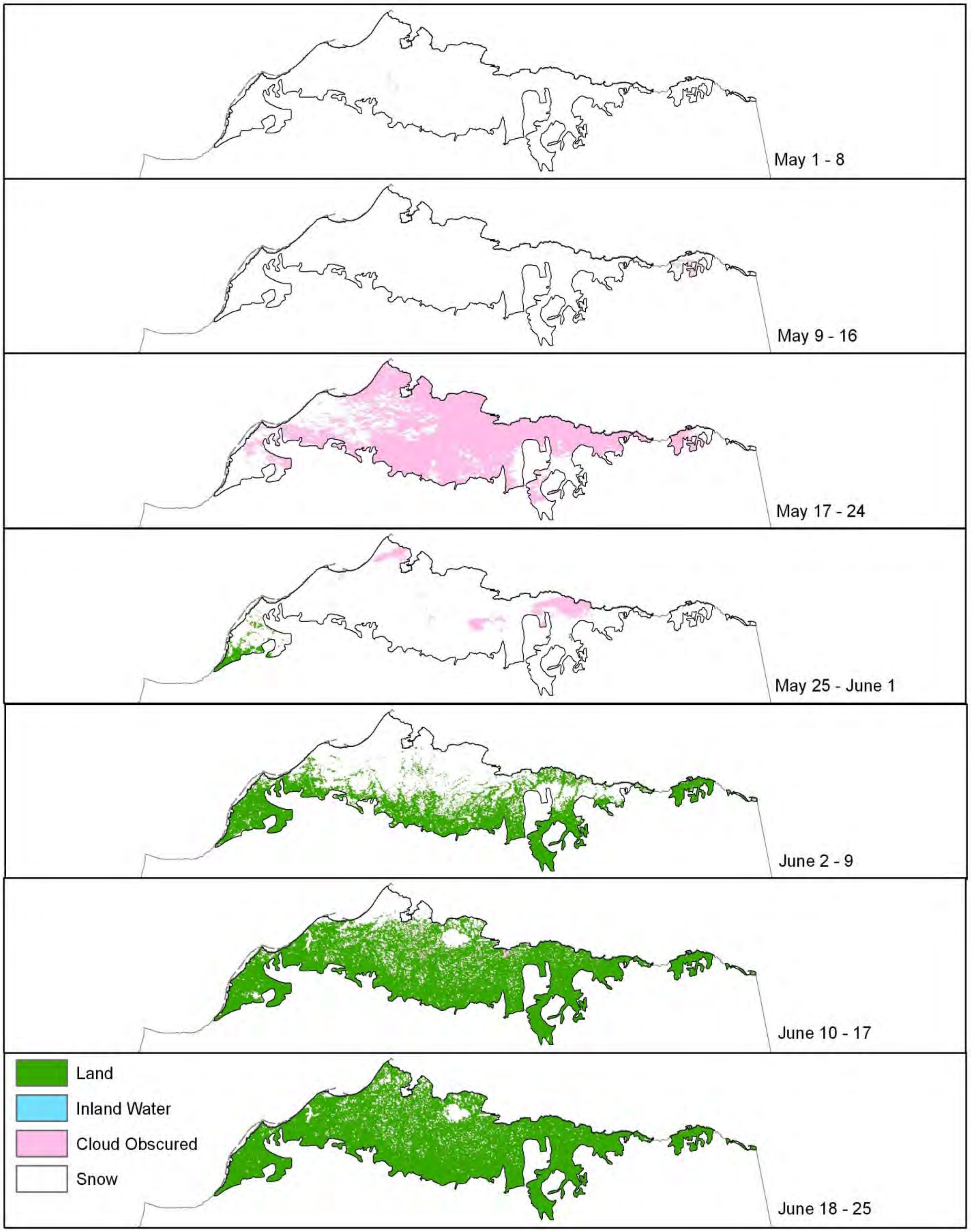


Figure 2. 2010 spring snow melt on the arctic coastal plain, Alaska, from Terra satellite MODIS 8-day maximum snow extent data.

Table 2. Average and range of ratios of lone males (single to 4) to total males (males 1-4 plus males in pairs) of selected duck species observed during the Eider Survey (1992-2006) and the ACP survey (2007-2010), arctic coastal plain, Alaska.

Species	LDI Avg. 1992-2009	LDI SD	LDI range	LDI 2010
Spectacled eider	0.49	0.08	0.28-0.58	0.57
King eider	0.35	0.12	0.14-0.57	0.34
Long-tailed duck	0.49	0.04	0.39-0.58	0.49
Northern pintail	0.83	0.07	0.67-0.91	0.69

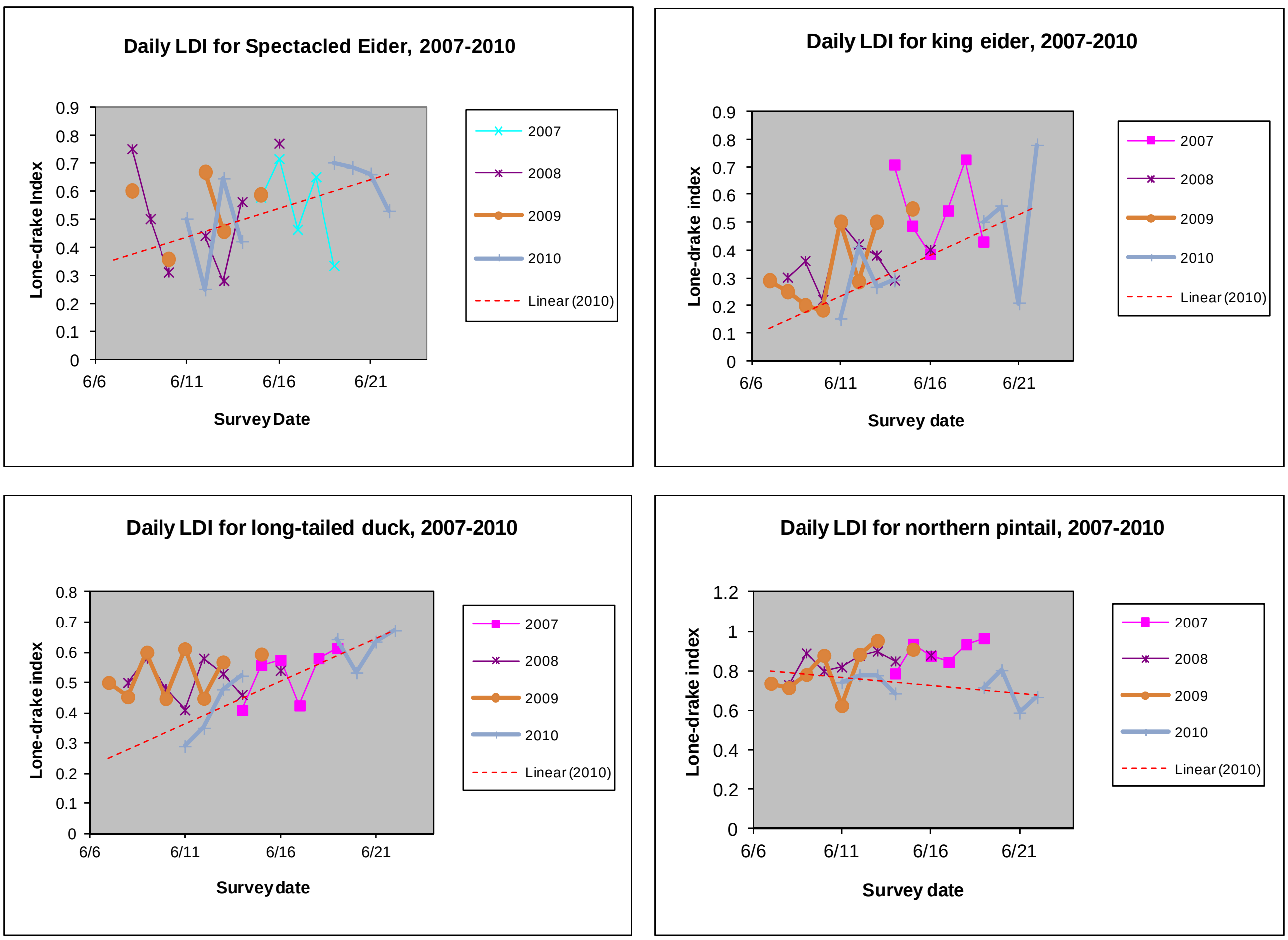


Figure 3. Daily ratio of lone males to total males (males single to 4 plus males in pairs) of selected duck species observed during the 2007-10 Waterfowl Breeding Population (ACP) survey, arctic coastal plain, Alaska. A higher value indicates a more advanced stage of the breeding cycle.

Table 3. Combined observations by starboard and port observers on aerial survey transects, arctic coastal plain, Alaska, June 2010, with observable population indices. Includes observations from northern coastal strata only (Fig. 1). Expanded indices for selected ducks were calculated using visibility correction factors (VCF) developed on the Yukon Kuskokwim Delta for tundra habitats (Conant et al. 1991).

Species	Single	Pair	Flocked Birds	Indicated Total	Density birds/km2	Population Index	Population 95%CI	VCF	Expanded Pop. Index	%CV
Yellow-billed loon	28	15	0	58 [1]	0.0409	1,223	814-1,632			17.1
Pacific Loon	150	272	9	703 [1]	0.514	15,362	12,946-17,778			8
Red-throated loon	22	24	11	81 [1]	0.0528	1,578	1,094-2,061			15.6
Jaeger spp.[3]	97	29	0	155 [1]	0.1235	3,690	2,683-4,697			13.9
Glaucous gull	257	98	88	541 [1]	0.4037	12,064	9,489-14,640			10.9
Sabine's gull	174	90	162	516 [1]	0.3459	10,338	7,356-13,319			14.7
Arctic tern	220	120	87	547 [1]	0.4078	12,188	9,489-14,887			11.3
Red-breasted merganser	3	2	0	10 [2]	0.0185	554	326-782	1.27	703	21
Mallard	1	0	0	2 [2]	0.0017	50	2-144	4.01	199	96.8
Am. wigeon	0	1	0	2 [2]	0.0008	24	Feb-67	3.84	91	91.6
Am. Green-winged teal	0	3	0	6 [2]	0.0075	224	80-367	8.36	1,871	32.7
Northern pintail	467	271	583	2059 [2]	1.3403	40,057	31,235-48,879	3.05	122,174	11.2
Northern shoveler	1	0	0	2 [2]	0.0016	48	2-137	3.79	180	96
Greater scaup	31	79	74	263 [1]	0.2235	6,680	4,587-8,772	1.93	12,892	16
Long-tailed duck	247	223	162	1102 [2]	0.8217	24,557	21,482-27,633	1.87	45,922	6.4
Spectacled eider	86	65	11	313 [2]	0.2103	6,286	4,877-7,695			11.4
Common eider	0	4	110	118 [2]	0.0949	2,836	118-8,409			100.2
King eider	110	212	134	778 [2]	0.5258	15,715	12,668-18,762			9.9
Steller's eider	0	0	0	0	0	0	0-			
Black scoter	4	0	0	8 [2]	0.0066	197	8-421	1.17	230	57.9
White-winged scoter	7	29	15	87 [2]	0.1703	5,090	3,453-6,728	1.17	5,956	16.4
Snow goose	7	54	333	448 [1]	0.2662	7,955	1,137-14,772			43.7
Gr. White-fronted goose	396	1,731	2,723	6977 [2]	4.9127	146,828	124,606-169,050			7.7
Canada goose	29	45	760	908 [2]	0.4241	12,676	6,378-18,973			25.3
Black brant	78	56	277	545 [2]	0.3552	10,615	3,229-18,001			35.5
Tundra swan	177	124	20	445 [1]	0.335	10,012	7,793-12,230			11.3
Sandhill crane	4	7	3	25 [2]	0.0194	580	308-853			24
Unid. Shorebird[4,5]	280	144	502	1070 [1]	0.815	24,357	18,211-30,504			12.9
Common raven	6	0	0	6 [1]	0.0052	155	6-313			51.9
Short-eared owl	1	0	0	1 [1]	0.0004	11	30-Jan			90.8
Snowy owl	7	0	0	7 [1]	0.0056	167	29-304			42.1
Golden eagle	4	0	0	4 [1]	0.0029	85	11-160			44.6

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

Table 4. Combined observations by starboard and port observers on aerial survey transects, arctic coastal plain, Alaska, June 2010, with observable population indices. Includes observations from all strata (Fig. 1). Expanded indices for selected ducks were calculated using visibility correction factors (VCF) developed on the Yukon Kuskokwim Delta for tundra habitats (Conant et al. 1991).

Species	Single	Pair	Flocked Birds	Indicated Total	Density birds/km2	Population Index	Population 95%CI	VCF	Expanded Pop. Index	%CV
Yellow-billed loon	29	26	0	81 [1]	0.0457	2,618	1,663-3,573			18.6
Pacific Loon	203	342	12	899 [1]	0.4658	26,704	23,030-30,379			7
Red-throated loon	23	29	11	92 [1]	0.0367	2,107	1,521-2,692			14.2
Jaeger spp.[3]	136	44	0	224 [1]	0.1375	7,883	6,310-9,456			10.2
Glaucous gull	308	123	129	683 [1]	0.3168	18,166	14,675-21,656			9.8
Sabine's gull	198	101	194	594 [1]	0.2473	14,177	10,921-17,433			11.7
Arctic tern	266	166	95	693 [1]	0.3526	20,215	15,590-24,839			11.7
Red-breasted merganser	6	7	0	26 [2]	0.0245	1,404	247-2,560	1.27	1,783	42.1
Mallard	3	0	0	6 [2]	0.0052	301	6-675	4.01	1,207	63.4
Am. wigeon	0	2	0	4 [2]	0.0023	131	4-297	3.84	503	64.7
Am. Green-winged teal	1	3	0	8 [2]	0.0054	308	136-479	8.36	2,575	28.5
Northern pintail	587	309	605	2397 [2]	1.0604	60,800	49,298-72,302	3.05	185,440	9.7
Northern shoveler	2	0	0	4 [2]	0.0034	195	4-479	3.79	739	74.5
Greater scaup	48	151	108	458 [1]	0.3227	18,500	12,988-24,012	1.93	35,705	15.2
Long-tailed duck	316	349	183	1513 [2]	0.8779	50,334	42,291-58,376	1.87	94,125	8.2
Spectacled eider	88	67	11	321 [2]	0.1157	6,637	4,958-8,315			12.9
Common eider	0	4	110	118 [2]	0.0492	2,818	118-8,456			102.1
King eider	120	234	134	842 [2]	0.3497	20,053	14,823-25,282			13.3
Steller's eider	0	0	0	0	0	0				
Black scoter	4	0	0	8 [2]	0.0033	191	8-427	1.17	223	62.9
White-winged scoter	14	82	57	249 [2]	0.2636	15,116	5,071-25,160	1.17	17,686	33.9
Snow goose	7	54	333	448 [1]	0.1383	7,929	926-14,933			45.1
Gr. White-fronted goose	454	1,968	3,415	8259 [2]	3.8531	220,918	170,596-271,240			11.6
Canada goose	42	52	766	954 [2]	0.2837	16,265	7,317-25,212			28.1
Black brant	78	56	277	545 [2]	0.187	10,720	3,091-18,349			36.3
Tundra swan	203	156	23	538 [1]	0.264	15,135	11,026-19,245			13.9
Sandhill crane	5	7	8	32 [2]	0.0163	935	547-1,323			21.2
Unid. Shorebird[4,5]	331	181	745	1438 [1]	0.8209	47,067	28,495-65,638			20.1
Common raven	9	0	0	9 [1]	0.0054	309	122-495			30.9
Short-eared owl	2	0	0	2 [1]	0.0015	86	2-233			87.4
Snowy owl	7	0	0	7 [1]	0.0029	167	42-292			38.2
Golden eagle	9	0	0	9 [1]	0.0072	411	131-691			34.7

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

Table 5. Mean population indices, population growth rates, and years to detect a population trend equivalent to a 50 percent growth or decline in 20 years, for observations of selected bird species in early to mid-June 1992-2010 sampling Arctic Coastal Plain wetlands in Alaska. Variance estimates used were based on within-year sampling error among transects as stratified by 10 physiographic regions (Northern coastal strata). Significant growth rates are colored green for positive trend, red for negative.

Species	Measure	Years	n years	Mean pop. Index	Log-linear slope	Mean pop. growth rate	Pop. Growth rate 90% CI	Avg. sampling error coef. of variation	Years to detect a slope of 0.0341	Mean pop. growth rate last 10 years	Pop. GR last 10 years 90% CI
Yellow-billed loon	S + 2*Pr + Fl	1992-2010	19	1,155	0.019	**1.019**	1.005-1.034	0.215	14.3	1.020	0.987-1.055
Pacific Loon	S + 2*Pr + Fl	1992-2010	19	20,952	0.004	1.004	0.990-1.019	0.070	6.8	1.006	0.968-1.045
Red-throated loon	S + 2*Pr + Fl	1992-2010	19	2,525	-0.040	**0.960**	0.937-0.985	0.153	11.4	0.986	0.939-1.035
Jaeger spp.	S + 2*Pr + Fl	1992-2010	19	4,131	0.009	1.009	0.979-1.040	0.118	9.6	1.045	0.963-1.133
Glaucous gull	S + 2*Pr + Fl	1992-2010	19	12,588	0.009	1.009	0.992-1.026	0.145	11.0	1.060	1.024-1.097
Sabine's gull	S + 2*Pr + Fl	1992-2010	19	7,506	0.030	**1.030**	1.008-1.053	0.133	10.4	**1.079**	1.033-1.126
Arctic tern	S + 2*Pr + Fl	1992-2010	19	10,851	0.033	**1.034**	1.023-1.044	0.111	9.2	1.004	0.978-1.032
Red-breasted merganser	2 * (S + Pr) + Fl	1992-2010	19	496	0.085	**1.089**	1.048-1.132	0.387	21.2	**1.024**	0.978-1.072
Mallard	2 * (S + Pr) + Fl	1992-2010	19	184	-0.065	0.937	0.865-1.014	0.758	33.1	0.961	0.785-1.177
Am. wigeon	2 * (S + Pr) + Fl	1992-2010	19	369	-0.047	0.955	0.875-1.041	0.673	30.6	0.885	0.680-1.151
Am. Green-winged teal	2 * (S + Pr) + Fl	1992-2010	19	282	-0.080	**0.923**	0.864-0.986	0.536	26.3	**1.108**	0.991-1.238
Northern pintail	2 * (S + Pr) + Fl	1992-2010	19	48,579	-0.012	0.988	0.961-1.016	0.101	8.7	0.996	0.944-1.051
Northern shoveler	2 * (S + Pr) + Fl	1992-2010	19	185	0.007	1.007	0.908-1.116	0.682	30.9	1.045	0.812-1.344
Greater scaup	S + 2*Pr + Fl	1992-2010	19	4,907	0.067	**1.069**	1.049-1.090	0.181	12.8	**1.065**	1.005-1.128
Long-tailed duck	2 * (S + Pr) + Fl	1992-2010	19	30,396	-0.012	0.988	0.975-1.002	0.069	6.7	0.994	0.949-1.040
Spectacled eider	2 * (S + Pr) + Fl	1993-2010	18	6,526	-0.013	**0.987**	0.974-0.999	0.112	9.3	**0.974**	0.950-0.999
Common eider	2 * (S + Pr) + Fl	1992-2010	19	504	0.024	1.025	0.951-1.104	0.792	34.1	1.172	0.955-1.438
King eider	2 * (S + Pr) + Fl	1993-2010	18	13,913	0.026	**1.026**	1.016-1.036	0.091	8.1	1.023	0.998-1.048
Steller's eider	2 * (S + Pr) + Fl	1992-2010	19	151	-0.007	0.993	0.898-1.098	0.820	34.9	0.895	0.710-1.126
Black scoter	2 * (S + Pr) + Fl	1992-2010	19	132	-0.002	0.998	0.920-1.083	0.858	36.0	**1.258**	1.102-1.436
White-winged scoter	2 * (S + Pr) + Fl	1992-2010	19	584	0.076	1.079	1.013-1.149	0.572	27.5	1.152	0.973-1.363
Snow goose	S + 2*Pr + Fl	1992-2010	19	7,960	0.191	**1.210**	1.111-1.318	0.561	27.1	1.228	0.932-1.617
Gr. White-fronted goose	2 * (S + Pr) + Fl	1992-2010	19	91,267	0.054	**1.055**	1.034-1.077	0.075	7.1	**1.099**	1.047-1.154
Canada goose	2 * (S + Pr) + Fl	1993-2010	18	8,295	0.008	1.008	0.973-1.045	0.259	16.2	1.084	0.983-1.196
Black brant	2 * (S + Pr) + Fl	1992-2010	19	7,244	0.096	**1.101**	1.076-1.126	0.253	15.9	**1.063**	1.010-1.120
Tundra swan	S + 2*Pr + Fl	1992-2010	19	6,921	0.037	**1.038**	1.023-1.052	0.110	9.1	**1.073**	1.049-1.096
Sandhill crane	S + 2*Pr + Fl	1992-2010	19	167	0.079	**1.082**	1.029-1.137	0.616	28.9	1.158	1.015-1.320
Unid. Shorebird	S + 2*Pr + Fl	1997-2010	14	51,071	-0.021	0.979	0.956-1.003	0.103	8.8	0.995	0.958-1.032
Common raven	S + 2*Pr + Fl	1992-2010	19	64	0.025	1.026	0.965-1.090	0.672	30.6	1.056	0.906-1.229
Short-eared owl	S + 2*Pr + Fl	1992-2010	19	78	0.062	1.064	0.965-1.173	0.614	28.8	1.041	0.839-1.293
Snowy owl	S + 2*Pr + Fl	1992-2010	19	809	-0.024	0.976	0.899-1.061	0.369	20.5	1.068	0.843-1.353
Golden eagle	S + 2*Pr + Fl	1992-2010	19	44	0.049	1.050	0.991-1.112	0.818	34.8	1.033	0.893-1.194

Table 6. Breeding population estimates, standard Alaska ACP Survey, 1986-2006 means (Mallek et al. 2007) compared with estimates from the current ACP survey, 2010 and averages from 2007-2010. Duck indices were converted to population estimates by multiplying by tundra visibility correction factors used in the Alaska-Yukon Breeding Population Survey (Conant et al. 1991).

Species	VCF	ACP Survey mean 1986-2006	All ACP strata 2007-2010 (95%CI)	All ACP strata 2010 (95%CI)
Yellow-billed loon	1.00	2,778	2,465 (1,817-3,113)	2,618 (1,663-3,573)
Pacific Loon	1.00	29,756	35,161 (23,031-39,541)	26,704 (23,030-30,379)
Red-throated loon	1.00	3,240	2,820 (2,030-3,610)	2,107 (1,521-2,692)
Jaegers	1.00	7,197	9,571 (7,706-11,436)	7,883 (6,310-9,456)
Glaucous gull	1.00	17,188	20,127 (16,445-23,808)	18,166 (14,675-21,656)
Sabine's gull	1.00	11,810	13,303 (10,074-16,532)	14,177 (10,921-17,433)
Arctic tern	1.00	23,544	22,506 (18,766-26,247)	20,215 (15,590-24,839)
Red-breasted merganser	1.27	2,340	1,900 (714-3,086)	1,783 (314-3,251)
Mallard	4.01	1,848	1,560 (74-3,174)	1,207 (24-2,707)
Am. wigeon	3.84	4,123	1,618 (380-2,905)	503 (15-1,140)
Am. Green-winged teal	8.36	3,210	3,781 (1,250-6,308)	2,575 (1,137-1,839)
Northern pintail	3.05	220,494	197,936 (162,581-233,291)	185,440 (150,360-220,521)
Northern shoveler	3.79	987	2,161 (271-4,247)	739 (15-1,815)
Greater scaup	1.93	32,721	39,450 (29,364-49,537)	35,705 (25,067-46,343)
Long-tailed duck	1.87	107,041	87,642 (76,487-98,796)	94,125 (79,084-109,163)
Spectacled eider	1.00	619	5,987 (4,436-7,537)	6,637 (4,958-8,315)
Common eider	1.00	441	935 (38-2,641)	2,818 (118-8,456)
King eider	1.00	3,999	20,444 (16,677-24,210)	20,053 (14,823-25,282)
Steller's eider	1.00	743	102 (6-348)	0
Black scoter	1.17	43	259 (8-579)	223 (9-500)
White-winged scoter	1.17	247	7,362 (2,801-11,924)	17,686 (5,933-29,437)
All scoters	1.17	10,381	7,621 (2,809-12,503)	17,909 (5,942-29,937)
Snow goose	1.00	3,025	27,110 (NA)	7929 (926-14,933)
Gr. White-fronted goose	1.00	123,963	220,202 (175,484-261,903)	220,918 (170,596-271,240)
Canada goose	1.00	18,309	17,796 (7,565-21,964)	16,265 (7,317-25,212)
Black brant	1.00	9,792	10,831 (4,621-17,333)	10,720 (3,091-18,349)
Tundra swan	1.00	9,971	14,458 (11,761-18,001)	15,135 (11,026-19,245)
Sandhill crane	1.00		451 (341-974)	935 (547-1,323)
Common raven	1.00		317 (63-610)	309 (122-495)
Short-eared owl	1.00		285 (32-555)	86 (2-233)
Snowy owl	1.00	1,219	814 (234-636)	167 (42-292)
Golden eagle	1.00	426	273 (122-499)	411 (131-691)

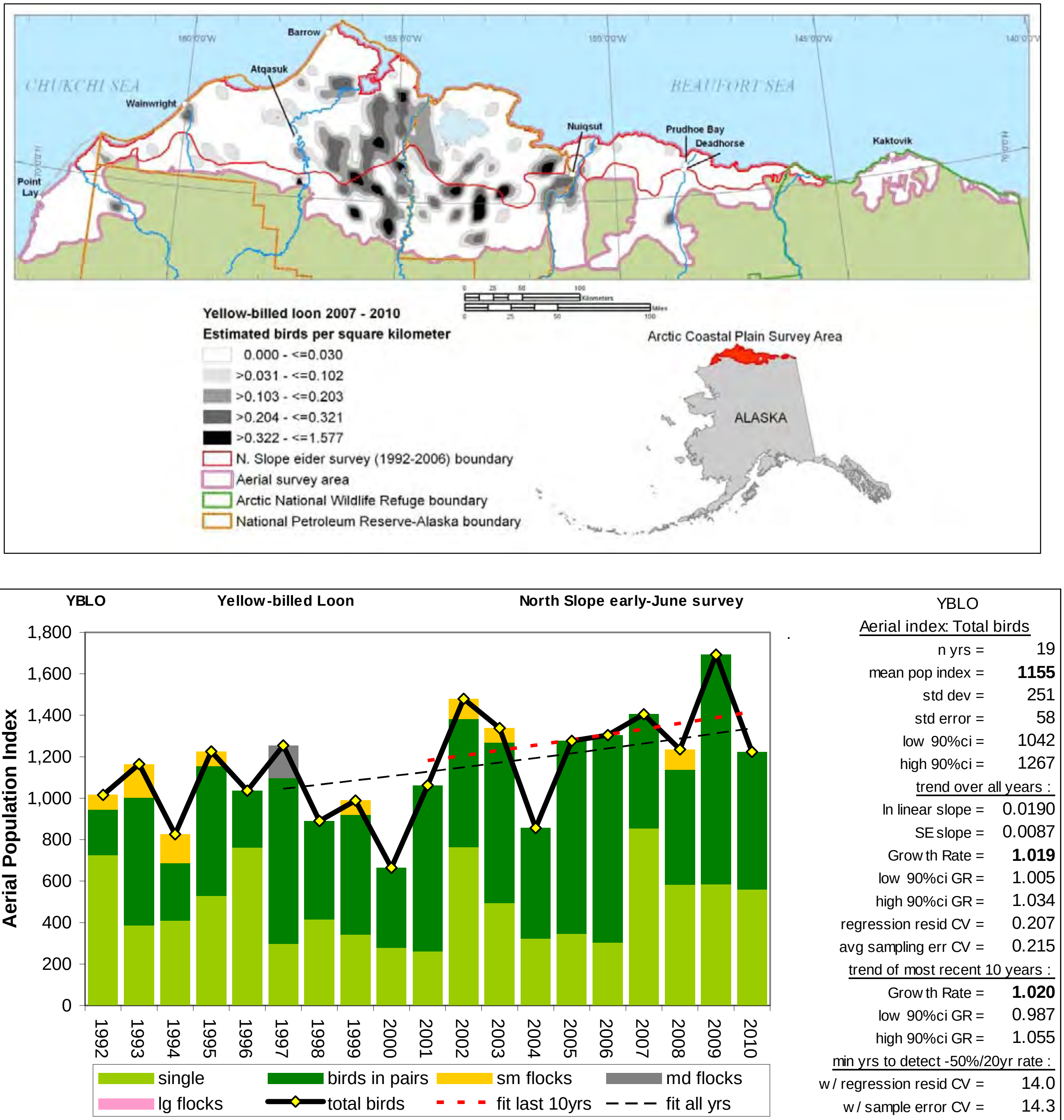


Figure 4. ***Top:*** Density distribution of yellow-billed loons (*Gavia adamsii*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for yellow-billed loons observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

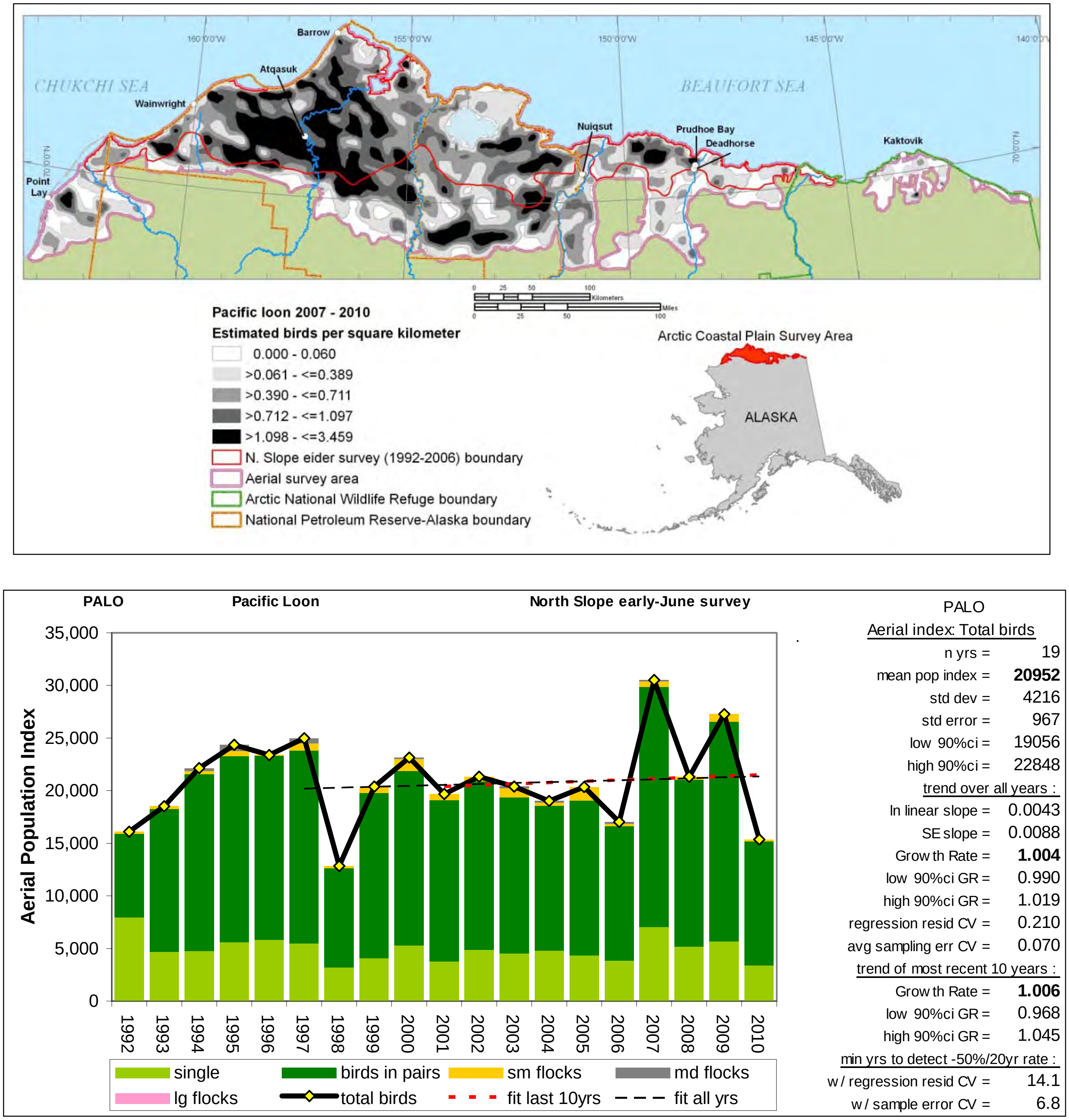
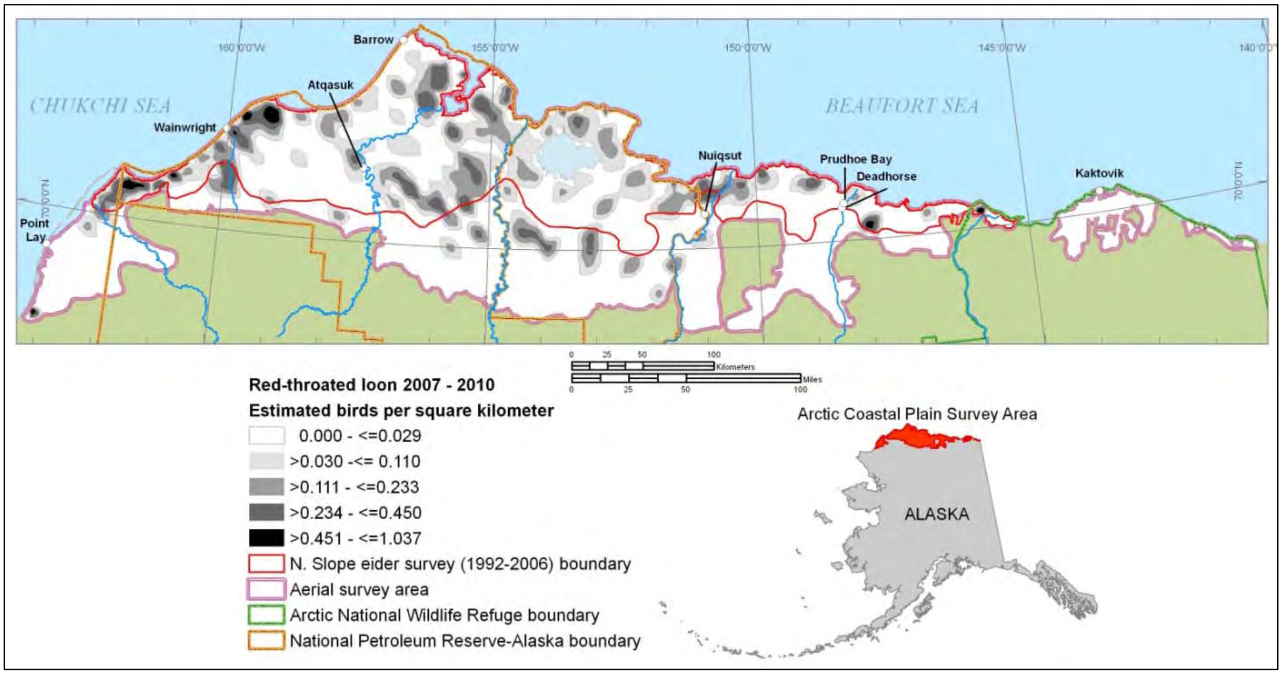


Figure 5. ***Top:*** Density distribution of Pacific loons (*Gavia pacifica*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for Pacific loons observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with *p*=0.10, beta at *p*=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



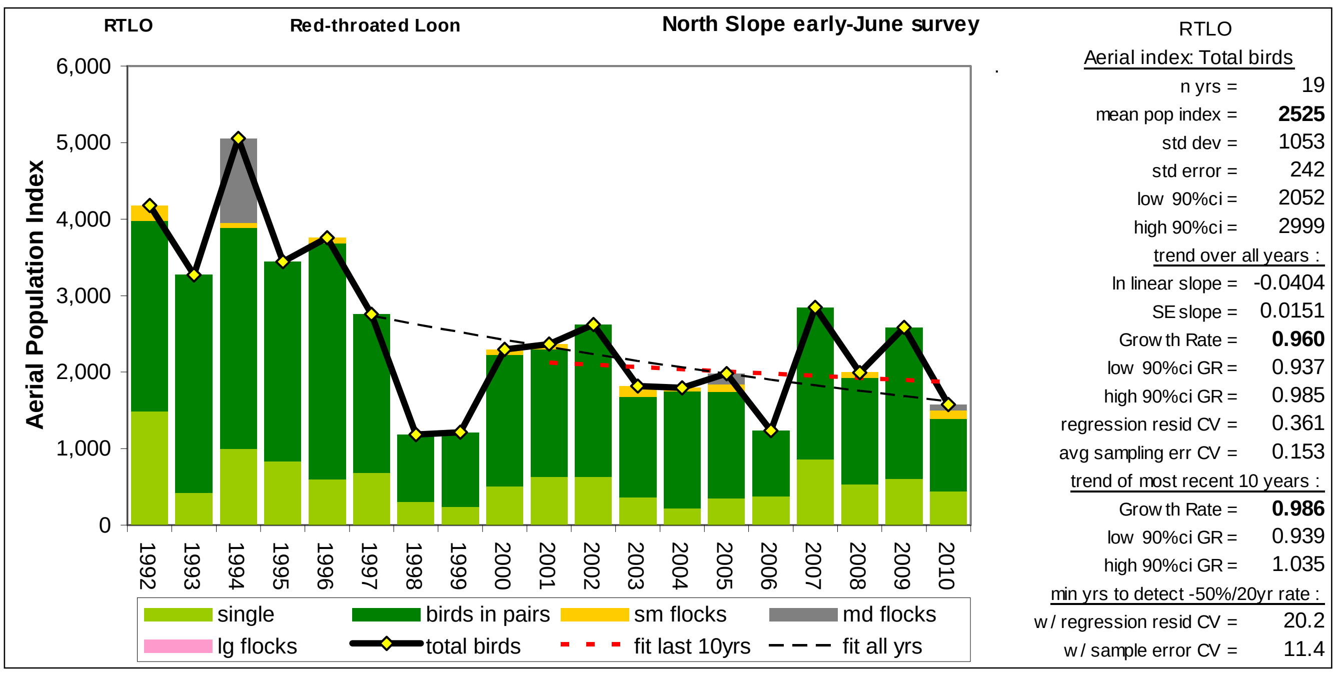


Figure 6. ***Top:*** Density distribution of red-throated loons (*Gavia stellata*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for red-throated loons observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

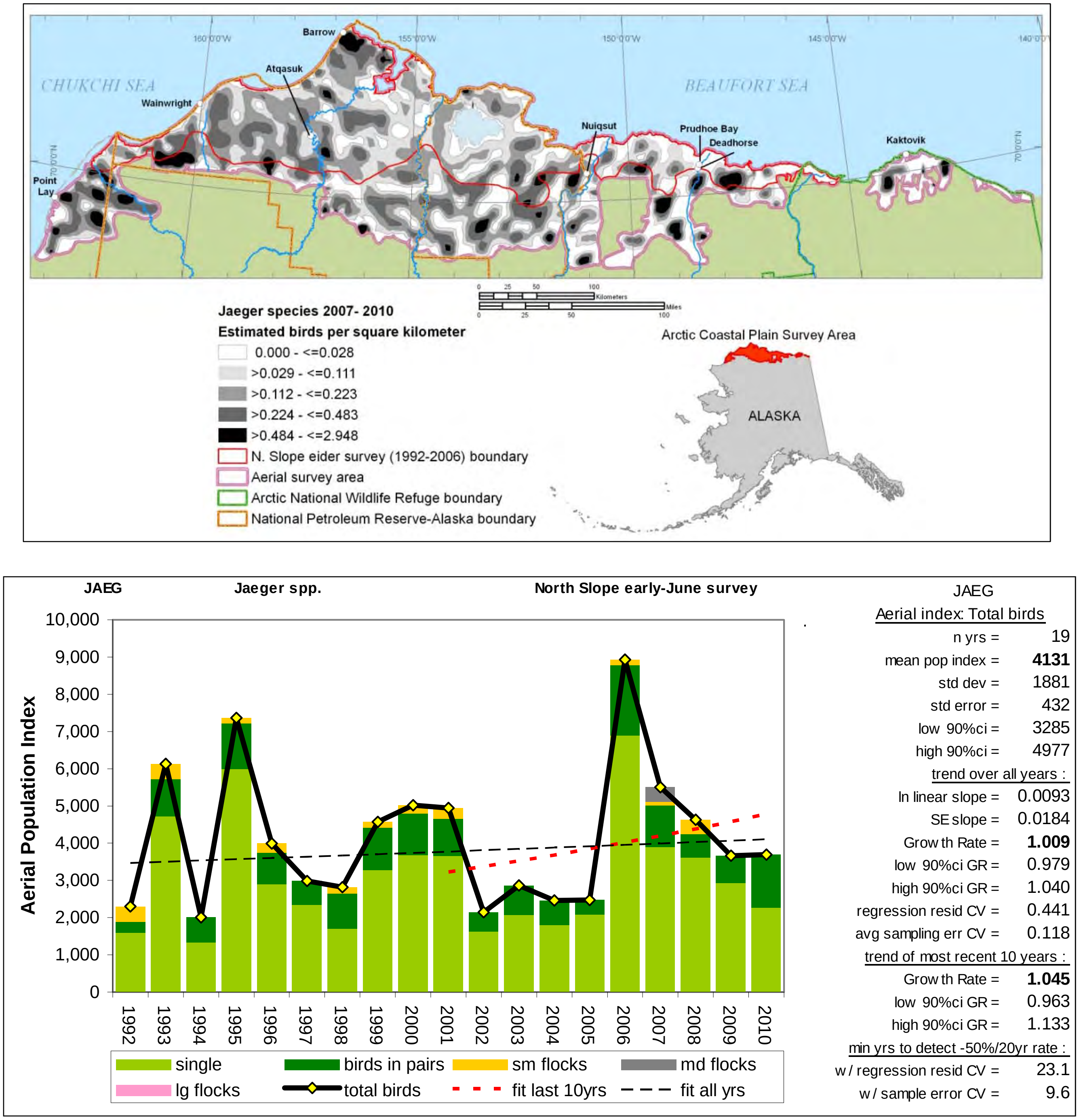


Figure 7. ***Top:*** Density distribution of jaegers (*Stercorarius spp*.) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for jaegers observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

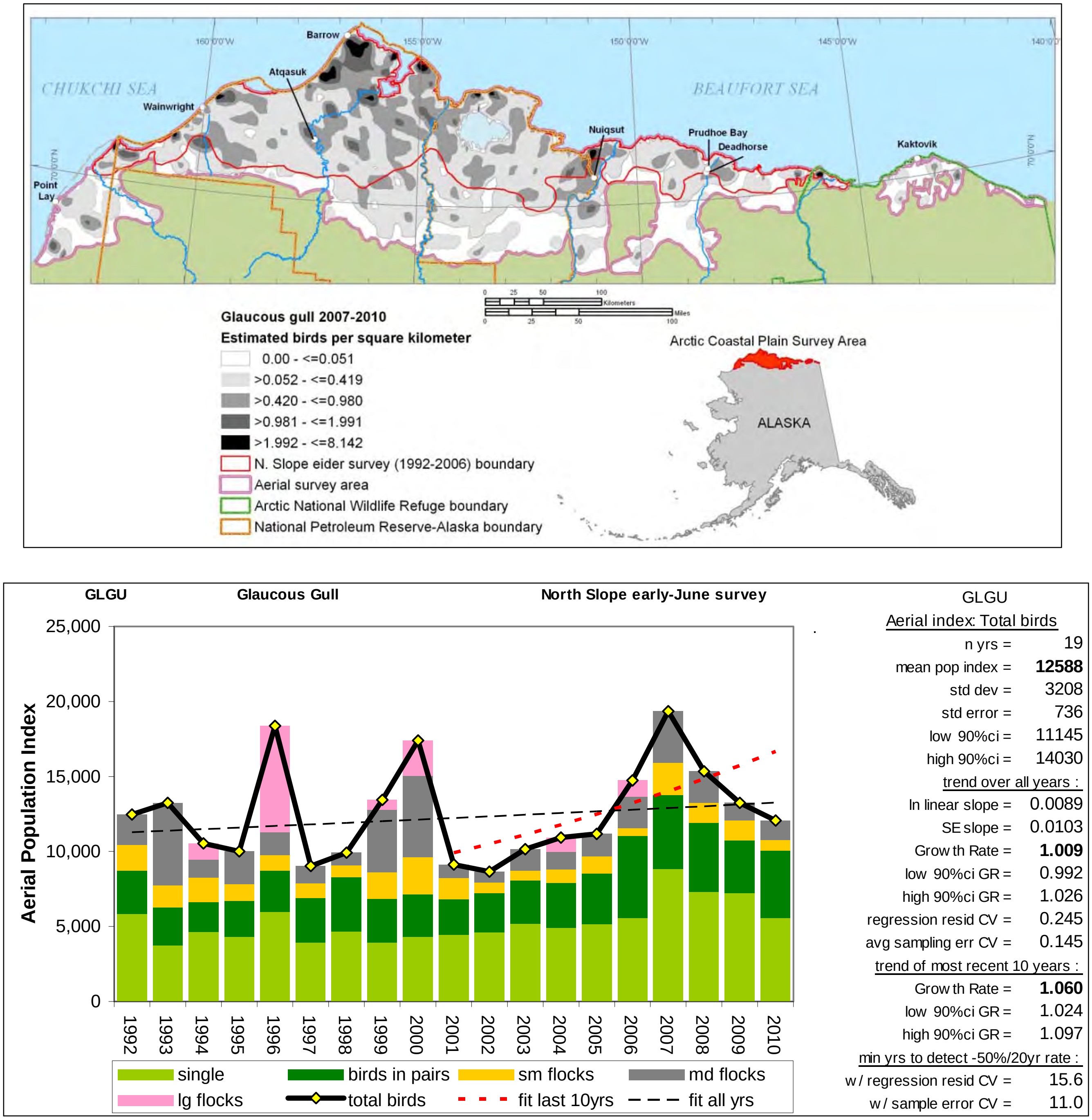


Figure 8. ***Top:*** Density distribution of glaucous gulls (*Larus hyperboreus*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for glaucous gulls observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

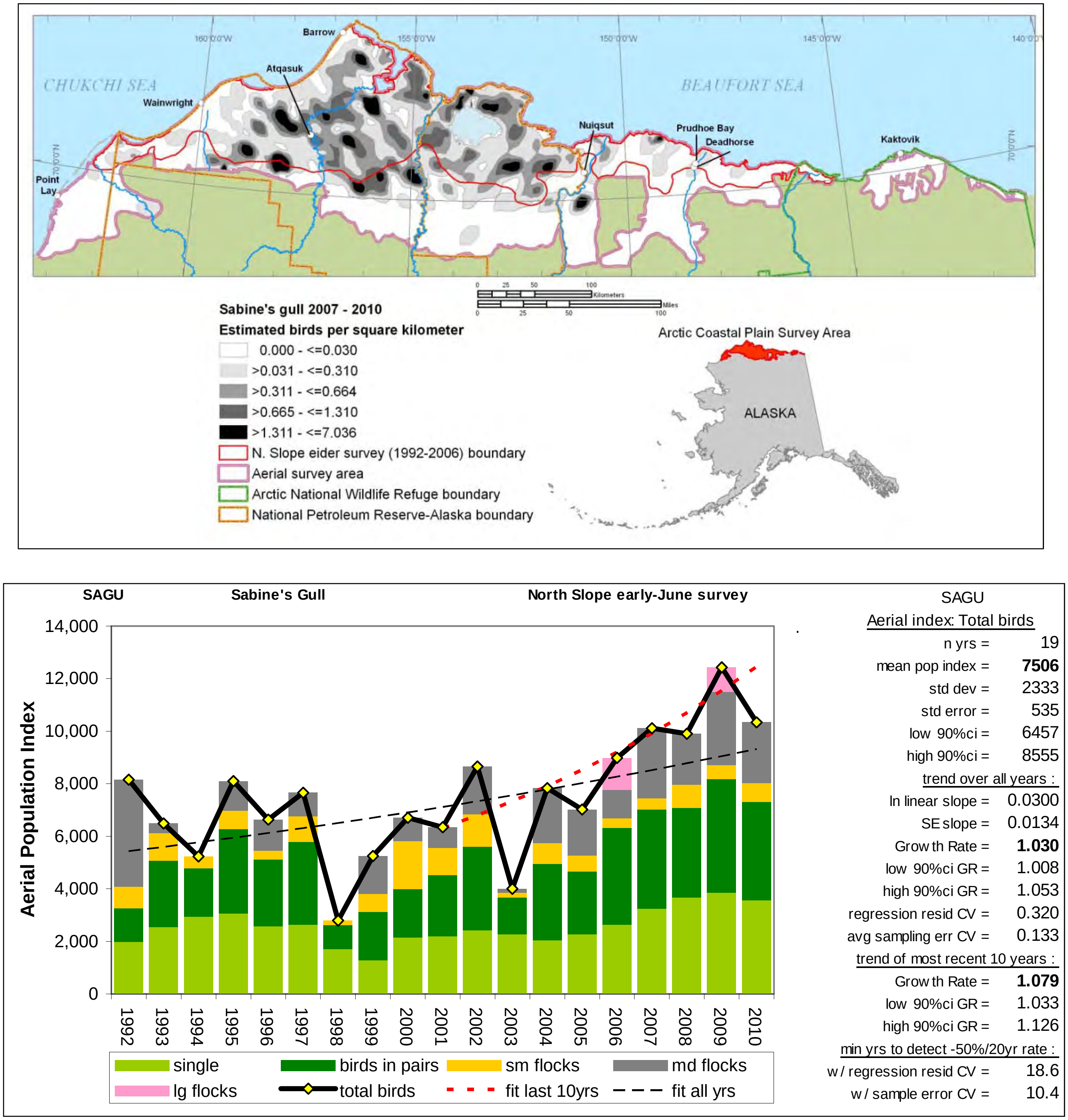


Figure 9. ***Top:*** Density distribution of Sabine's gulls (*Xema sabini*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for Sabine's gulls observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

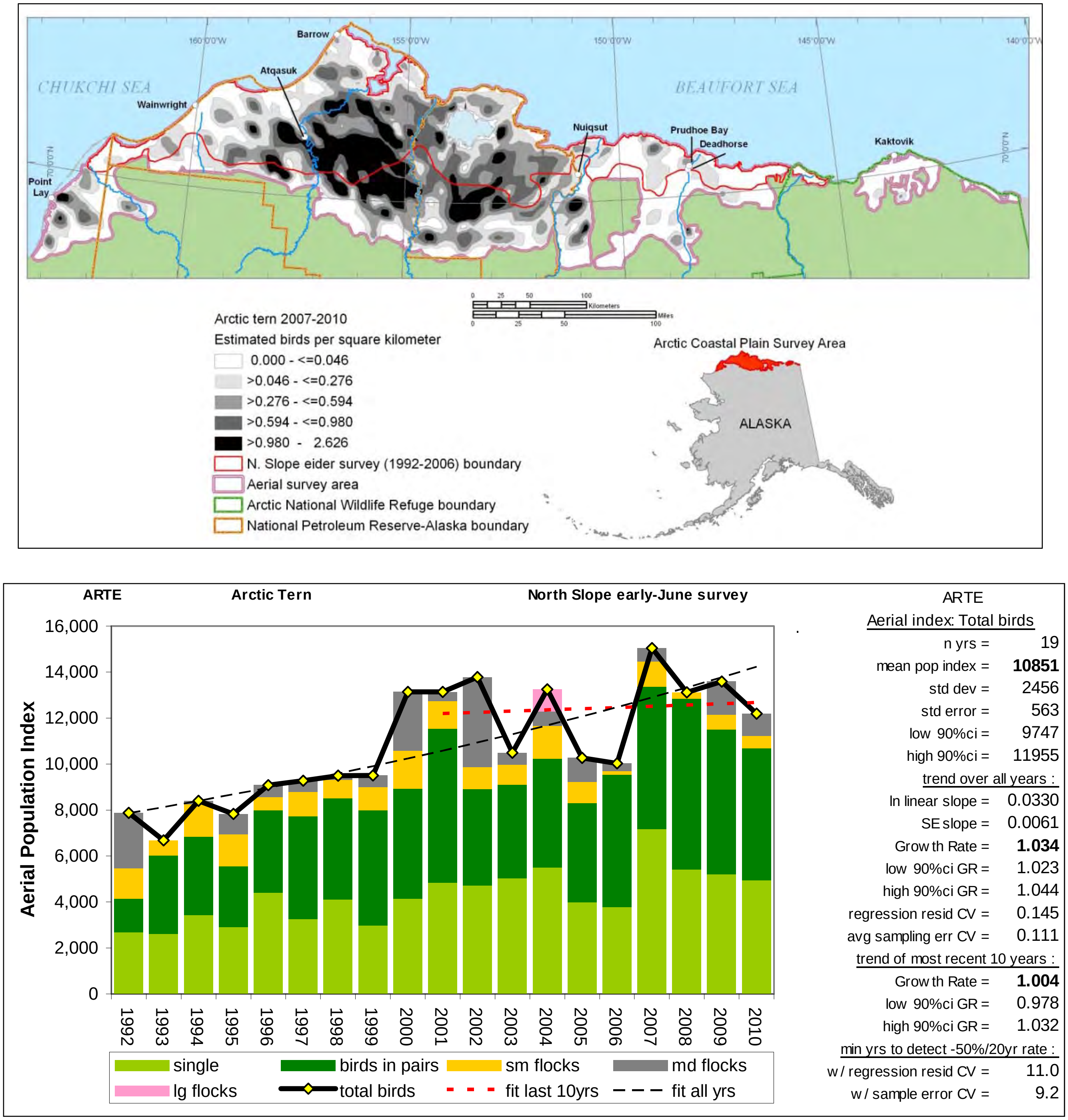
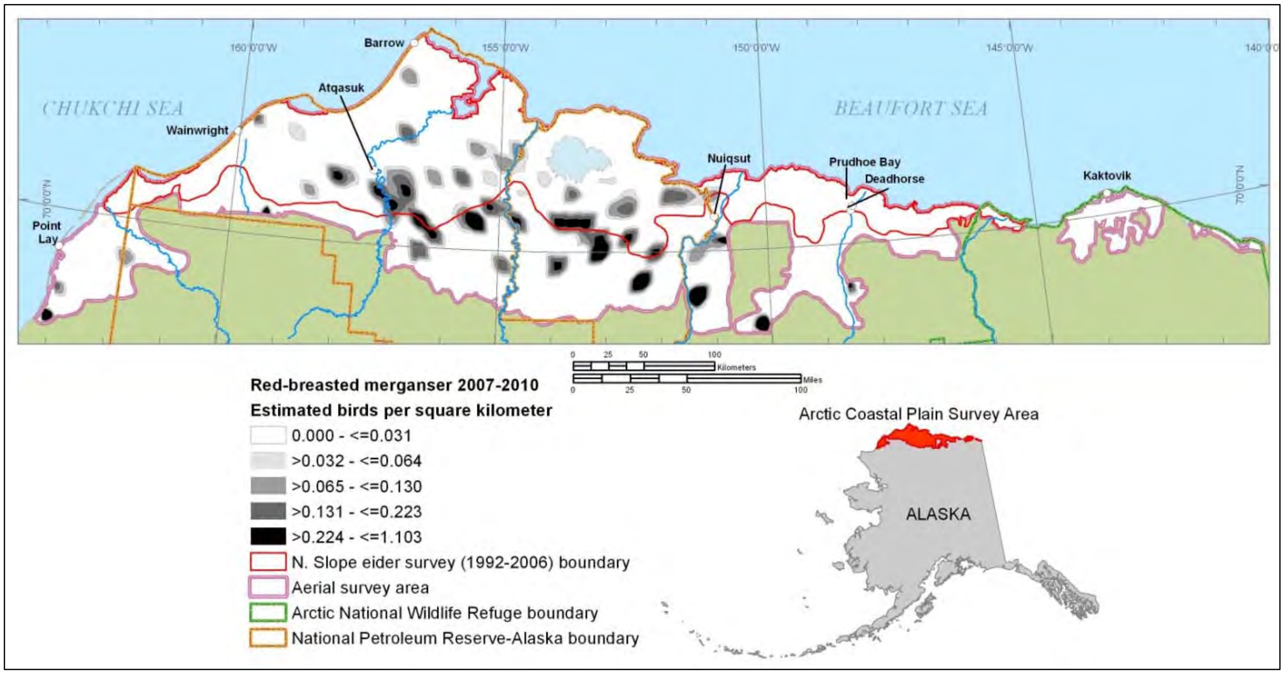


Figure 10. ***Top:*** Density distribution of Arctic tern (*Sterna paradisaea*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for Arctic terns observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



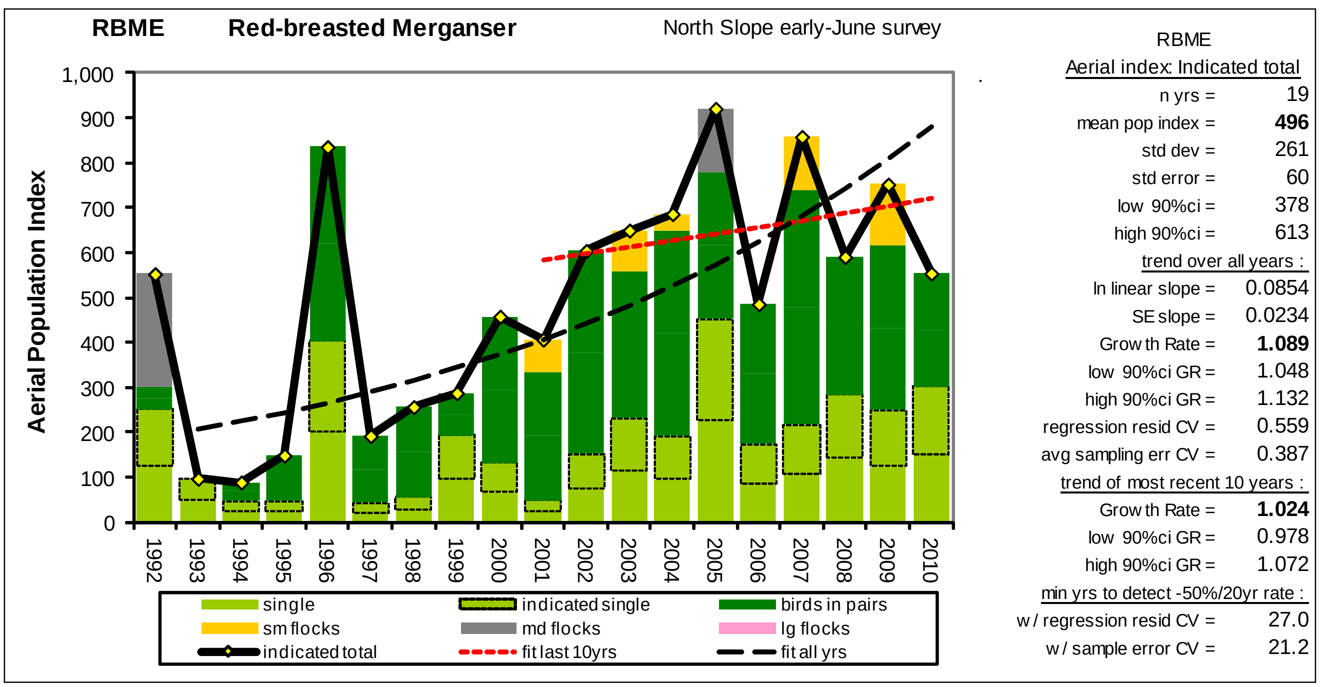


Figure 11. ***Top:*** Density distribution of red-breasted mergansers (*Mergus serrator*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for red-breasted mergansers observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

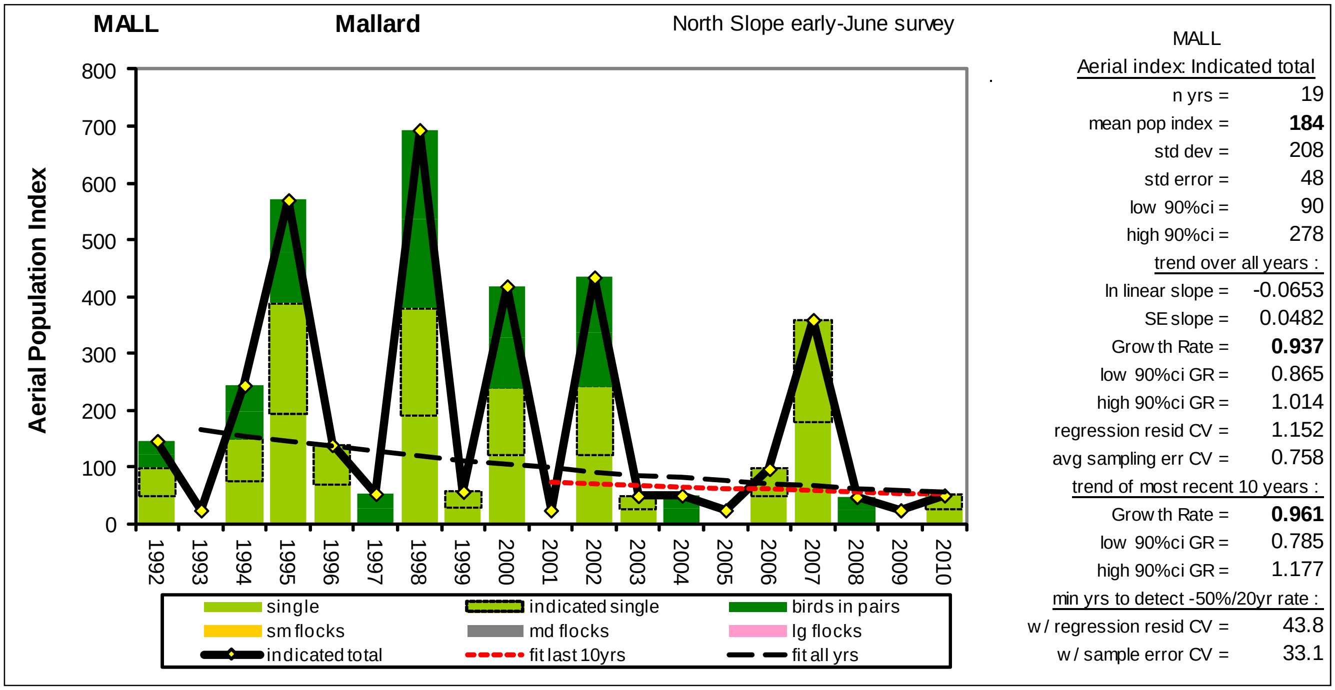


Figure 12. Population trend for mallards (*Anas platyrhynchos*) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.

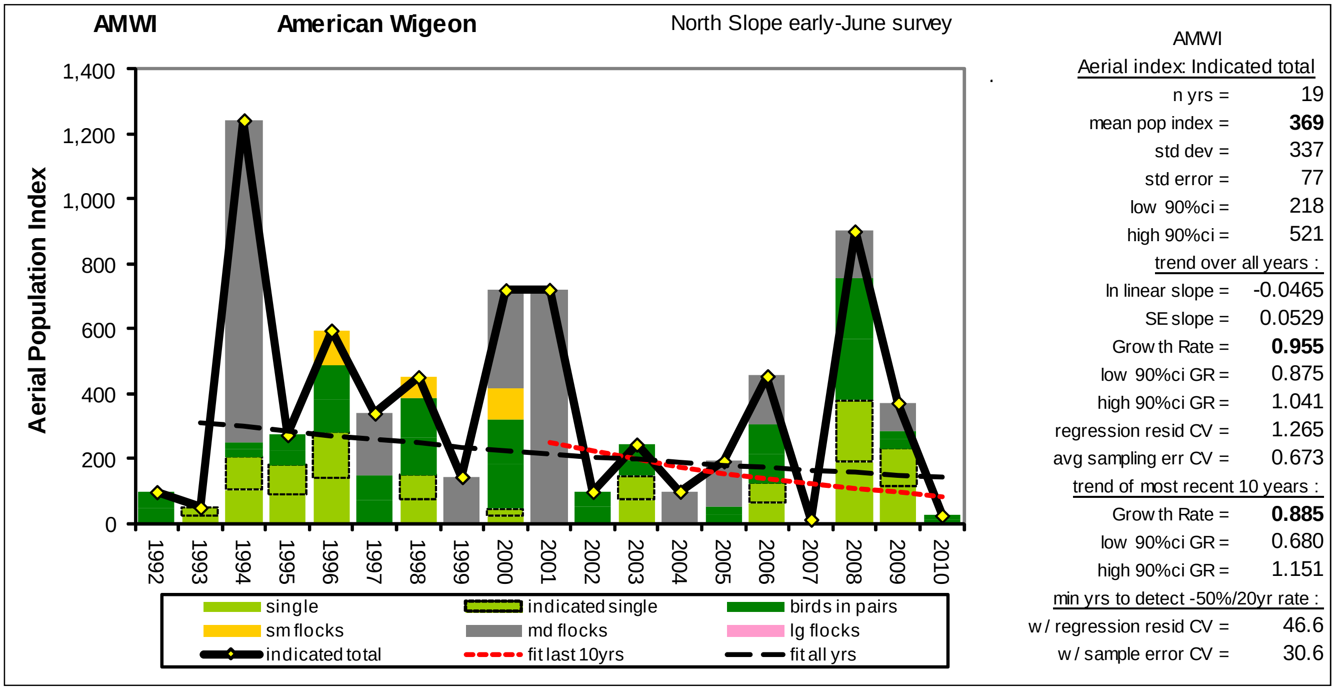


Figure 13. Population trend for American wigeon (*Anas Americana*) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.

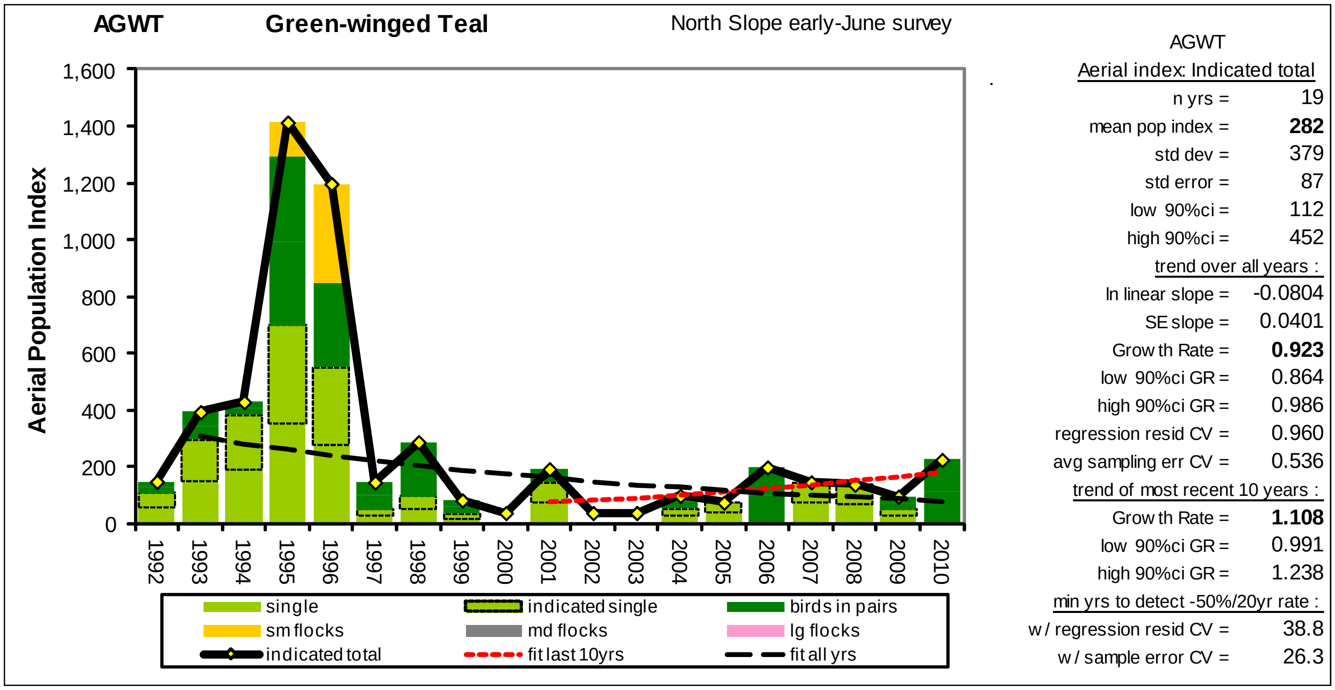
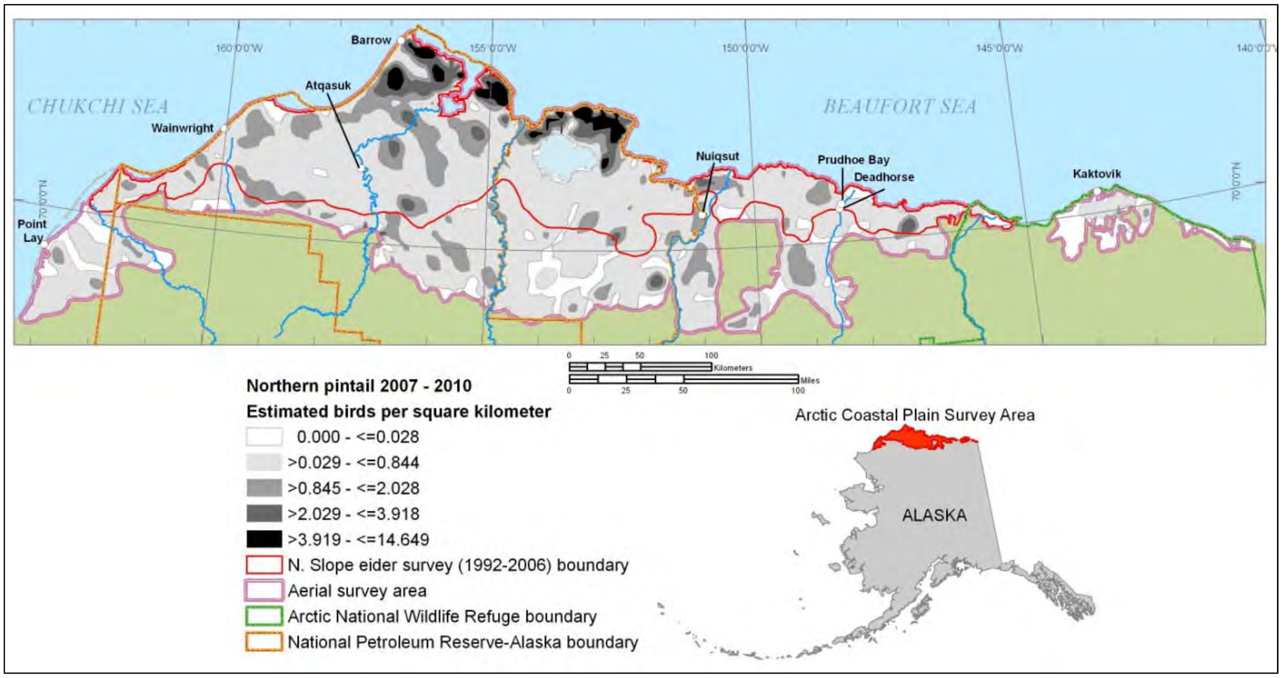


Figure 14. Population trend for green-winged teal (*Anas crecca*) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.



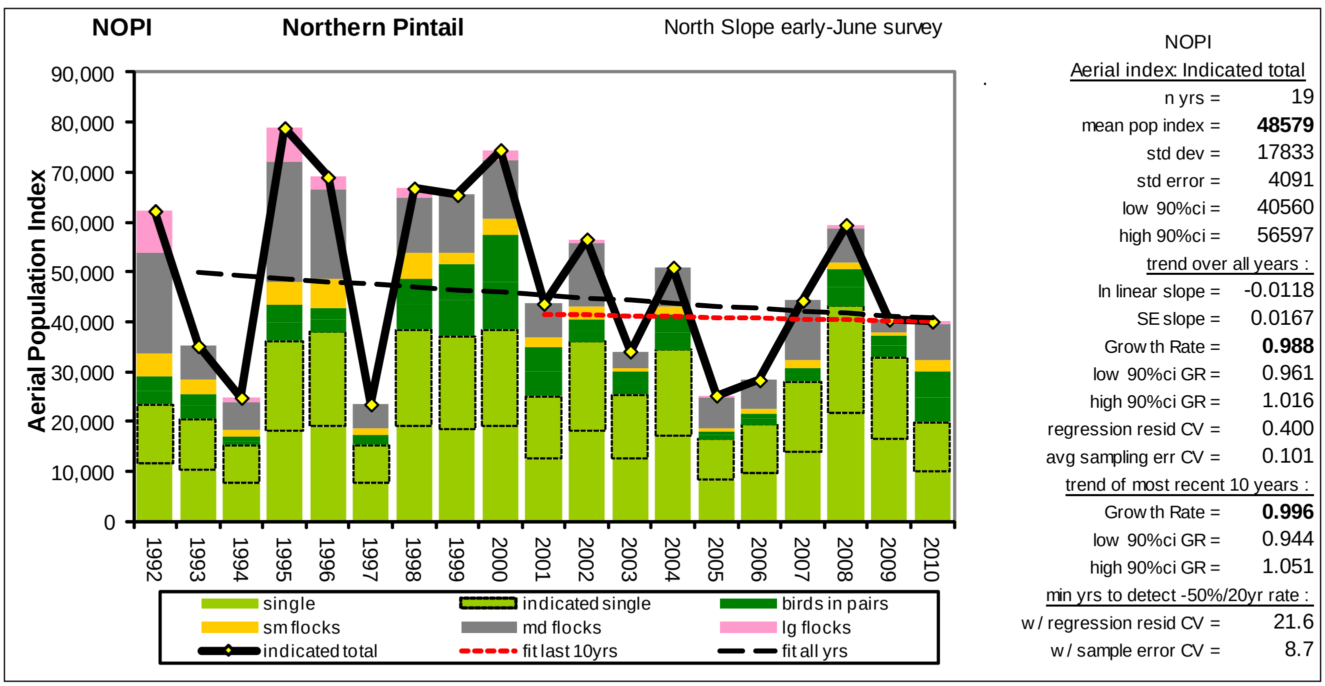


Figure 15. ***Top:*** Density distribution of northern pintails (*Anas acuta*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for northern pintails observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

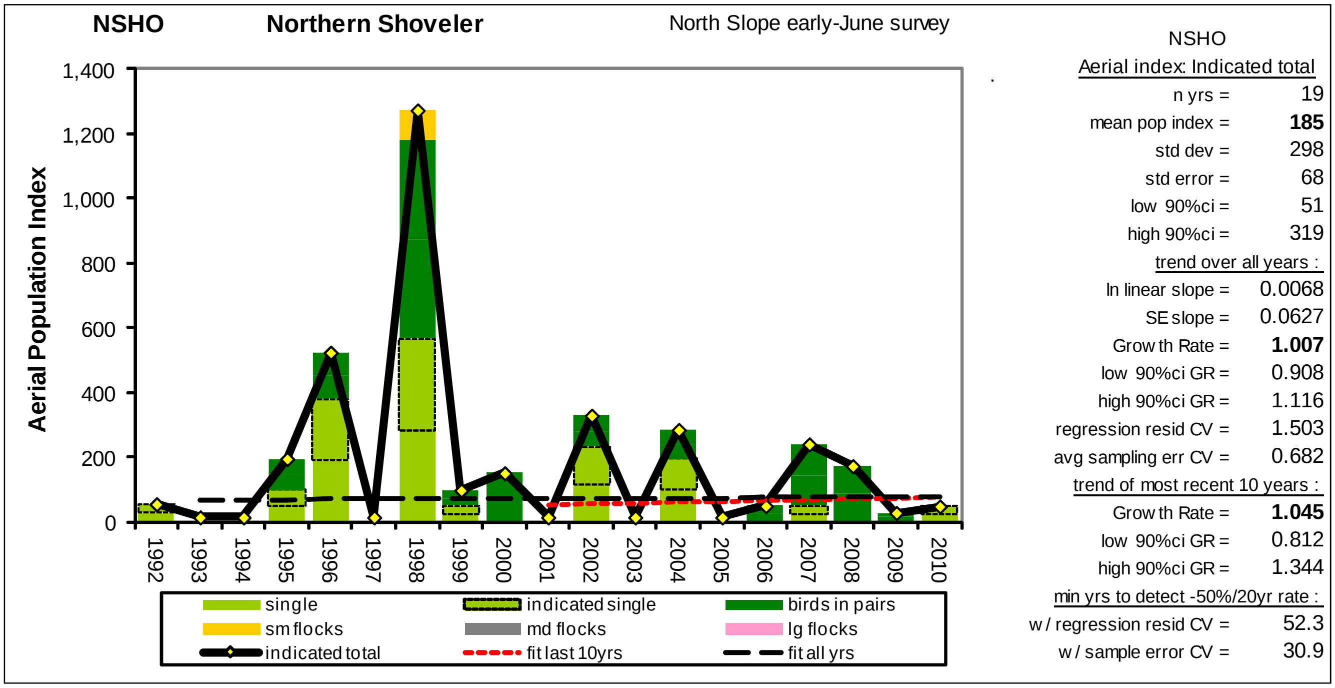
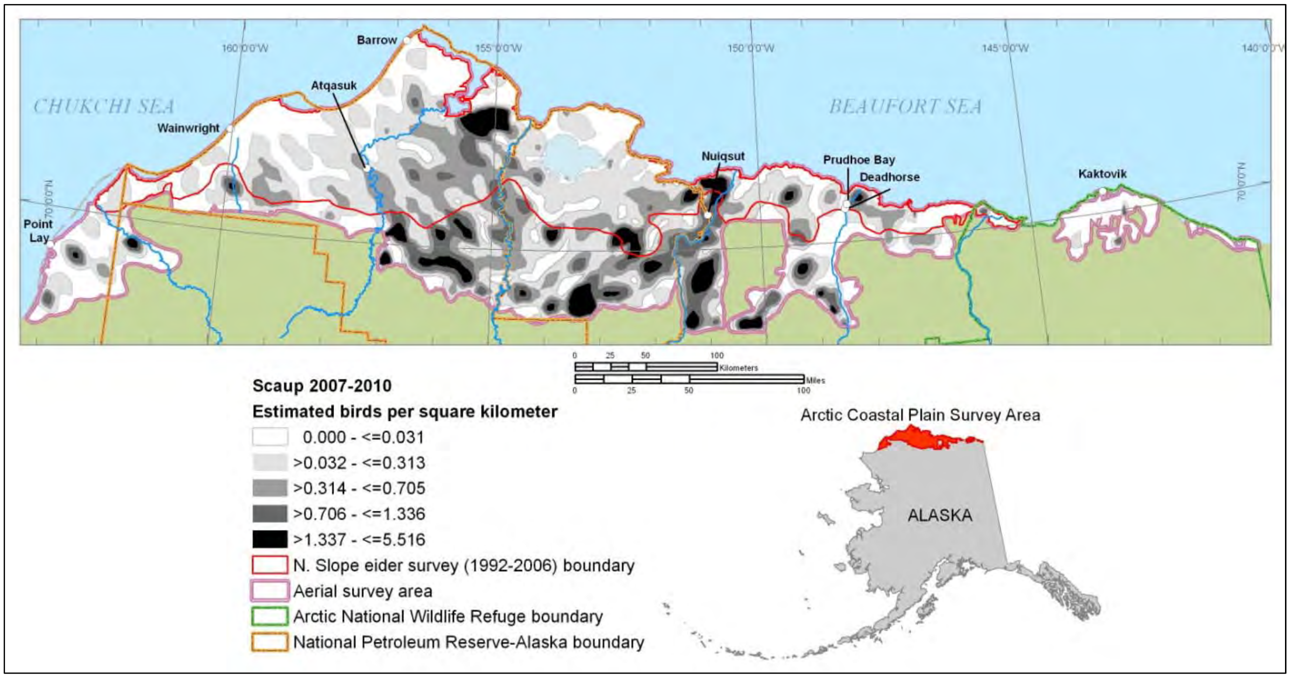


Figure 16. Population trend for northern shovelers (*Anas clypeata*) observed on aerial transects sampling 30,465 km^2 of wetland tundra on the North Slope of Alaska during early to mid June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.



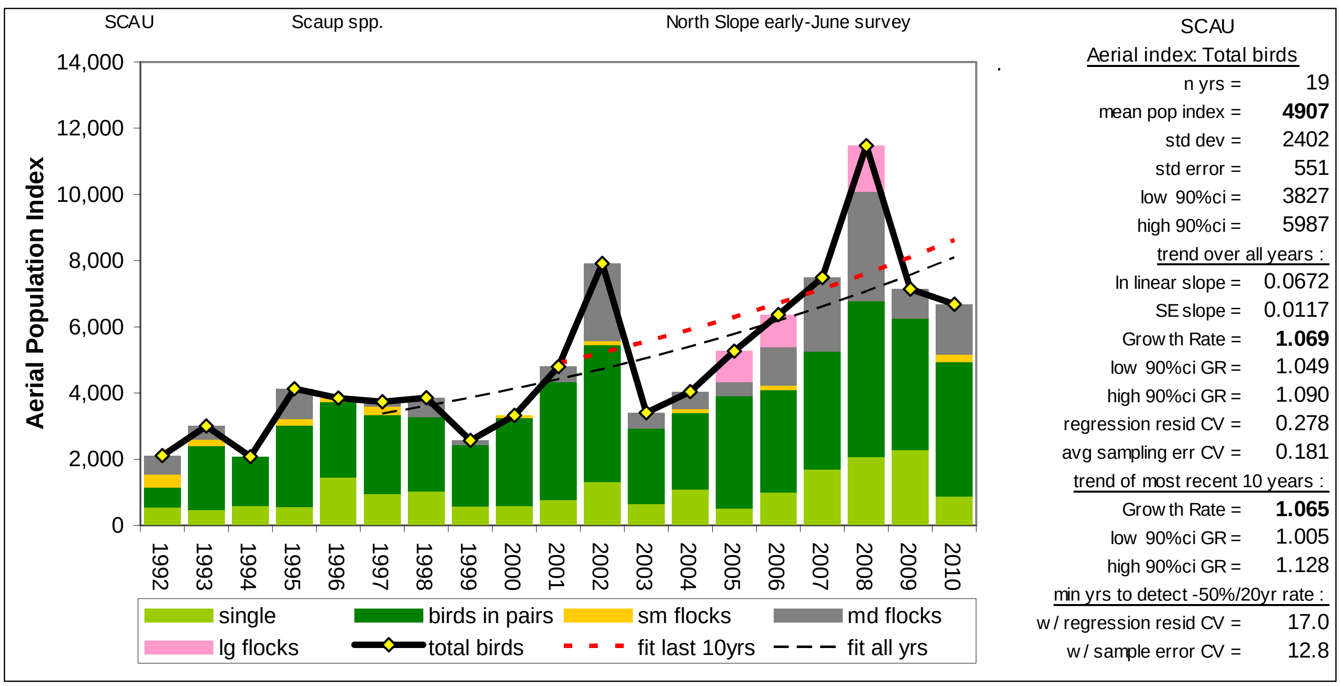


Figure 17. ***Top:*** Density distribution of scaup (primarily *Aythya marila*, possibly some *A. affinis*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for scaup observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

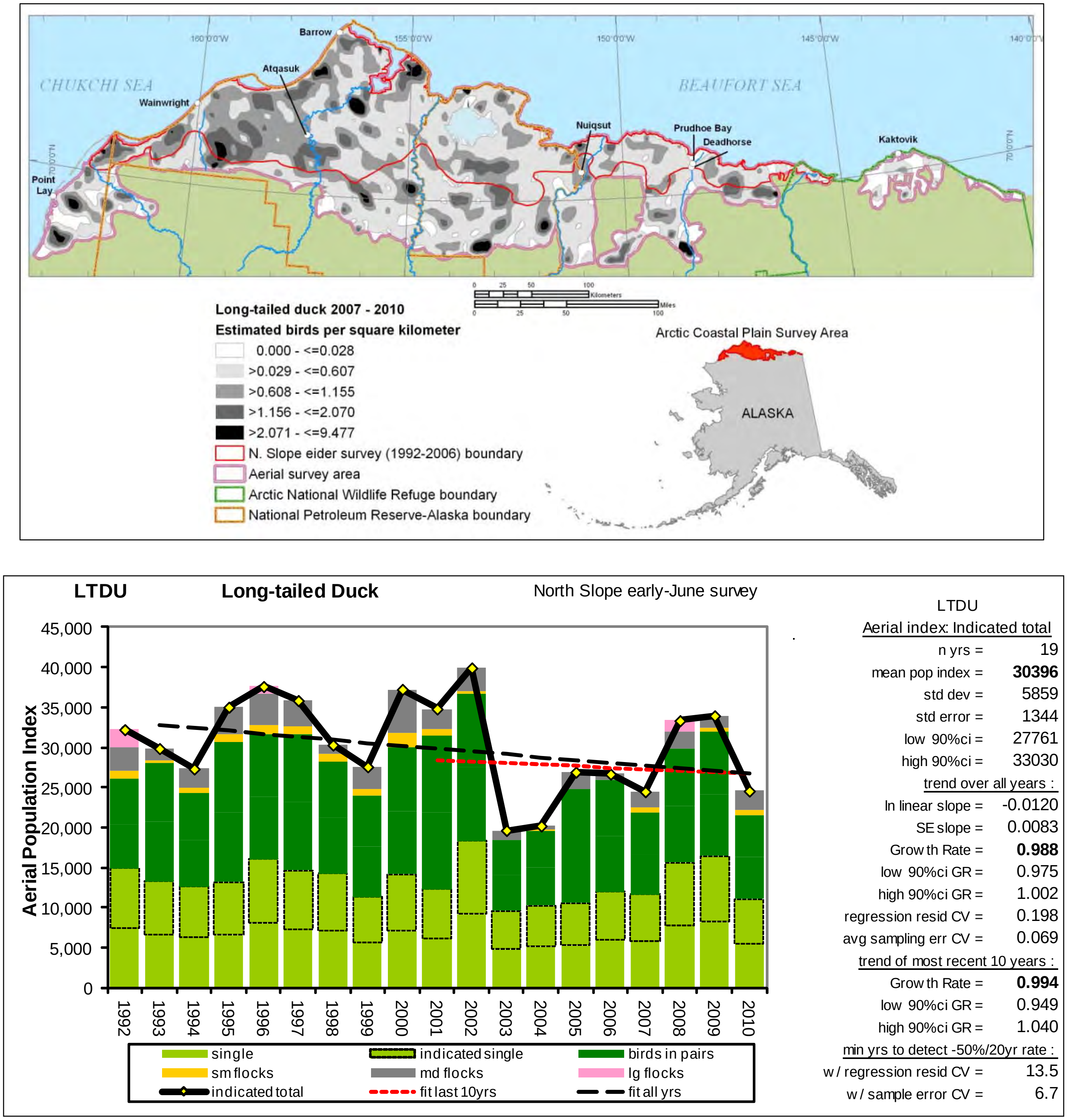
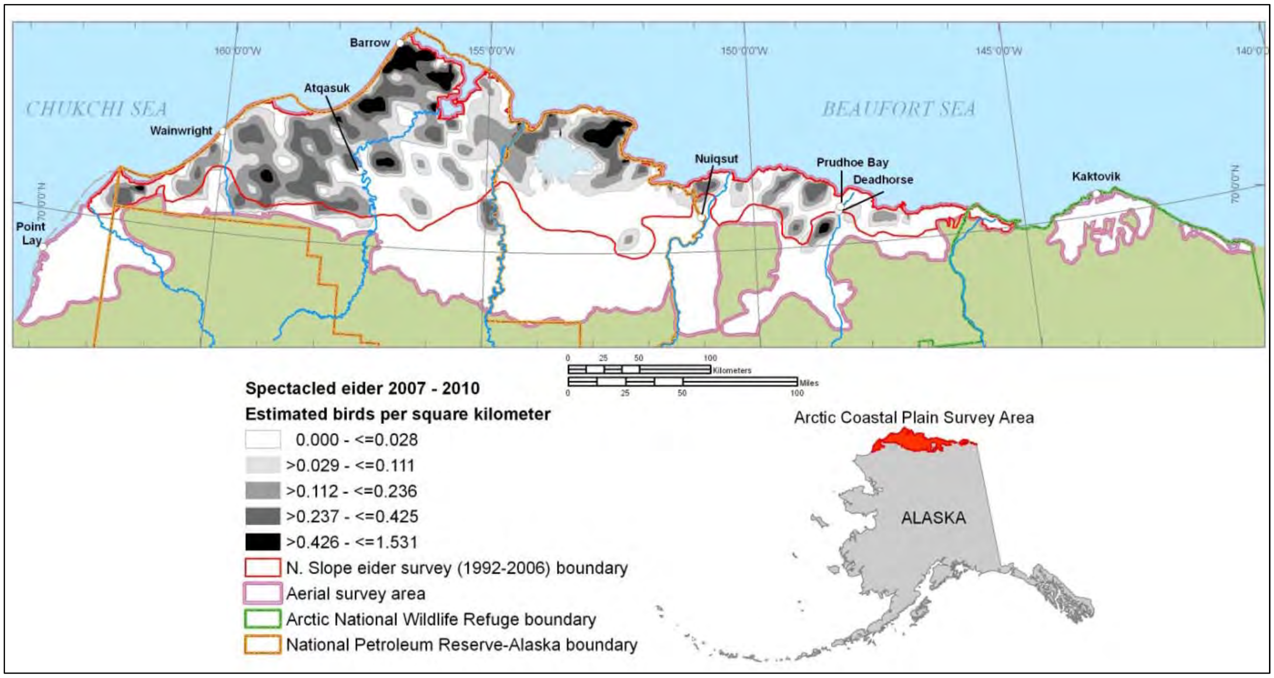


Figure 18. ***Top:*** Density distribution of long-tailed ducks (*Clangula hyemalis*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for long-tailed ducks observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with *p*=0.10, beta at *p*=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



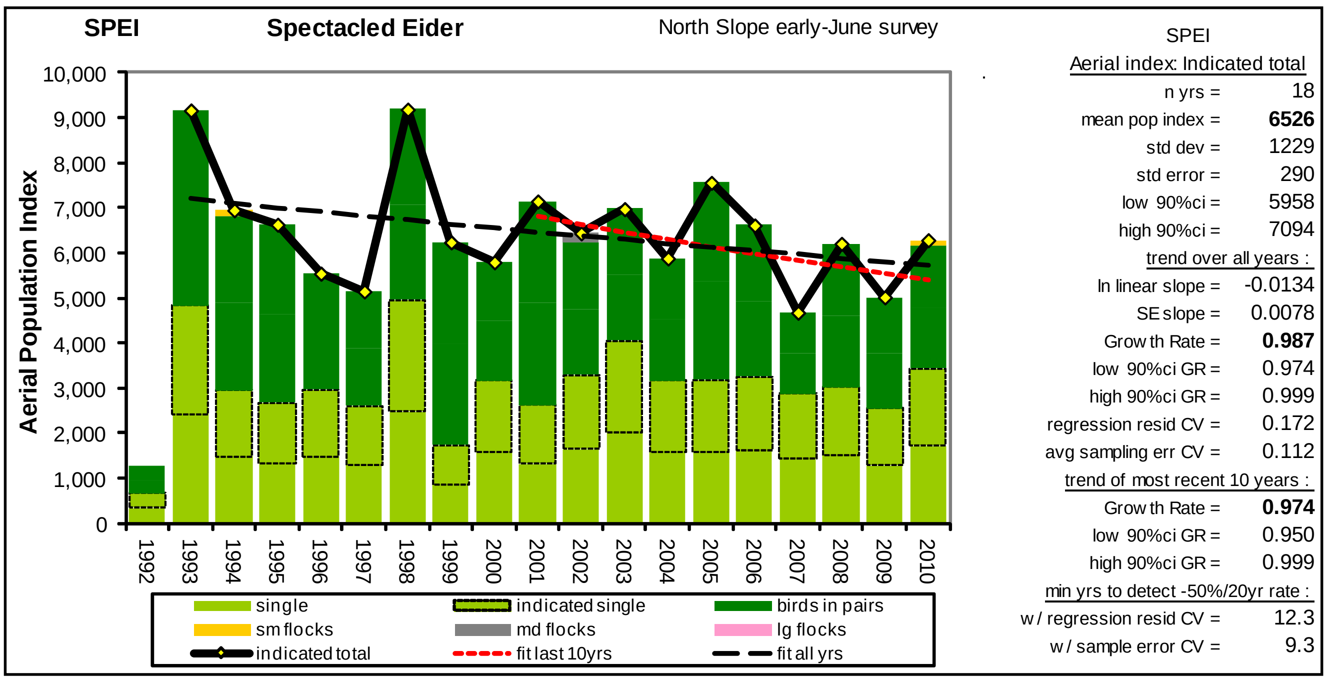


Figure 19. ***Top:*** Density distribution of spectacled eiders (*Somateria fischeri*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for spectacled eiders observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

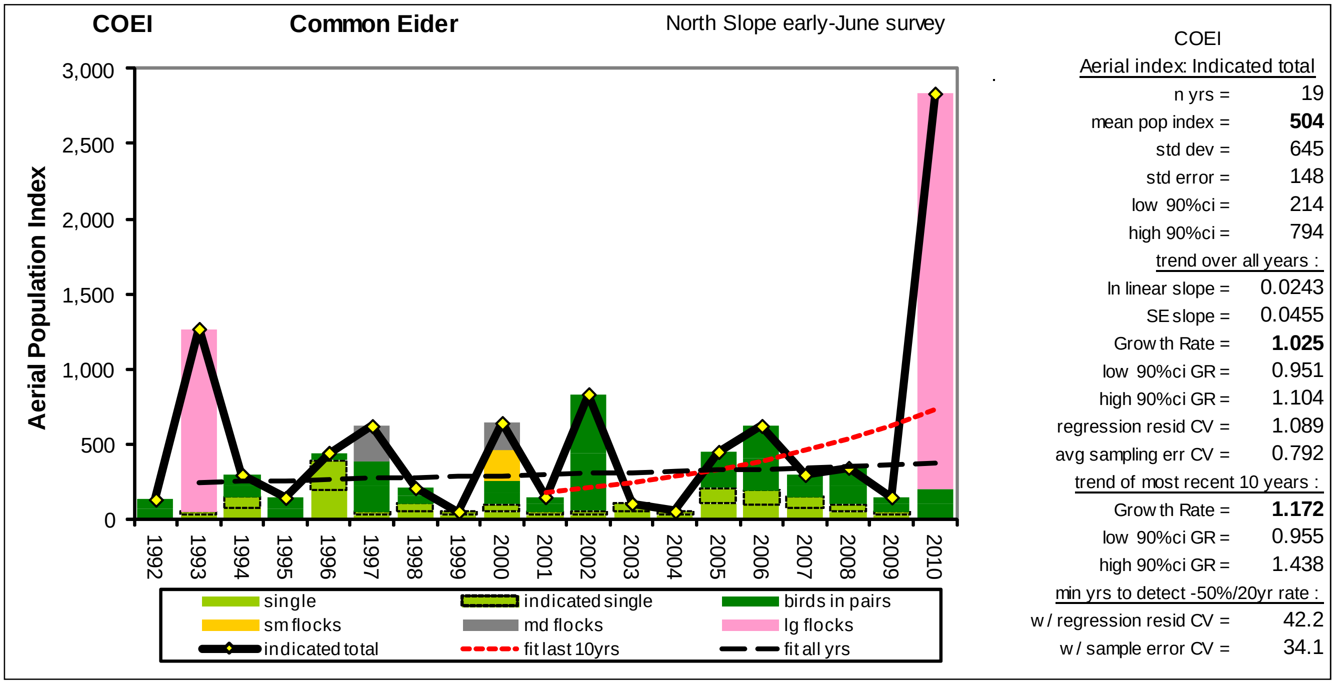
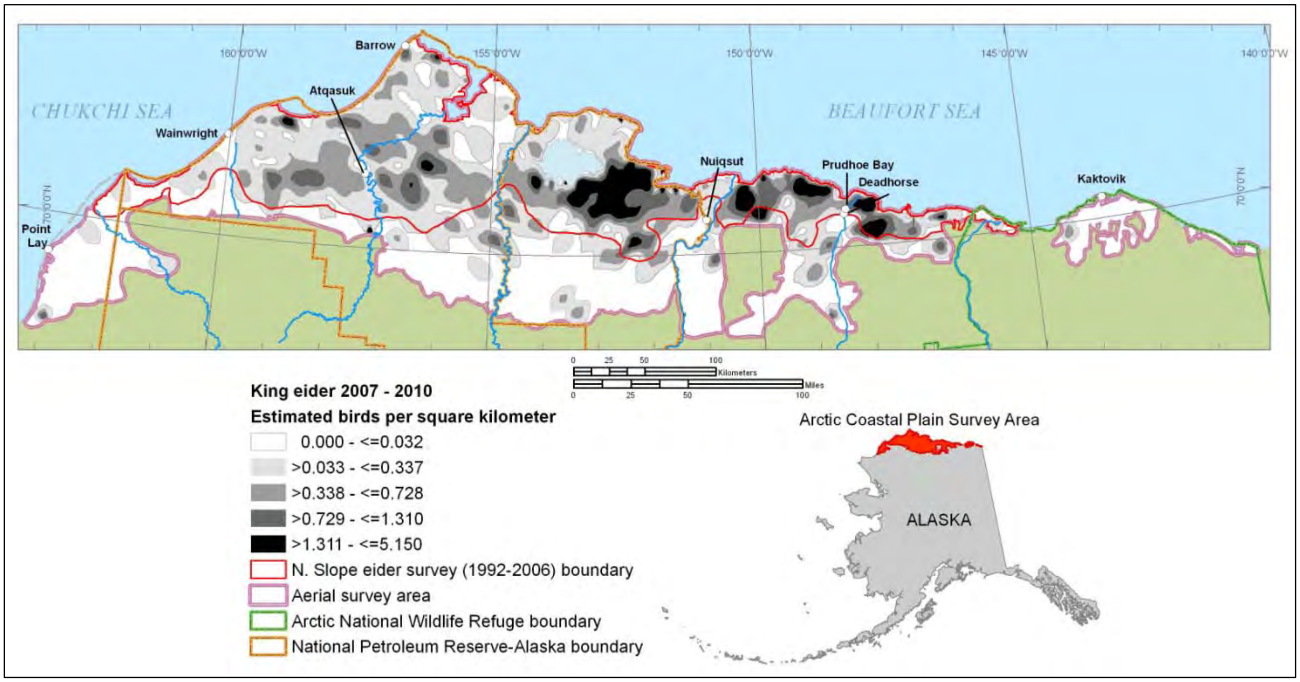


Figure 20. Population trend for common eiders (*Somateria mollissima*) observed on aerial transects sampling 30,465 km^2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.



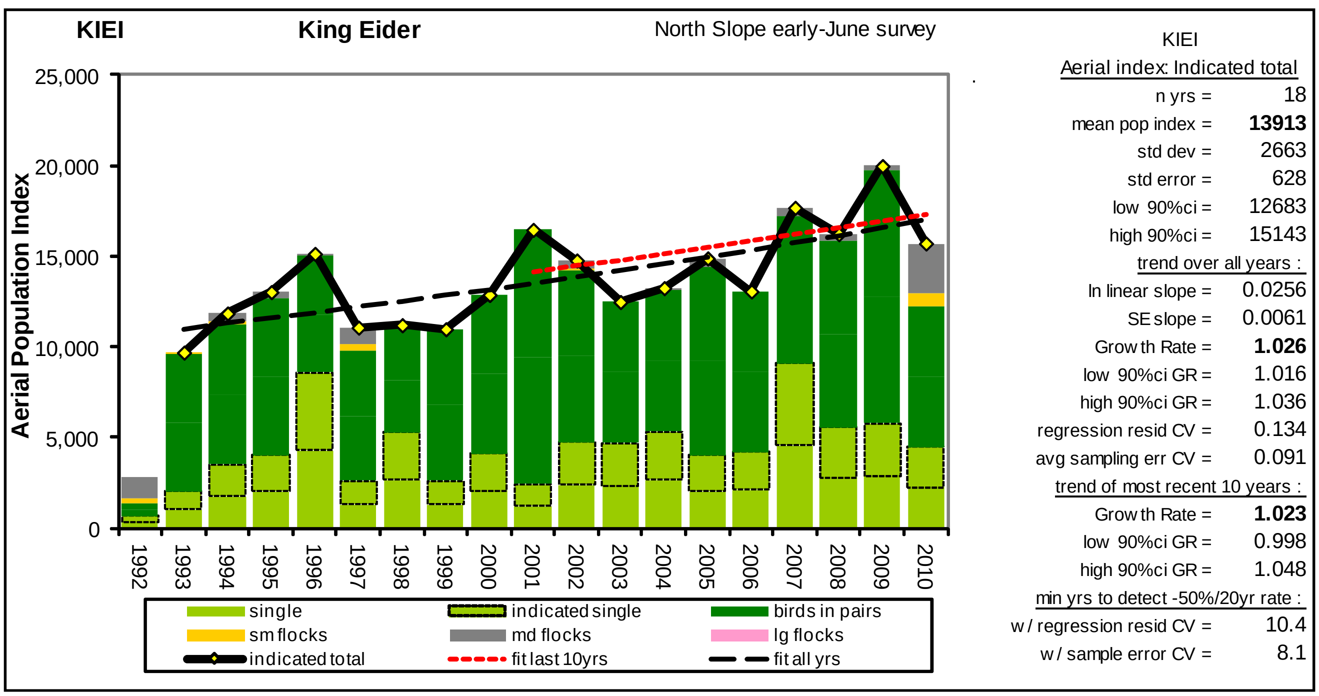


Figure 21. ***Top:*** Density distribution of king eiders (*Somateria spectabilis*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for king eiders observed on a 30,465 km^2 portion of the ACP survey area (depicted on the above map as the North Slope Eider Survey boundary), 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

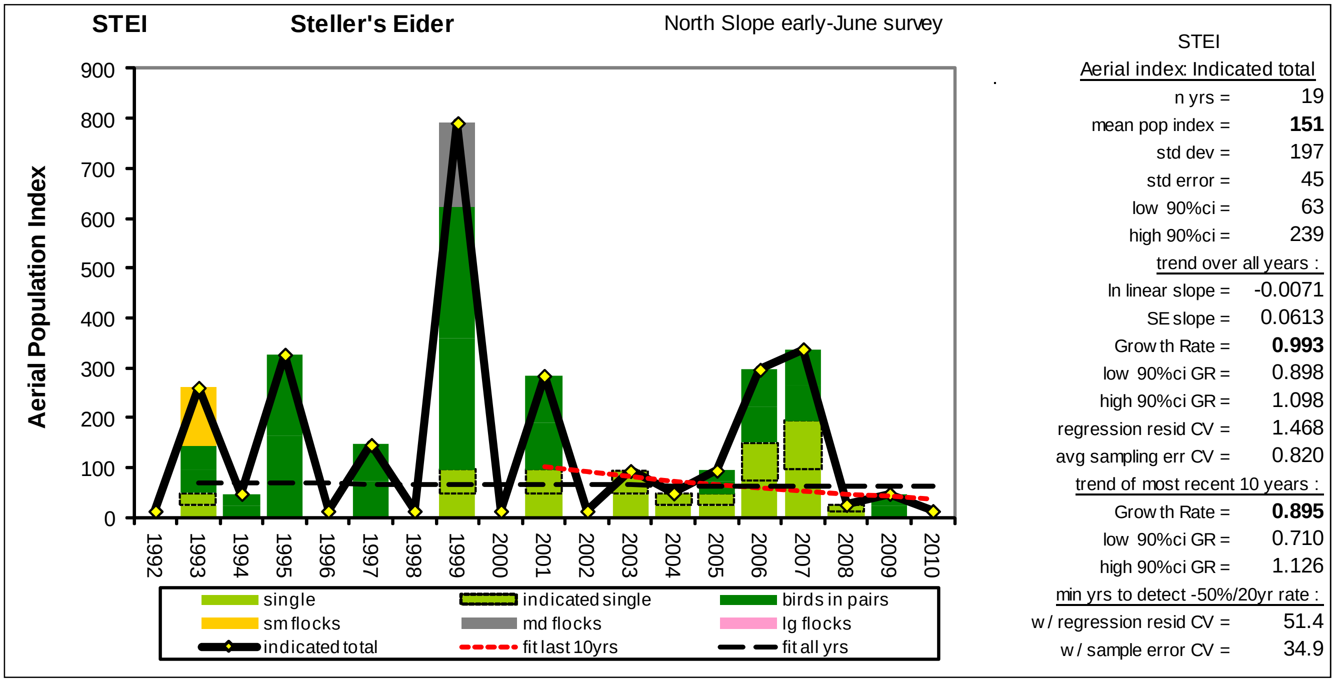
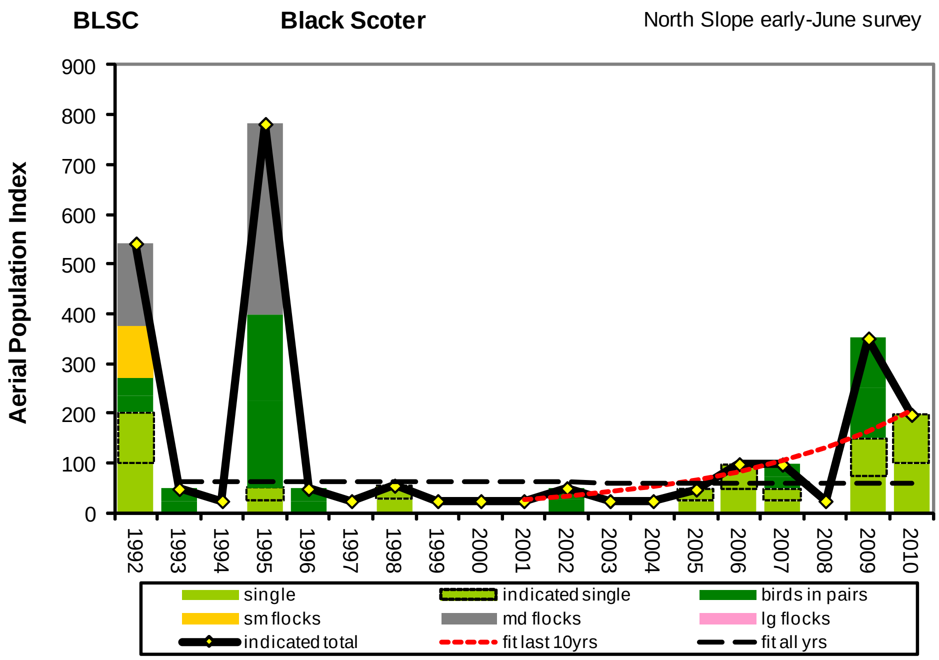


Figure 22. Population trend for Steller's eiders (*Polysticta stelleri*) observed on aerial transects sampling 30,465 km^2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.



BLSC	
Aerial index: Indicated total	
n yrs =	19
mean pop index =	**132**
std dev =	207
std error =	48
low 90%ci =	38
high 90%ci =	225
trend over all years :	
ln linear slope =	-0.0020
SE slope =	0.0495
Growth Rate =	**0.998**
low 90%ci GR =	0.920
high 90%ci GR =	1.083
regression resid CV =	1.184
avg sampling err CV =	0.858
trend of most recent 10 years :	
Growth Rate =	**1.258**
low 90%ci GR =	1.102
high 90%ci GR =	1.436
min yrs to detect -50%/20yr rate :	
w / regression resid CV =	44.6
w / sample error CV =	36.0

Figure 23. Population trend for black scoters (*Melanitta nigra*) observed on aerial transects sampling 30,465 km^2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.

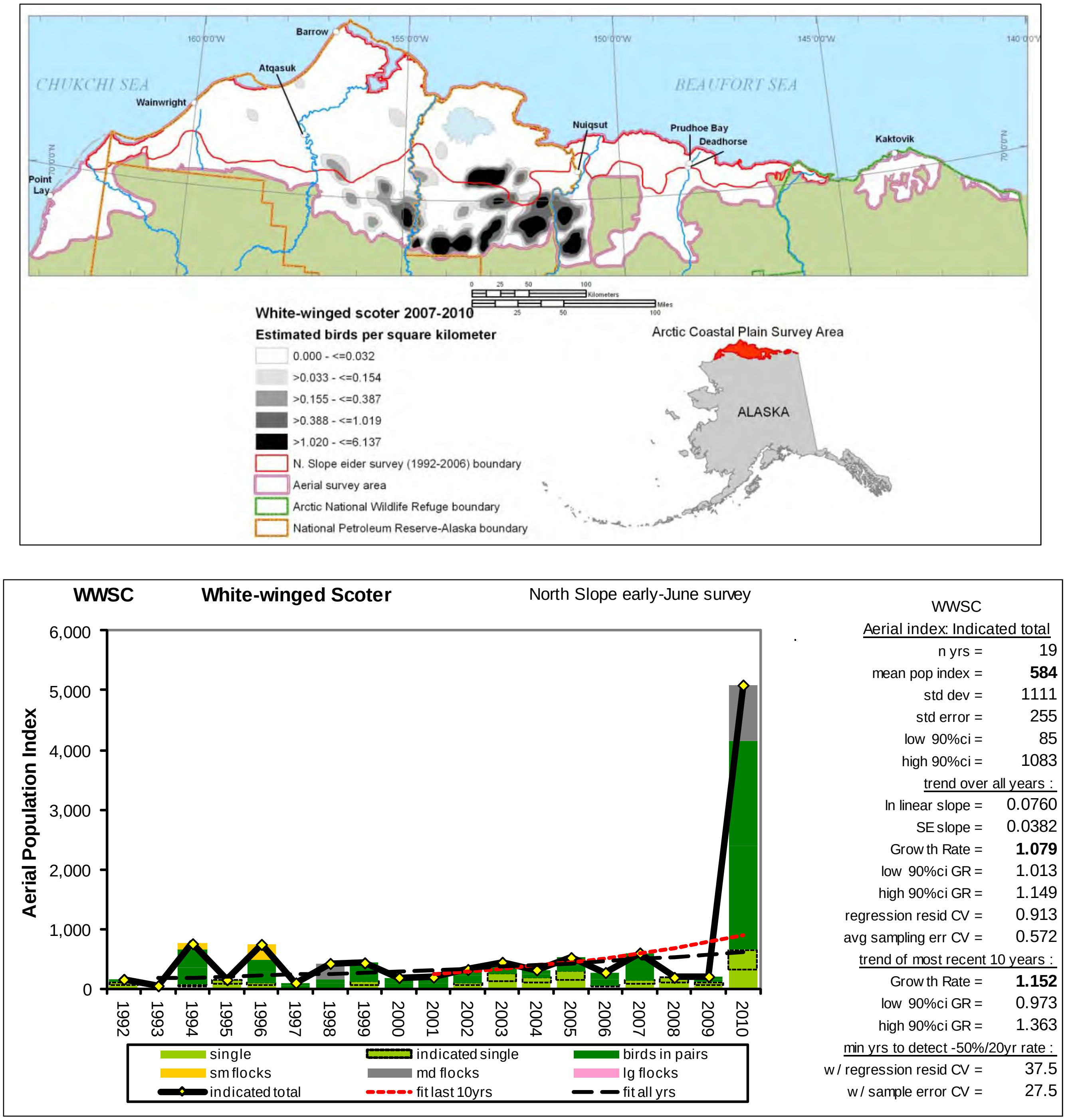
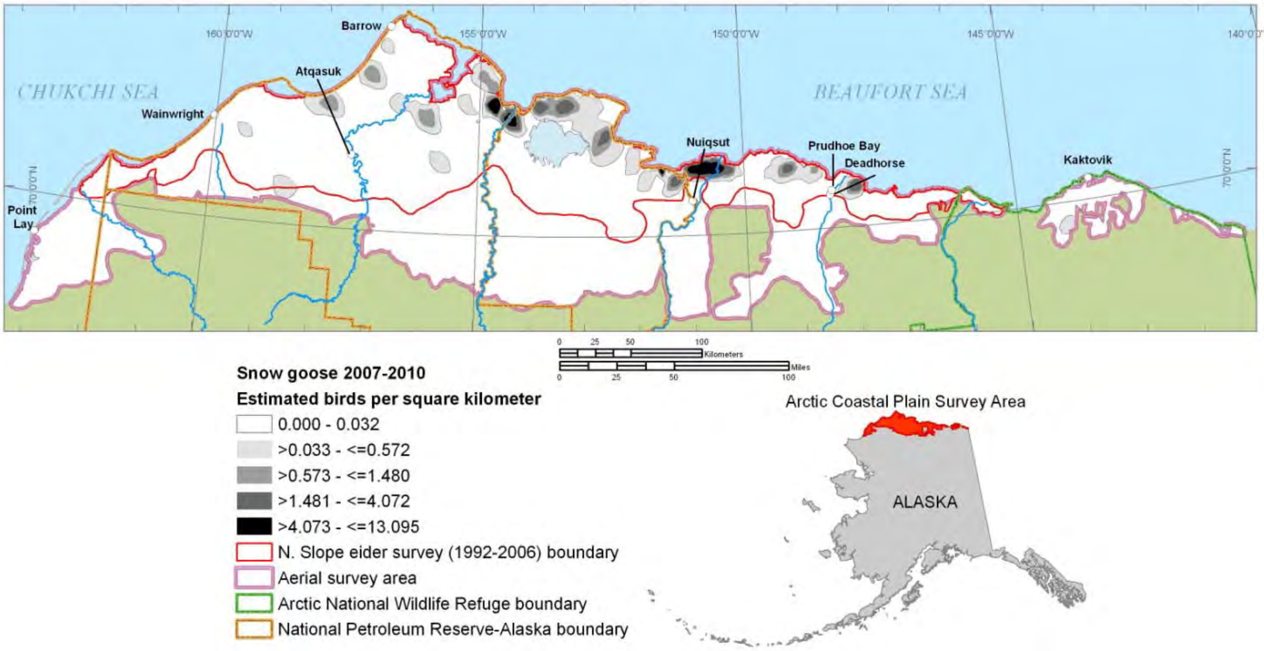
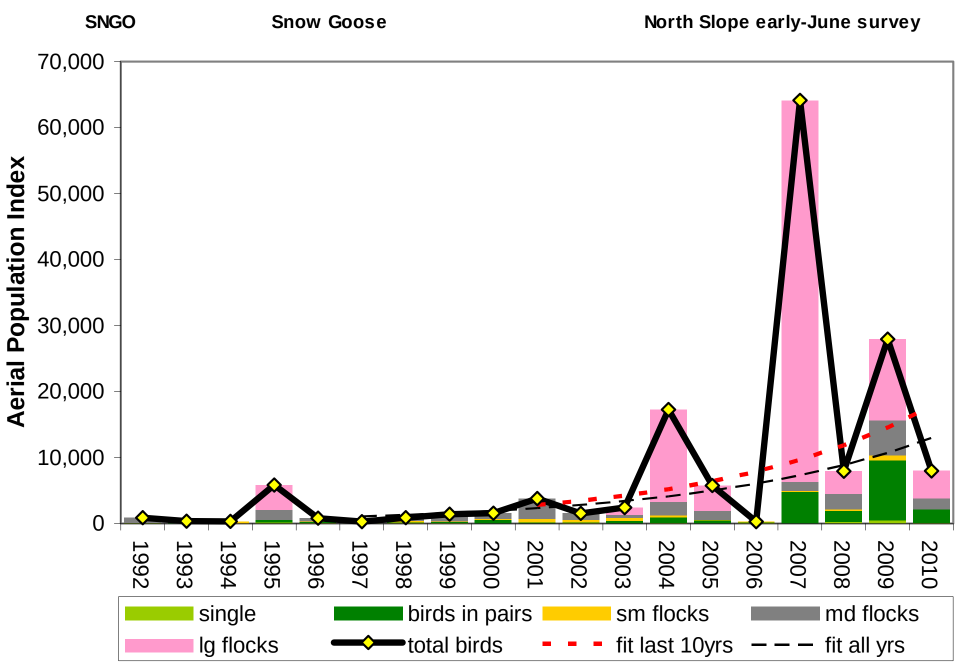


Figure 24. ***Top:*** Density distribution of white-winged scoters (*Melanitta fusca*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for white-winged scoters observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with *p*=0.10, beta at *p*=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.



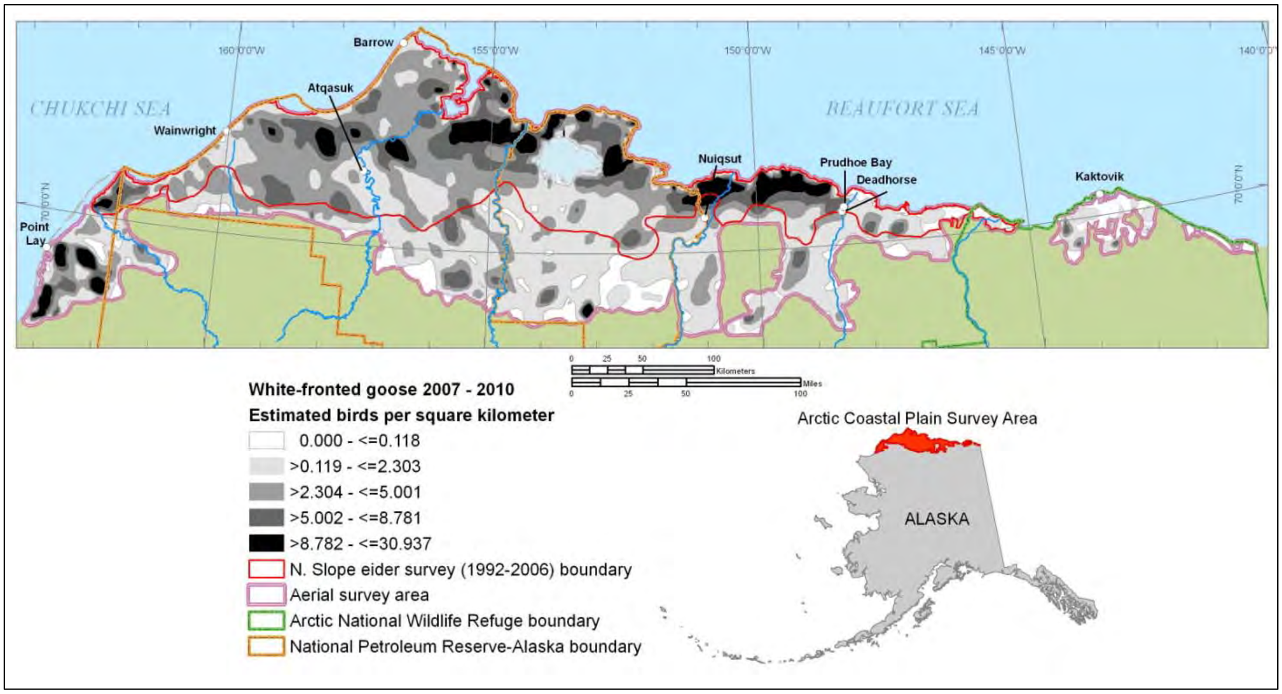


SNGO

Aerial index: Total birds

n yrs =	19
mean pop index =	**7960**
std dev =	15289
std error =	3508
low 90%ci =	1085
high 90%ci =	14835
trend over all years :	
ln linear slope =	0.1906
SE slope =	0.0520
Growth Rate =	**1.210**
low 90%ci GR =	1.111
high 90%ci GR =	1.318
regression resid CV =	1.244
avg sampling err CV =	0.561
trend of most recent 10 years :	
Growth Rate =	**1.228**
low 90%ci GR =	0.932
high 90%ci GR =	1.617
min yrs to detect -50%/20yr rate :	
w / regression resid CV =	46.1
w / sample error CV =	27.1

Figure 25. ***Top:*** Density distribution of snow geese (*Chen caerulescens*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for snow geese observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



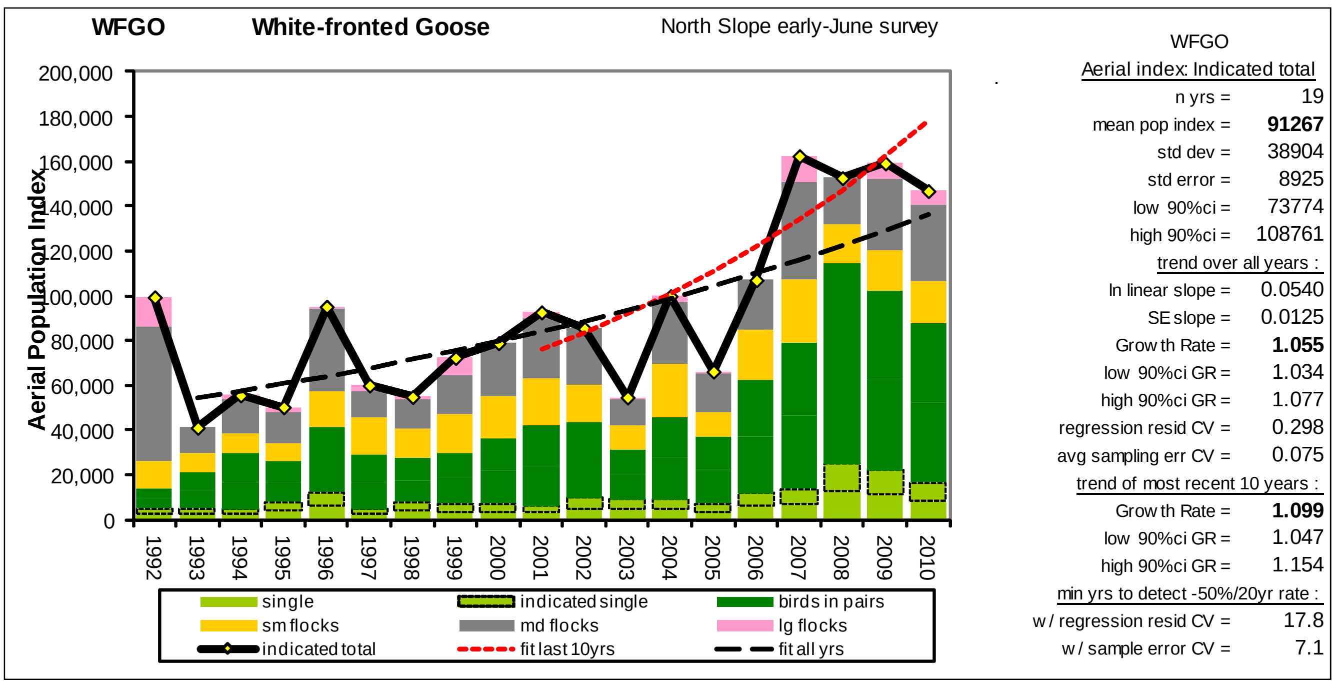
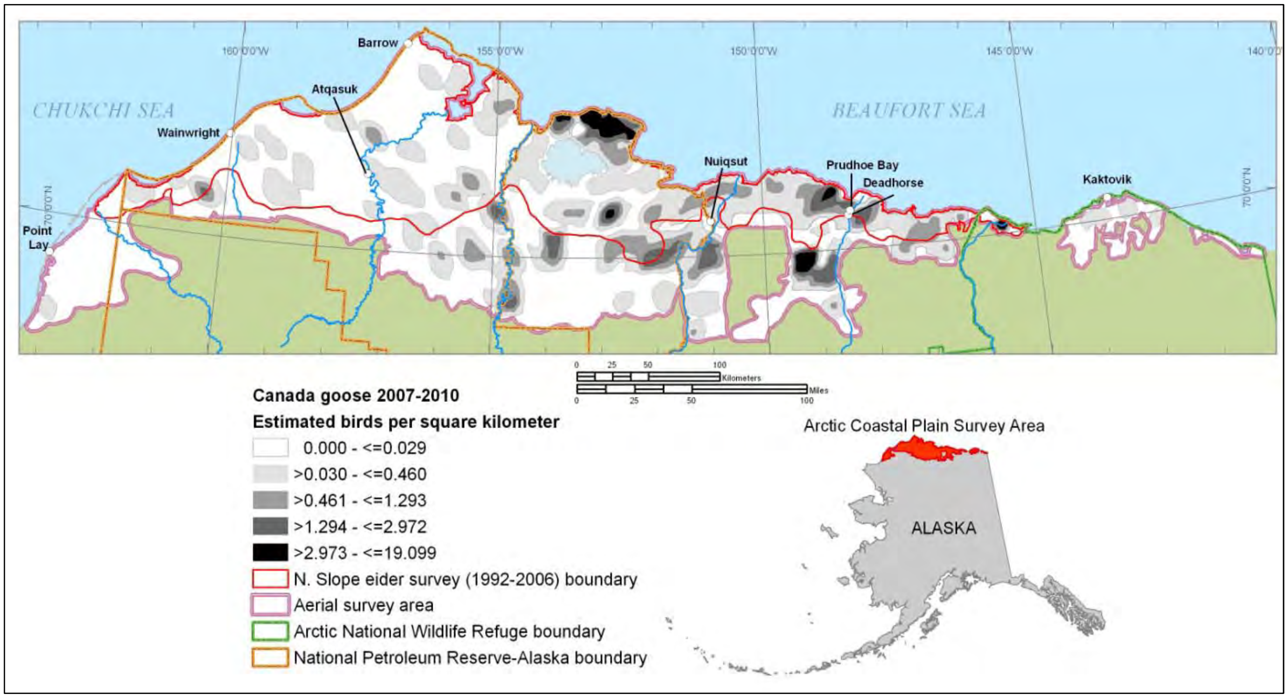


Figure 26. ***Top:*** Density distribution of white-fronted geese (*Anser albifrons*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for white-fronted geese observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



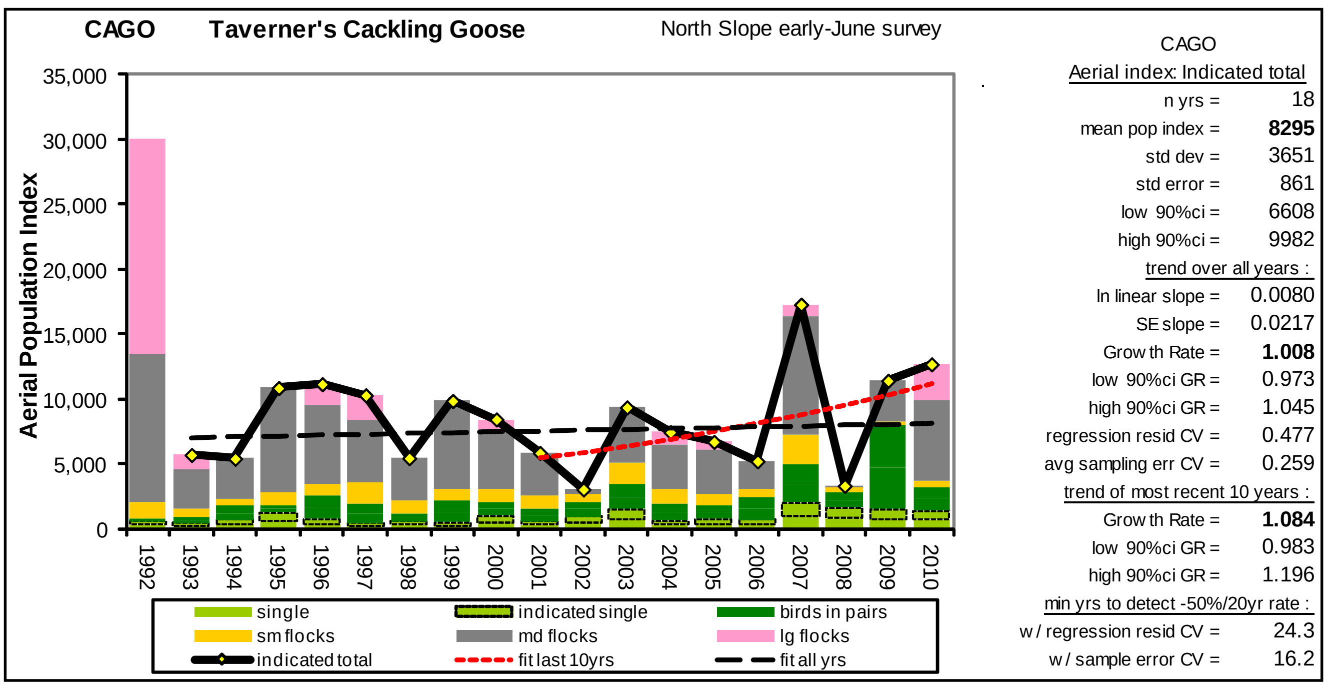
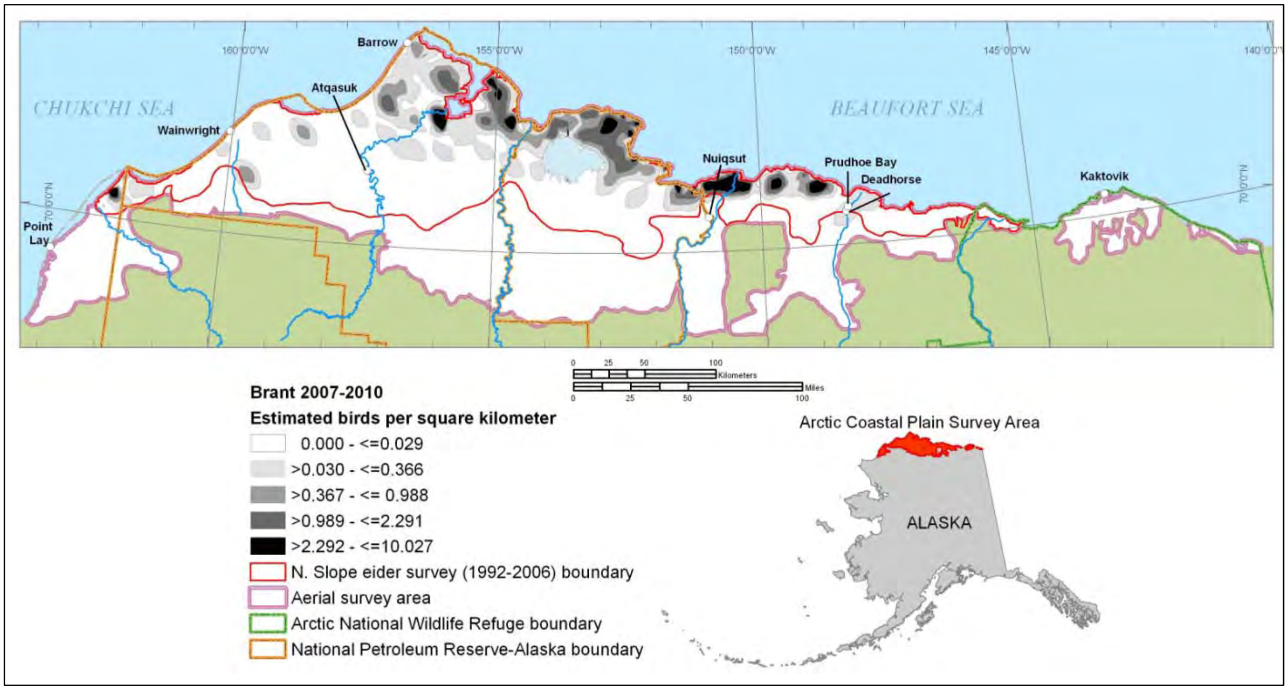


Figure 27. ***Top:*** Density distribution of Taverner's cackling geese (*Branta hutchinsii taverneri*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for Taverner's cackling geese observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with *p*=0.10, beta at *p*=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



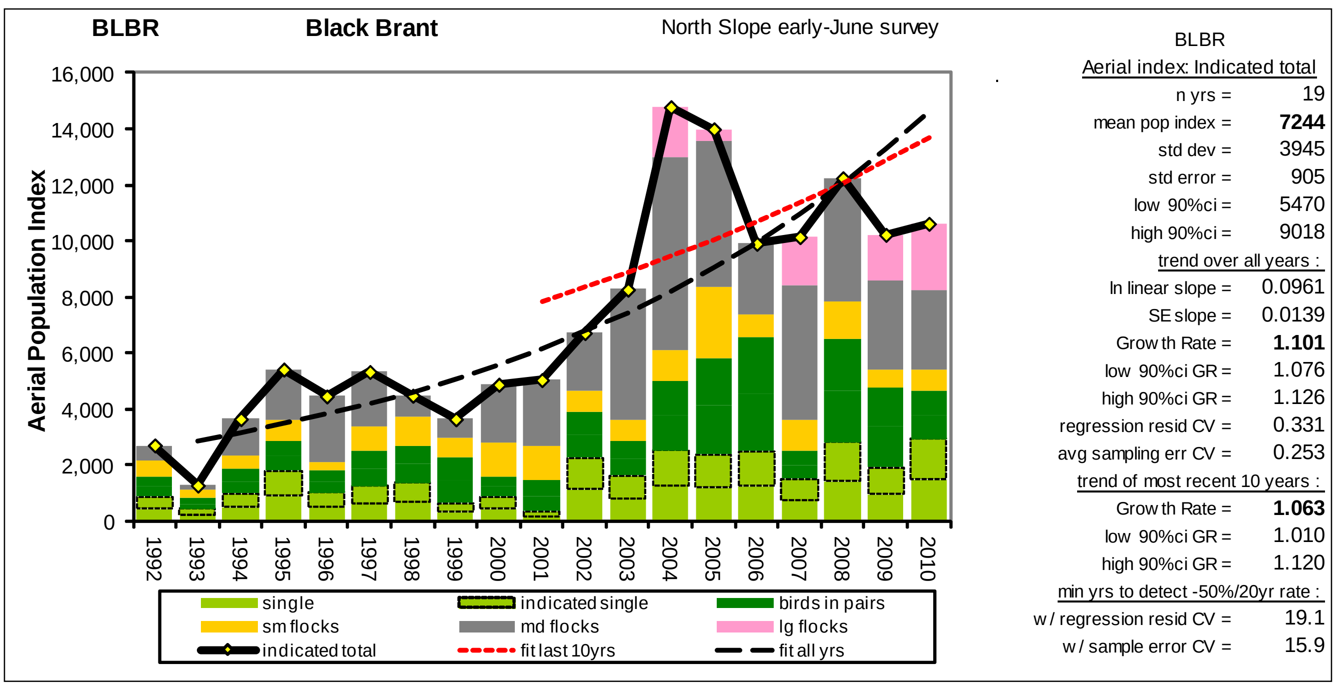
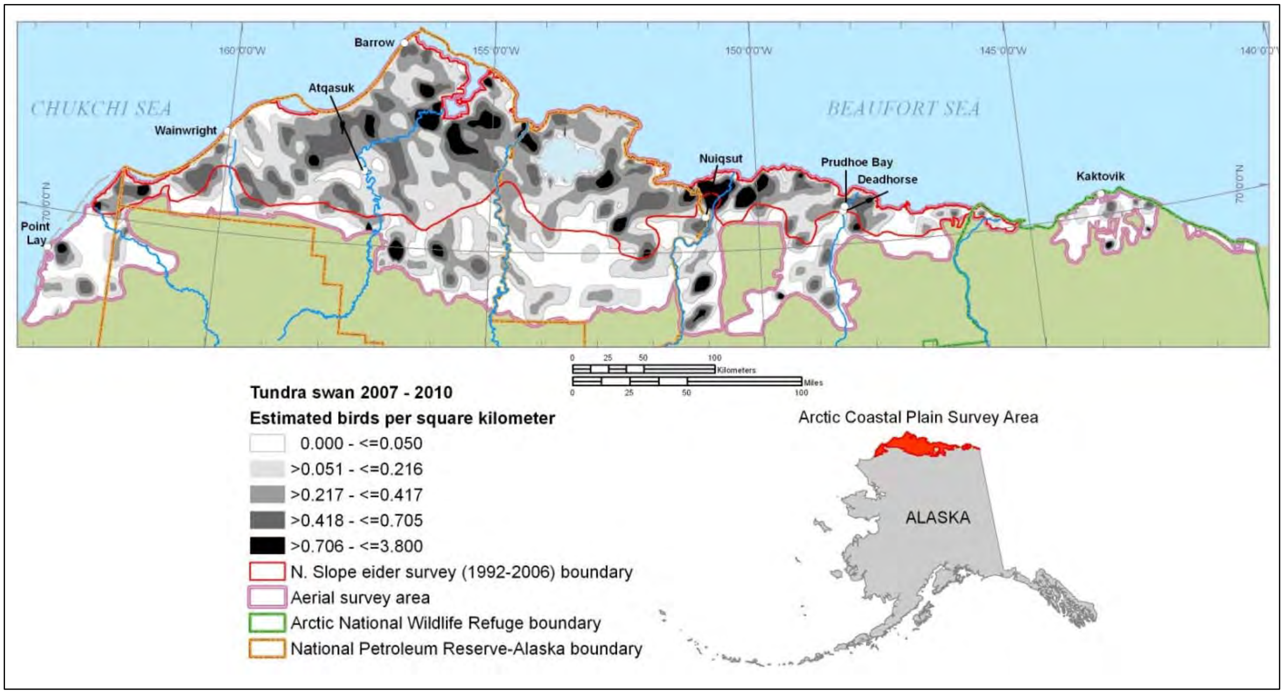


Figure 28. ***Top:*** Density distribution of black brant (*Branta bernicla*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010.
Bottom: Population trend for black brant observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



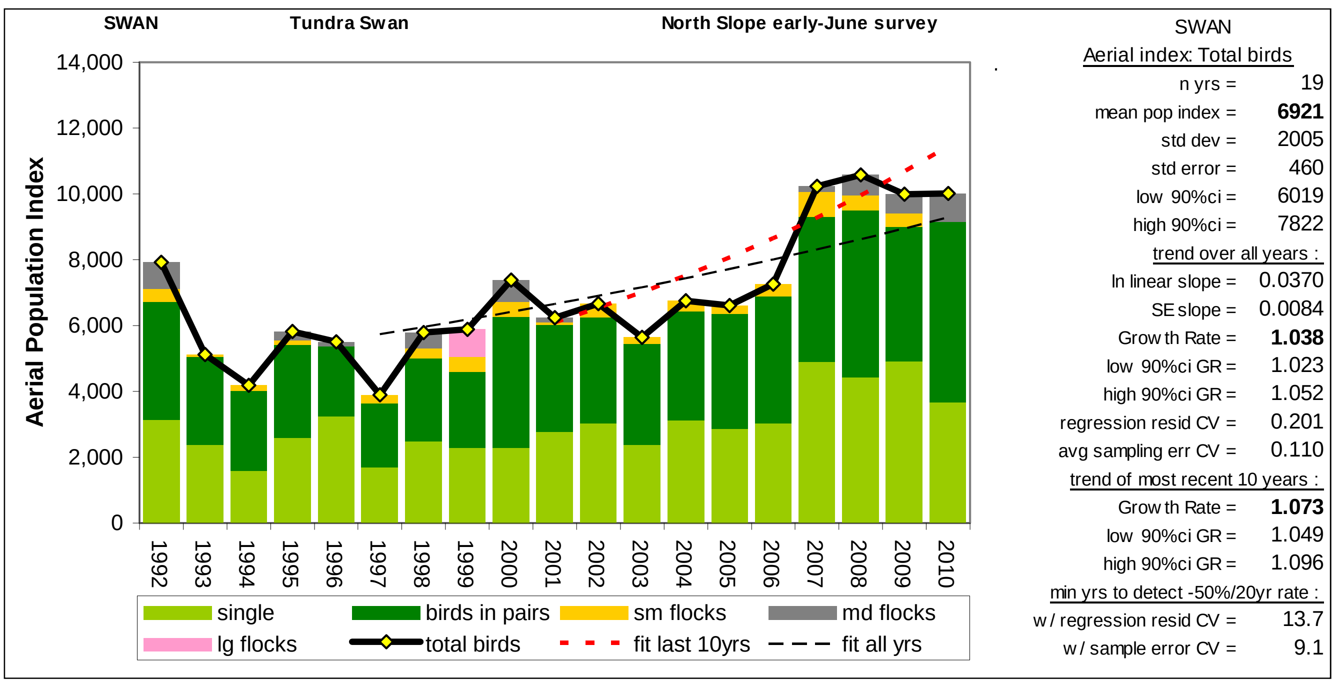
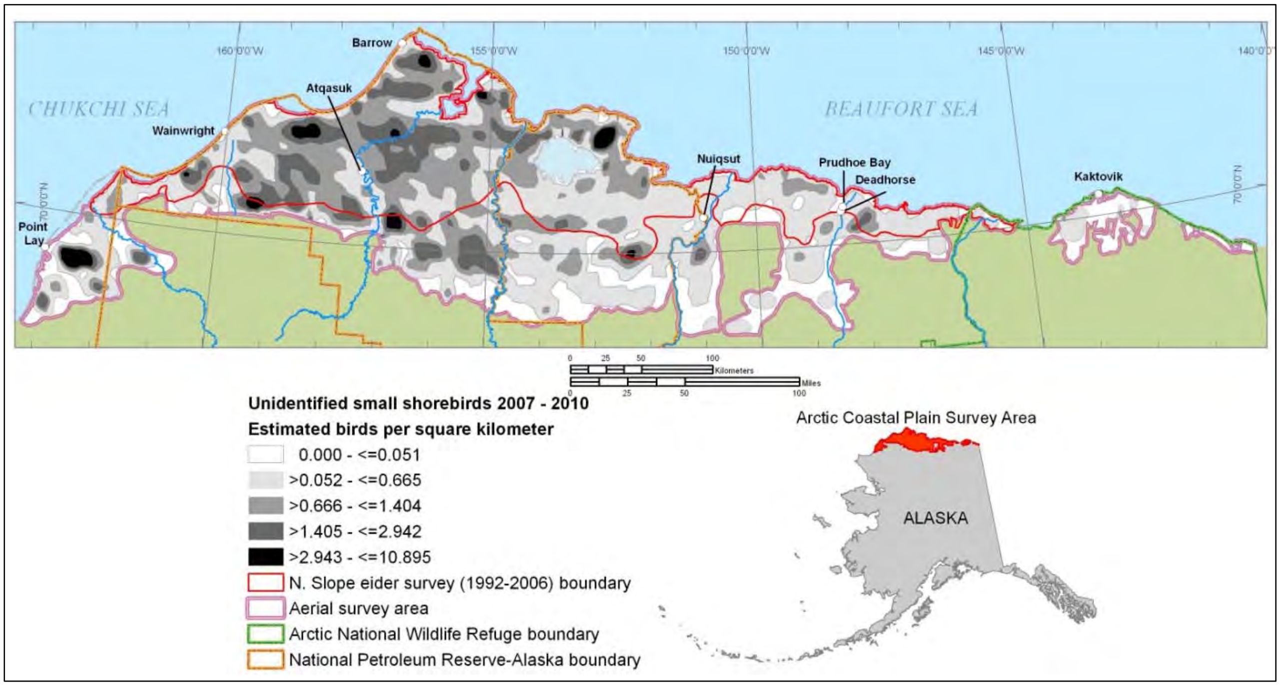


Figure 29. ***Top:*** Density distribution of tundra swans (*Cygnus columbianus*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for tundra swans observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1992-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.



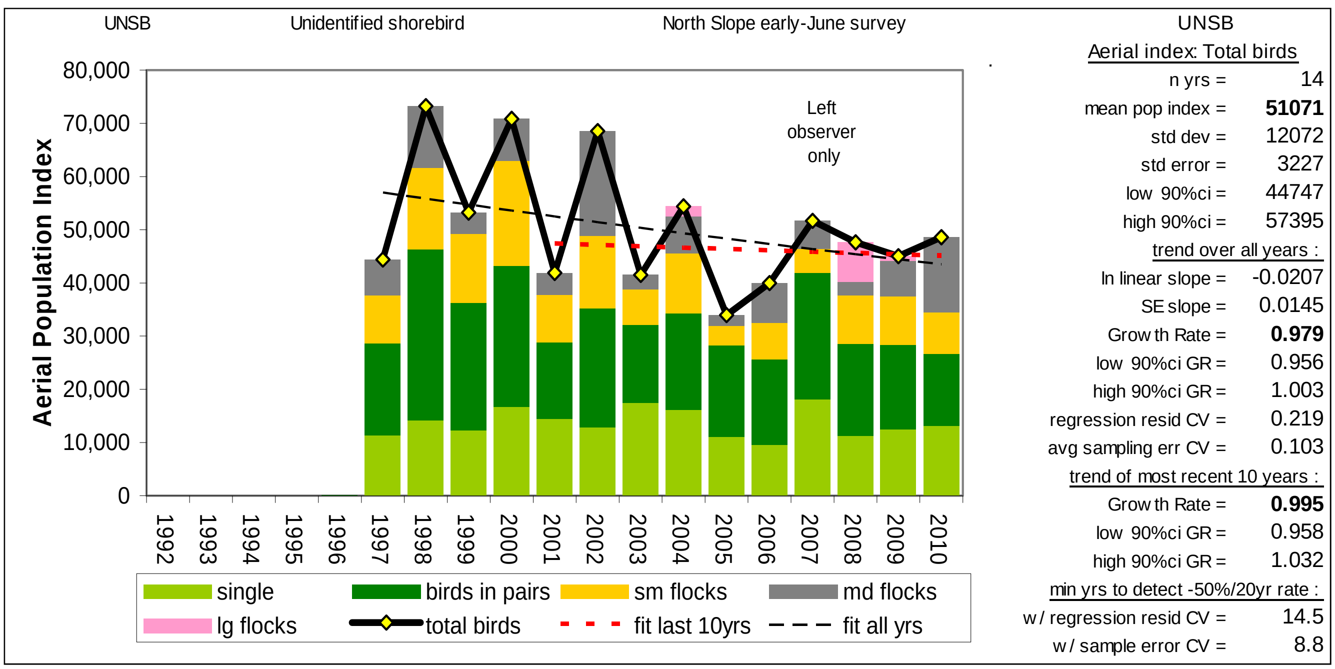


Figure 30. ***Top:*** Density distribution of unidentified shorebirds (families *Charadriidae*, *Scolopacidae*) observed on aerial transects sampling 57,336 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 2007-2010. ***Bottom:*** Population trend for shorebirds observed on a 30,465 km^2 portion of the above survey area corresponding to the North Slope Eider Survey, 1997-2010. The total bird population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with *p*=0.10, beta at *p*=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. We did not record shorebirds prior to 1997.

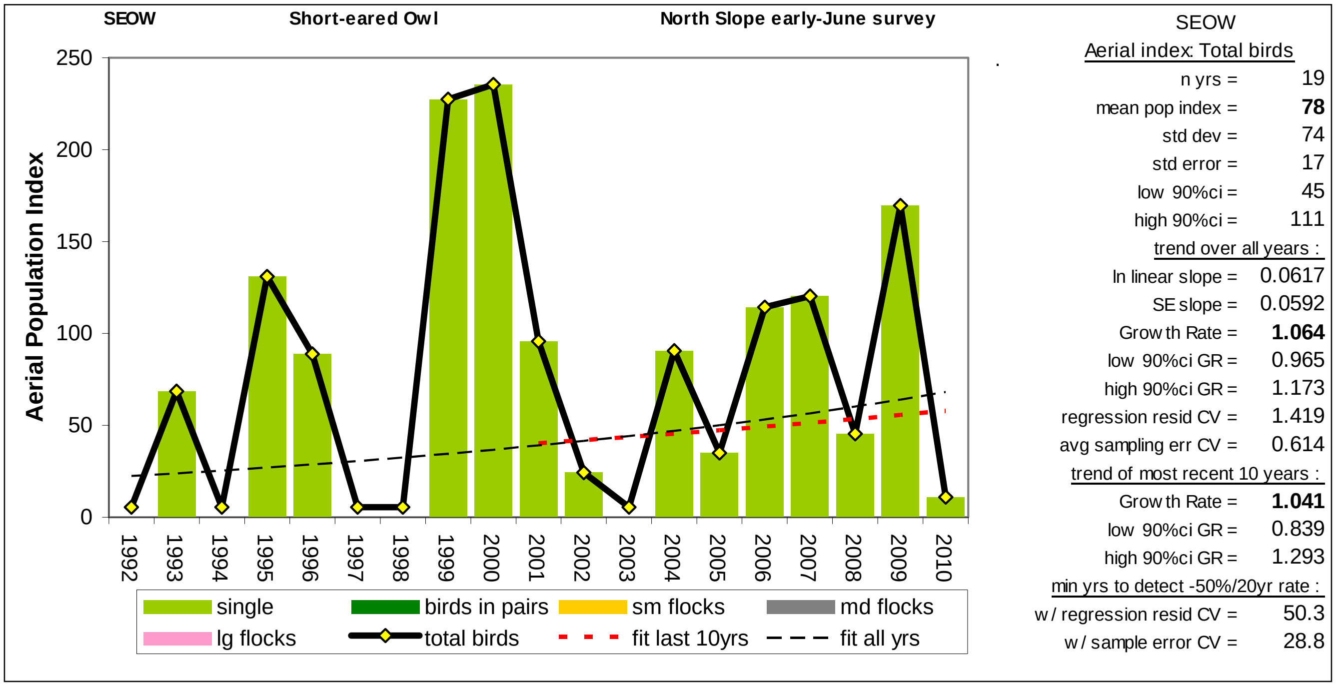


Figure 31. Population trend for short-eared owls (*Asio flammeus*) observed on aerial transects sampling 30,465 km^2 of wetland tundra on the North Slope of Alaska during early to mid-June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur. To calculate slope, an index value equal to one-half the minimum index >0 was substituted for years with no observations.

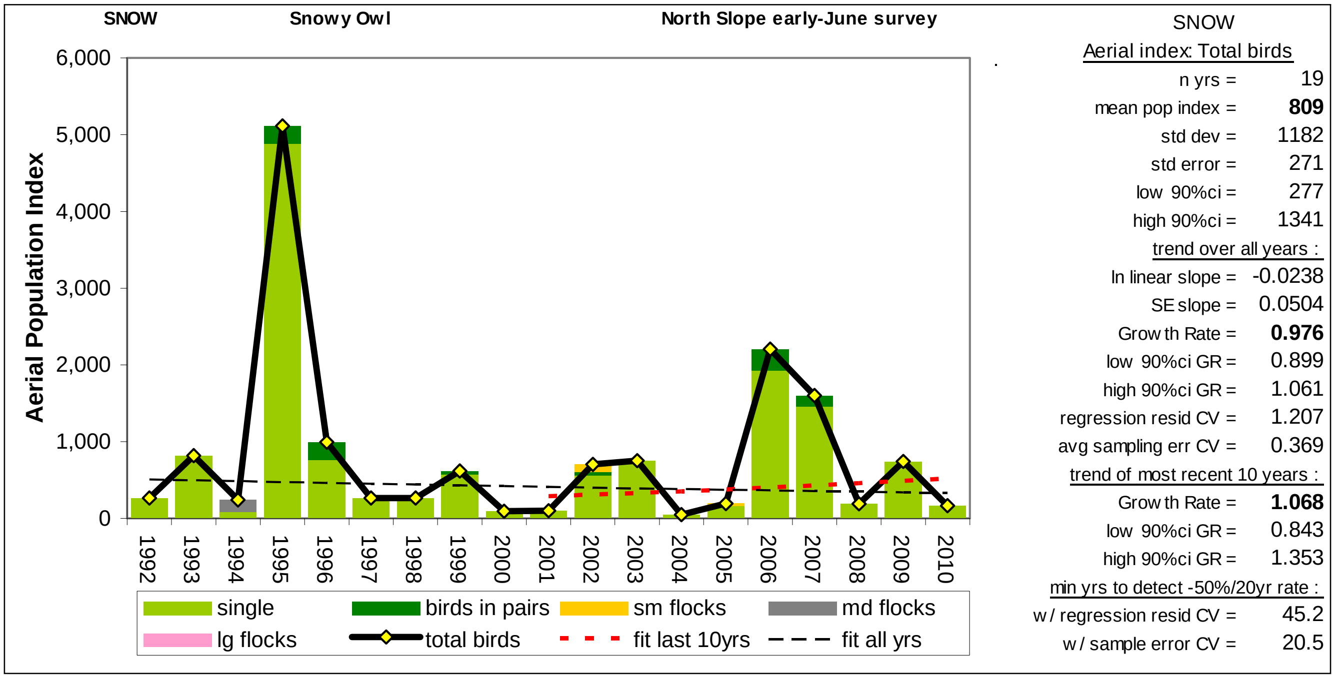


Figure 32. Population trend for snowy owls (*Bubo scandiacus*) observed on aerial transects sampling 30,465 km2 of wetland tundra on the North Slope of Alaska during early to mid June, 1992-2010. Geographic coverage corresponds to that of the North Slope Eider Survey (1992-2006). The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha with p=0.10, beta at p=0.20, and a coefficient of variation based on either regression residuals or averaged sampling error. The power to detect a significant trend can be compared among species as the estimated minimum number of years needed to detect a growth rate of -0.0341, a 50% decline in 20 years, if it were to occur.

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

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