# Abundance and Trend of Waterbirds on Alaska's Yukon-Kuskokwim Delta Coast based on 1988 to 2006 Aerial Surveys

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## Abundance and Trend of Waterbirds on Alaska's Yukon-Kuskokwim Delta Coast based on 1988 to 2006 Aerial Surveys

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***Abstract:*** We summarized nineteen years of aerial survey observations 1988 to 2006 that indexed abundance, trend, and distribution of waterbird nesting populations in the Yukon-Kuskokwim delta coastal zone. Analysis of previous year's data showed a strong correlation between mean May temperatures and average spectacled eider hatch dates. We used this relationship along with average survey timing to determine the start date for the 2006 survey. In 2006, due to cold May temperatures, the coastal zone became snow-free around the third week of May indicating a late spring relative to the past several springs. We started the 2006 survey on June 6 and finished on June 15, timing that was appropriate for the subsequent June 28 average spectacled eider hatch date as determined by nest plot data.

Similar to 2005, in 2006 the three most numerous waterfowl species were northern pintails (*Anas acuta*) with a visibility corrected estimate of 179,331 birds, greater scaup (*Aythya marila*) with 79,159 birds, and northern shovelers (*Anas clypeata*) at 51,972 birds. The estimated population sizes for special interest species were 17,717 threatened spectacled eiders (*Somateria fischeri*), 6,730 common eiders (*Somateria mollissima*) currently designated a focal species, 15,042 long-tailed ducks (*Clangula hyamelis*), 15,766 black scoters (*Melanitta nigra*), and 3,462 red-throated loons (*Gavia stellata*). All surveyed waterfowl species except for black scoters, American wigeon (*Anas americana*), and canvasbacks (*Aythya valisineria*) had population estimates for 2006 above the long term averages (LTA).

Of the gull species in 2006, glaucous gulls (*Larus hyperboreus*), were most numerous with an estimated 38,321 birds (3% below LTA) followed by 20,852 Sabine's gulls (*Xema sabini*) (+32%) and 16,232 (+35%) mew gulls (*Larus canus*). The estimated population size for Arctic terns (*Sterna paradisaea*) was 22,471 (+22%). Pacific loons (*Gavia pacifica*) were estimated at 20,403 birds (+23%).

Population trends based on log-linear regression showed significant decline ($p<0.10$) only for American wigeon. Significant increase occurred for spectacled eider, common eider, greater scaup, long-tailed duck, red-breasted merganser, Pacific loon, red-throated loon, mew gull, Sabine's gull, and arctic tern. We examined the effect of observer experience and change in survey timing on the trend in the population index for spectacled eiders. Corrected for observer experience and survey timing, the annual population growth rate for spectacled eiders was 1.042, lower than the uncorrected trend of 1.067.

We continued to compile individual geographic locations for sightings of 23 species of waterbirds and now have over 100,000 bird locations in a geographic information system useful for research and management.

***Key words:*** aerial survey, Alaska, geographic information system, GIS, population index, *Somateria fischeri*, spectacled eider, trend, waterbird, waterfowl, Yukon-Kuskokwim delta.

Annual aerial survey observations on the Yukon-Kuskokwim delta (YKD) coastal zone in western Alaska provide population indices, trend, and distribution data for many species of breeding waterbirds that are used by the Pacific Flyway Council, the Alaska Migratory Bird Co-management Council, U.S. Fish and Wildlife Service (USFWS) refuge managers, and other biologists. This intensive aerial survey was initiated in 1985 to monitor populations of geese that had shown substantial declines in fall population counts in California. The initial YKD surveys were flown with a pilot/observer in the left front seat and an additional observer in the right front seat, each counting geese, swans, and cranes (Eldridge 2003). Data on these species are reported in July each year in the Pacific Flyway Data Book (USFWS, Portland, Oregon).

In 1988, an additional observer in the right rear seat began to monitor populations of other waterbird species. The high density of geese of the YKD made it too difficult for front seat observers to also observe and record all species. The objective for the back seat observer was to document the relative abundance, trend, and distribution of ducks, loons, grebes, gulls, terns, and jaegers. These survey data have become a primary source to monitor the threatened population of spectacled eider and other species of concern such as the red-throated loon, black scoter, and long-tailed duck. The objective in this report is to summarize the population indices and trends for all species recorded from 1988 to 2006 by the rear seat observer.

## METHODS

### Survey Design

The survey area included the coastal tundra from Norton Sound in the north to Kuskokwim Bay in the south, extending from the west coast to about 50 km inland, and encompassing 12,832 km$^2$. This area was divided into 18 strata by identifying areas of generally homogeneous physiographic features from an unclassified LANDSAT image mosaic at 1:250,000 scale (Fig. 1). We used a custom True BASIC program and ARC/INFO® (Environmental Systems Research Institute, Inc., Redlands, California) geographic information system (GIS) software to generate systematic transects from a random coordinate within the survey area. Transects were oriented east west along great circle routes. Annual flights totaled about 2,500 km on roughly 100 transects (Fig. 1) with an observed sample area of about 500 km$^2$. The survey design has changed slightly over the years in the number and placement of transects. Strata known to have higher numbers of waterfowl were allocated more transects. Prior to 1998, we used 1.61 km transect spacing in the higher density areas, and in strata with fewer waterfowl, intervals of 3.22, 6.44, or 12.88 km. Since 1998, transects have been spaced at 1.60, 3.20, 6.40, or 12.80 km within the various strata, and we designed a 4-year rotating panel of transect coverage. A different set of transects was flown in each year, 1998-2001, such that we obtained complete coverage of the habitat at the 1.60 km interval after combining transects from four years. In 2002, we began a second replicate of each set of transects by flying the same lines as in 1998. In 2006, we flew the same transects as in 2002 completing the first year of the third 4-year rotation.

### Data Collection

Survey methods followed the standard protocol established for waterfowl breeding ground surveys in North America (USFWS and Canadian Wildlife Service 1987). We flew the surveys generally within the first 2 weeks of June (Fig. 2) to coincide with egg-laying or early incubation stages for breeding waterfowl, although prior to 1993, surveys extended for a longer period and nesting was late in some years. Timing of surveys was based on variable information on spring phenology obtained from field camps and therefore was not precise. For 2006 we estimated our start date based on 2 factors. We calculated the mean number of days before mean spectacled eider hatch that we started the aerial survey over the last 6 years (2000-2005). The aerial survey has begun on average 22 days before mean spectacled eider hatch. We also calculated the regression between mean May temperatures at Bethel and mean spectacled eider hatch date which showed a strong correlation ($R^2 = 0.7523$) between higher May temperatures and earlier hatch dates (Fig. 3). The average May temperature in 2006 was 40.9 ºF which when entered into the regression equation predicted mean hatch would occur about June 28. Therefore, we obtained a target start date for the survey of June 6, 2006. A Cessna 206 amphibious aircraft was flown at 145-170 km per hour, 30-46m of altitude, with wind speed <24 km per hour, ceilings >152 m, and visibility >16 km. The pilot used a LORAN (1985-1991) or global positioning system (GPS, 1992-2006) and reference to topographic maps to maintain a precise course while flying transects.

Data collection prior to 1998 used voice recording of observations to a cassette tape recorder running continuously while on transect (Butler et al. 1995). Since 1998, the observer used a computerized data collection program called Survey Recording Program written by John Hodges (USFWS, Migratory Bird Management, Juneau, Alaska). This system consisted of a notebook computer connected with the aircraft's GPS receiver, a remote microphone, and mouse. The observer voice recorded each transect number, start and stop point, every bird sighted within the 200 m wide strip to the right side of the aircraft into a WAV format sound file using the remote computer microphone and mouse click. The observer identified birds to species and recorded group size as a single, pair, or number of birds in flocks. Simultaneously, at the mouse click for each sighting, the latitude/longitude coordinates were automatically downloaded from the aircraft GPS to a computer file. We then used a computer transcription program to replay the sound files, enter header information (e.g. year, month, day, observer initials, etc.), enter species and group size, and combine these with the geographic coordinates to produce a final data file. Leslie Slater was the observer in 1988, Karen Bollinger observed in 1989 and 1990, and Bob Platte has collected the data every year since 1991.

We have nineteen years (1988 to 2006) of counts on ducks but data on other waterbird species were not complete for all years. Jaegers were recorded in 1989, then 1993 to 2006. We began counting loons in 1989, and gulls and terns in 1992. The back seat observer was unable to collect data on 13 transects north of the Askinuk Mountains in 1997, therefore we duplicated the data from the 1996 survey for those transects to include in the 1997 data set to make up for the missing transects. Twenty-three transects were not flown in 1999, and population indices were calculated with fewer transects in some strata. Because the survey was generally flown without covering every adjacent transect in sequence (e.g. some transects were skipped early in the survey and flown later to geographically spread the survey effort over time), the transects that were flown still sampled each stratum at reasonably systematical intervals. In 2001, the back seat observer was unable to fly 13 transects in the central coastal zone and 23 transects north of the Askinuk Mountains. For the missing northern transects, William Eldridge, the right front seat observer, was able to record observations for all species because of the relatively low density of geese, swans, and cranes north of the Askinuk Mountains. In 2003, eleven transects north of the Askinuk Mountains had no data due to a microphone malfunction. In 2004, two short transects in the Scammon Coast stratum and one transect crossing the South Yukon and North Yukon strata were skipped due to wind. In 2006, transects 81 and 83 were inadvertently flown twice on different days and transects 82 and 84 were inadvertently missed, however we still included all the data from these transects. Otherwise, all other transects were flown in 2006. Transects were flown in 2006 in a progression similar to previous years as shown in Fig. 4.

The relative timing of snowmelt was determined by examination of sequential 8-day mosaics of snow extent from Terra satellite MODIS data with a 500 m grid cell resolution. Temperature data for Bethel was available from the National Weather Service.

## Data Analysis

We calculated densities, population indices, and variability for each species using a ratio estimate (Cochran 1977). Duck population indices were based on indicated total birds: 2 * (S + P) + F, where S = number of single birds sighted, P = number of pairs sighted, and F = number of birds in flocks. A flock was defined as 5 or more ducks occurring together. A single male duck was assumed to represent a breeding pair because the nesting hen was usually not observable, and therefore a single male duck was doubled for all species except scaup. Scaup tend to have an unbalanced sex ratio with an excess of males in the population, therefore a single male scaup does not reliably indicate an unseen female. We did not double single birds for other waterbird species such as grebes, loons, terns, and gulls where the sexes are not obviously dimorphic and their population indices only included total birds sighted. Within each stratum, the sum of indicated total or observed total birds divided by the sum of sampled transect area estimated the average density. The variance of density was based on the variability among sampling units (transect sections) within each stratum. Density multiplied by stratum area calculated the population index. The sum of the population indices and sum of the variances for each of the 18 strata provided the total population index and variance for each year. For most species, the stratified analysis reduced the variance of the total population index in comparison to analysis using only the minimum four sampling intensity strata.

We plotted the species population index for each year as a column shaded to indicate single, pair, and flock components (Figs. 8 - 26). The range shown with a vertical line indicated the 95% confidence interval (1.96 times the standard error) of the indicted total or total observed index. The standard error of the sample divided by its mean estimated the coefficient of variation (CV) of the annual population index. The average across all annual CVs provided a measure of average survey precision, the sampling error CV.

Log-linear least squares regression determined the average slope of annual population indices across years. Following exponentiation, the log-linear slope is the rate of annual change or the growth rate. Annual % change is the (growth rate-1)*100. The residuals around the log-linear regression provided another estimate of survey precision. The estimated standard error of growth rate is the residual mean square error from log-linear regression multiplied by the growth rate. The residual CV, that included both regression model lack-of-fit error and sampling error, was usually larger than the estimated sampling error CV. We calculated a standardized measure of the relative precision of the aerial survey for each species using the approximate formula of Gerrodette (1987) that links the sample size, slope, CV, and probabilities for Type 1 and Type 2 errors. With alpha set at 0.10 and beta at 0.20, assuming a population growth with a slope of 0.0341 (50% change over 20 years), and using the observed average sampling error CV, the minimum years to detect a slope significantly different from zero was calculated for each species. Growth rates were also calculated for all species using only the last 7 years of data.

Timing of snowmelt and temperature can affect the breeding chronology of waterfowl (Batt et al. 1992). This variation, possibly in combination with differences in survey timing, may have an influence on population indices. The number of spectacled eiders observed on the YKD aerial survey is strongly influenced by the survey timing relative to nest chronology because male eiders depart to marine habitat as females begin incubation. In this report, we included the observed population indices and data on survey timing and nesting chronology, but a full analysis remains necessary to account for correlation between the two and the potential bias in the trend. When completed, this will be reported separately.

Similarly, any change in detection rate may introduce bias in the trend of observed population indices. From 1995 to 2002, the right-front seat observer, as well as the right-rear seat observer, recorded Spectacled and Common eiders, and using this independent double-count data, we calculated annual spectacled eider detection rates.

## RESULTS

### Survey conditions

The 2006 survey was flown from June 6 – 15 (Fig. 2) with no flying on June 7, 9, and 13 due to weather for a total of 7 survey days (about 38 hours on transect). The average May 2006 temperature in Bethel (about 140 km east of survey area) was 40.9º F, one of the colder Mays in the history of the survey (Figs. 5 and 6). Weather conditions were mostly cool, cloudy, and rainy during the 2006 survey.

Spring phenology in 2006 was relatively late compared to recent previous years. The progression of snowmelt (Fig. 7) showed the coastal zone became snow-free around the third week of May. With 7 years of MODIS satellite data on snow melt, the time when the coastal zone became snow-free has varied by as much as about 4 weeks. In 2000 and 2001, the coastal zone was snow free by around the last week of May. Snow in the survey area had melted around the third week of May in 2002 and 2005. Early snowmelt occurred in 2003 by the second week of May and in 2004 by the first week of May.

### Relative abundance

Number of birds sighted on each sampled transect and the sampling effort in each strata provided the data to calculate the aerial population indices expanded to the entire survey area (Figs 8 – 26), and the visibility-corrected population estimates for 2006 (Table 1). To convert the aerial index to estimated populations, we used the standard visibility correction factors determined by the ratio of helicopter to fixed-wing aircraft observations for tundra Alaska species (Conant et al. 2000). Pintails (179,331 birds), scaup (79,159), and shovelers (51,972) were the most numerous waterfowl species in 2006, similar to 2005. Pintails were 39% above the 2005 estimate and 17% above the LTA (Table 2). In contrast, greater scaup were 5% lower than 2005 but 11% higher than the LTA. Shoveler estimates were 34% higher than in 2005 and 39% higher than the LTA. The spectacled eider population with 17,717 birds was the highest estimate for the history of the survey. This species estimate showed an increase of 94% from the LTA, as well as a 19% increase above 2005. Common eider estimates changed little from the previous year but were 53% higher than the LTA. Black scoters were down 27% from 2005 and 5% from the LTA. Long-tailed ducks were 24% above the 2005 estimate and 26% above the LTA. Red-throated loons were around 11% above the 2005 estimate and 61% above the LTA.

The aerial population indices, with no correction for visibility bias, showed the relative abundance by group size category for all survey years (Figs. 8 - 26). Cautious interpretation is necessary for those species with relatively low numbers of sightings that can fluctuate greatly in estimated population size. For example, an observation of a single flock of 200 red-breasted mergansers in 2006 greatly influenced the population index and trend.

## Population trend

American wigeon showed a consistent strong decreasing trend (Fig. 16 and Table 3). Significantly increasing trends occurred for greater scaup, spectacled eiders, long-tailed ducks, common eiders, Pacific loons, mew gulls, Sabine's gulls, and arctic terns. The rest of the species showed relatively stable trends over the history of the survey. We calculated the most recent 7-year trends for all species as well. Mallards, scaup, red-throated loons, mew gulls, Sabine's gulls and arctic terns showed significantly increasing trends during the last 7 years. Only Pacific loons showed a significantly decreasing trend.

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## Spectacled eider population and trend

The number of indicated total spectacled eiders from the aerial survey in 2006 was 4,949 birds or 2,475 pairs, uncorrected for visibility bias. The spectacled eider nest estimate corrected with a nest detection rate for the entire coastal zone based on the ground plot sample in 2006 was 6,127 (Fischer et al. 2006). The ratio of aerial pairs to nests was 0.404 (=2,475/6,127, or stated as the inverse, 2.48 nests were estimated for each pair of spectacled eiders seen by the aerial observer. Estimated average spectacled eider hatch date in 2006 was about 9 days later than in 2005 and about four days later than the long-term ground plot average (Fischer et al. 2006). The population growth rate from 1988 to 2006 for the aerial indicated total bird index was 1.067 (Fig. 14). A more thorough analysis accounting for observer experience and survey timing yielded a 1993-2006 adjusted growth rate of 1.042 (Stehn et al. 2006). The growth rate from the nest populations estimated from ground studies during this same period was 1.017. There was overlap in the confidence intervals for these estimated growth rates indicating no real differences.

## Relationship of aerial observations to nests

Birds observed along aerial transect samples provide an index to the actual population size. If visibility detection rate for each sighting of a single, pair, or flock of each species could be determined, the actual population size of birds could then be calculated from the aerial index results. Because the detection rates may vary over time or space, for example as influenced by weather conditions, observers, geographic area, and population density, the estimated trend as well as the size of the population has potential for bias. The magnitude of bias in the trend of the population index is the trend of the index ratio over the same period (Bart et al. 2004). The index ratio is defined as the survey result (the aerial observation index measure) divided by actual population size as determined by a more intensive or additional data (Bart et al. 1998, Bart et al. 2004). Of course, the remaining problem is to obtain a representative sample of the survey area with such additional data to determine the actual population.

We do not have any data that measured the actual birds present in the 400m strip indexed by the aerial observers. Nevertheless, we did have data on the population of nests for a portion of the aerial survey area. We calculated an index ratio between the aerial population index and the nest population size (after correction for nest detection rate) to examine the relationship between these two independent measures of different, but presumably closely related, populations. We expected a constant index ratio between aerial observations and nests. If a species nests strictly as monogamous pairs, if renesting is absent, and if immature or non-nesting birds are not observed at the time of the survey, we assumed that each nest should be associated with just two birds, the male and female of each pair, and therefore with 100% visibility, the expected index ratio would be 2.00. Eiders and loons approximate these nesting characteristics unlike most of the waterfowl species nesting on the YKD.

We used only the aerial transect observations and nests found on plots within the core eider area of 716 $km^2$ (Fischer et al. 2006). To ensure accurate correspondence between the aerial strata, sampling intensities, and the ground-sampled area, aerial survey data were analyzed with 27 strata (stratification design A2G). The aerial population index measure for geese, brant, crane, eider, and other ducks already included the doubling single birds an adjustment to compensate for unseen cryptic females on nests. Single birds are not doubled for swans, loons, gulls, and terns. The index ratio related the indicated birds observed on the aerial survey to the estimated population of nests corrected for nest detection rate from the ground plots. This ratio differs from the actual index ratio for visibility rate of birds because:

1) some birds may be unavailable for sighting if they are outside the area at the time of survey due to temporary or seasonal departure of the males back to marine foraging areas,
2) the aerial index number already counted observed single males as two birds in an attempt to correct for unseen females on nests,
3) occasional single females are seen but by standard protocol, they are not recorded by aerial observers, and
4) birds may be present that did not initiate a nest.

Swans are probably the most highly visible bird on aerial surveys (Fig. 27). The average index ratio was 1.6 birds in singles or pairs observed from the air per nest estimated from the ground plot sampling (Table 4). The index ratio was 3.36 swans observed per nest when swans in flocks were included. We interpret this as an indication that a substantial number of non-nesting immature birds were present on the breeding area (Table 4). If all birds in singles or pairs have a nest and if no nesting birds are in flocks, an assumption of 1.6 / 2.0 = 80% visibility detection rate was supported. The higher index ratios for ducks and terns certainly indicated that many non-nesting birds are present even though they were seen in singles and pairs. High index ratios for aerial indices that include flocked gulls certainly indicated many were non-breeders, but it was not clear whether the 0.92-0.96 index ratios for aerial indices of singles and pairs of gulls would indicate 46-48% visibility rates. Because few flocks were observed, the 0.61-0.66 index ratios for loons (Table 4), and the 0.67-0.72 index ratios for eiders may indicate approximate visibility rates of 32% and 35% respectively. The low index ratios for geese and brant of 0.28-0.44, or 0.53-0.79 with flocked birds included, indicated the relatively low visibility rates for these species.

## Distribution

The geographic locations of over 100,000 sightings of 23 species of waterbirds have been collected over the 19 years of this survey. Average location accuracy of the observations when the surveys were flown using LORAN for navigation was within 367 meters along transect compared to 214 meters when using the GPS (Butler et al. 1995). Locations from GPS in recent years are expected to be more accurate. These spatial data have been incorporated into a GIS database for research and management purposes.

## DISCUSSION

Three different observers have collected data for this survey, although the same observer has collected the last 16 years data. All observers were experienced at identifying and counting birds from aircraft, however especially for the less common species, a "learning curve" effect is possible during the first 2 or 3 years for each observer and the first 5 years in this data set. Observers become more skilled over time resulting in increasingly more reliable information. As observers gain experience with a specific survey, we expect that improvements were possible in several aspects of aerial observations. First, accuracy of species identification improves with development of “search images” for each species seen in various distance, light, behavior, and habitat conditions. Second, skill in counting large flocks increases. Third, complete coverage of a 200 m strip width becomes less variable, both within a survey and between years, even though survey flights did include some training by flying over known-width marks or checking sight angles with an inclinometer. Fourth, with more practice, observers improve in their ability to quickly detect, identify, and record each observation and then mentally switch back to all possible search images over the full width of the transect. It is possible that less-experienced observers contributed relatively lower counts in the first years of this survey. Because a single observer completed the last 16 years of survey, the magnitude of possible bias in long-term trends becomes very small.

Some variation in detection rate occurs each day due to weather conditions, with higher wind speed and bright sun causing glare likely to be the most detrimental factors. The average of all conditions experienced over the 7-day survey is much less variable among years than are the day-to-day changes. We assumed no long-term trend in detection rate. Preliminary analysis of 8 years of double-count data where the front-seat observer independently recorded spectacled eiders showed little variation and no significant trend in the detection rate for the rear-seat observer (Platte, Eldridge, and Stehn, unpubl. data). The average spectacled eider detection rate for the 8 years of double-count data for the right-rear seat observer was 67.8%. A non-significant increase of 1.6% per year was noted, however based on this preliminary analysis, the small magnitude of change in detection rate strengthens the validity of the observed trend index for eiders and probably other species.

Seasonal timing of surveys was also a factor potentially affecting the number of observations and the trend. Behavior and the visibility of many species changes with the stage of incubation; therefore, to get the best trend information, the surveys should be timed consistently relative to nesting chronology. Different stages of nesting may correlate with changes in the flocking behavior, single:pair ratio, or tendency to flush from the aircraft. The intended survey timing was to fall within the first half of incubation for the average of nesting geese. Although the dates of earliest nests found were available from field camp observations, when we begin the aerial survey we do not know the degree of nesting synchrony and the average date of nest initiation, and we cannot always time our survey optimally. Weather, pilot flight hours, and aircraft mechanical problems can also have an influence. For most species both birds of a nesting pair remain in the nesting area, but for spectacled eiders, the much more visible males begin their departure from the breeding grounds shortly after the hens begin incubation, and depending on timing, the survey can miss a variable proportion of the males. If the survey timing were late relative to phenology, a greater proportion of spectacled eider males would have departed which results in a lower population index in that year (Platte et al. 1999). The discrepancy between population trends shown by the population of nests as measured by ground sampling (Fischer et al. 2006) and the trend of aerial population indices was analyzed more fully in 2006. Increased aerial counts were strongly correlated with a change to slightly earlier average survey timing beginning in 1998. When observer experience and survey date were added as variables in log-linear regression, the average growth rate changed from 1.067 to 1.042 and there was no significant difference in trends between the aerial and ground data (Stehn et al., 2006).

The number of spectacled eider pairs observed during the aerial survey in 2001 was the highest in the history of the survey. This may have been caused by increased visibility of the birds due to high fox predation on nests that year and/or late nesting chronology. Predation was also high in 2003 but nest initiation was relatively early. Predation may account for relatively higher numbers of pairs of spectacled eiders observed in 2003. Spring chronology and nesting was very early in 2004, however the survey was flown 1-7 June relatively closer to average timing, and that may have caused the index to be lower. In 2006, the survey was flown earlier relative to average hatch date that may have contributed to the larger population index for eiders.

The geographic locations of birds collected over the 19 years of this survey have been used for a number of purposes. Interpolated density polygons for most species have been developed to show species distribution and can be used as a baseline to detect any future changes in distribution due to such factors as climate change. Distribution information was included in evaluation of YKD coastal zone areas for inclusion as designated critical habitat for spectacled eiders. Relative density distribution maps help illustrate and evaluate impacts of potential land ownership exchange on waterbirds. Survey information was incorporated into the Birds of North America species account for Sabine's gulls. Loon information has contributed to the Loon Working Group for baseline monitoring and in plans for red-throated loon sampling. Population trends were used to compare with other information in a review of seaduck population status.

The survey was designed to monitor geese, however because the distribution of Cackling geese (*Branta hutchinsii*) largely coincided with that of the spectacled eider, the survey also was appropriate for monitoring spectacled eiders. For species such as scoter and scaup with relatively higher numbers farther inland, where the sampling is less intense, the allocation of sampling effort is not optimal.

## RECOMMENDATIONS

Currently there are two survey efforts to monitor the spectacled eider population on the Yukon Delta, the coastal zone aerial survey and the ground plot sampling for nests. Because it is impractical for the nest plot survey to sample the entire coast, it is necessary to continue the aerial survey to gather data necessary to expand the nest population to the entire YKD coast. We believe these two surveys are highly complementary. Together they provide a unique combination of detailed information at two scales of geographic extent and intensity of coverage. Both are better than either one alone for monitoring the spectacled eider population.

The aerial survey also provides information on many other species of interest, although interpretation must be qualified if a significant part of the range of those species extends beyond the coastal zone. Long-tailed ducks, scoters, and scaup are abundant in the more inland strata that were not sampled as intensively, and even further inland, not sampled at all. For better information on these species, we could allocate more effort in this area. We should consider expanding coverage and adding transects in inland areas to obtain better information on seaducks. Because the survey aircraft is flown from Bethel, much of this area must be traversed anyway, just to reach the coast. With the considerable change in populations of some geese since the late 1980s, a re-examination of the allocation of sampling effort might reveal that a moderate decrease in the number of transects in the high-intensity strata may result in a minimal decrease in precision for geese and eiders.

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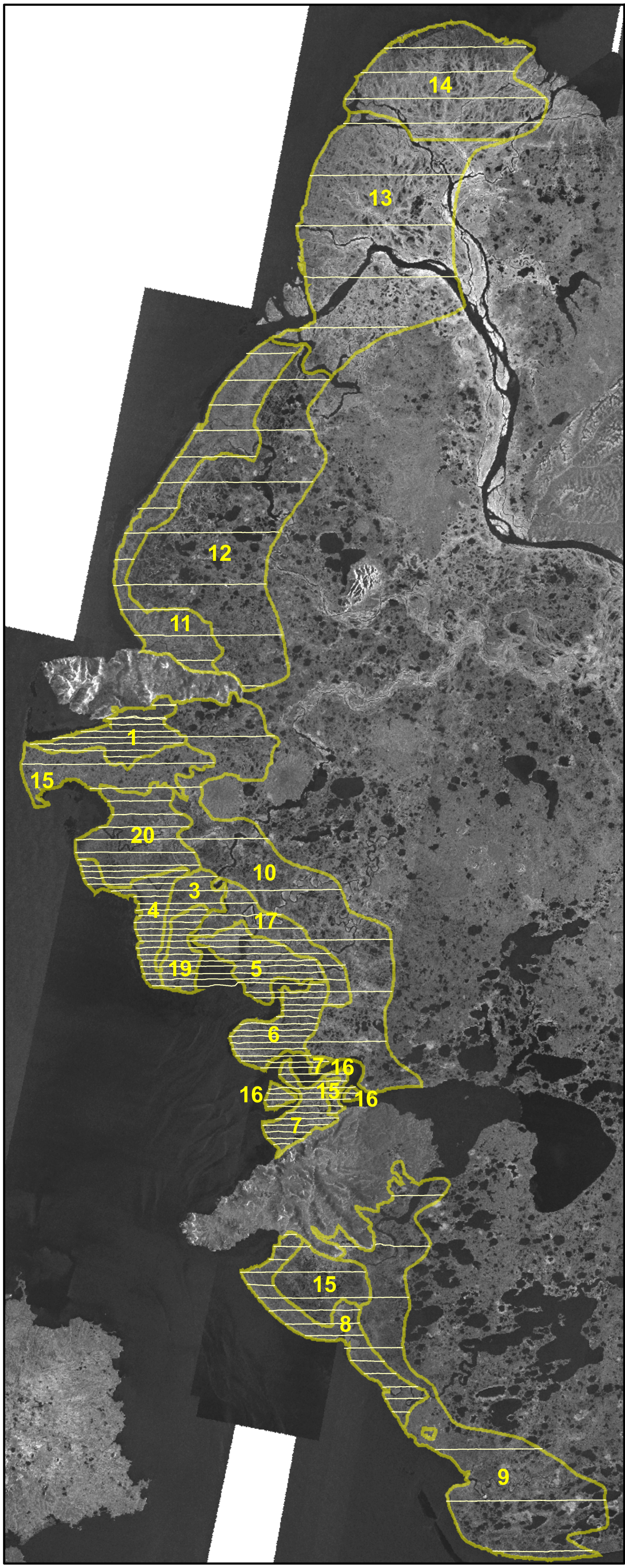
| Stratum Number | Stratum Name | Survey Area km$^2$ | Sample Area km$^2$ | % Sample |
|---|---|---|---|---|
| 1 | Kokechik | 288.7 | 34.1 | 12.9% |
| 3 | Aphrewn | 140.8 | 11.7 | 8.4% |
| 4 | Tutakoke | 236.9 | 29.0 | 12.1% |
| 5 | Hazen Bay | 288.3 | 35.6 | 12.1% |
| 6 | Naskonat Peninsula | 274.5 | 33.6 | 8.4% |
| 7 | North Nelson Island | 191.4 | 21.8 | 12.9% |
| 8 | South Nelson Coast | 398.8 | 24.9 | 6.7% |
| 9 | Kipnuk Uplands | 1691.4 | 28.2 | 1.6% |
| 10 | Central Uplands | 1698.1 | 32.0 | 1.5% |
| 11 | Scammon Coast | 855.9 | 26.8 | 3.8% |
| 12 | Scammon Uplands | 1889.6 | 29.2 | 1.7% |
| 13 | South Yukon | 2078.1 | 33.1 | 1.4% |
| 14 | North Yukon | 1059.0 | 34.5 | 1.8% |
| 15 | Coastal Uplands | 723.5 | 27.6 | 3.8% |
| 16 | Kigigak/Baird Islands | 59.8 | 7.3 | 12.2% |
| 17 | Intermediate | 298.8 | 18.4 | 6.7% |
| 19 | Oparagyarak | 155.3 | 19.3 | 16.1% |
| 20 | Chevak | 502.8 | 32.0 | 7.2% |
|  | TOTAL | 12831.5 | 479.1 | 3.7% |



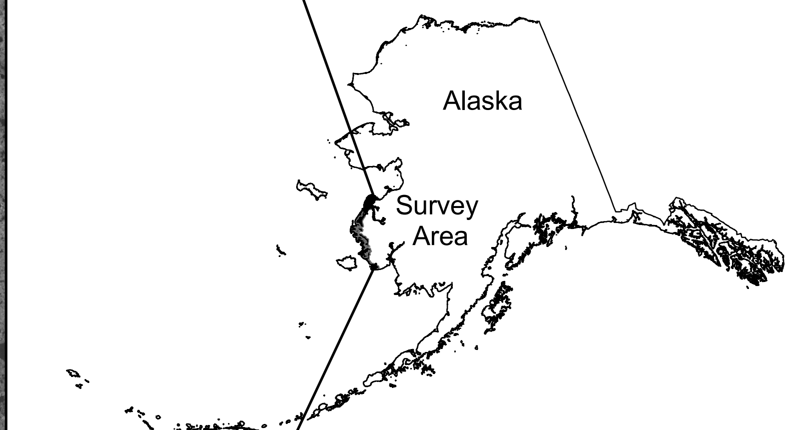




Fig. 1. Transects and strata for aerial waterbird survey, June 6 - 15, 2006, Yukon Delta coastal zone, Alaska. Strata 1, 4, 5, 6, 7, 16, and 19 were sampled every mile. Strata 3, 8, 17, and 20 were sampled every 2 miles. Strata 11, 14, and 15 were sampled every 4 miles. Strata 9, 10, 12, and 13 were sampled every 8 miles.

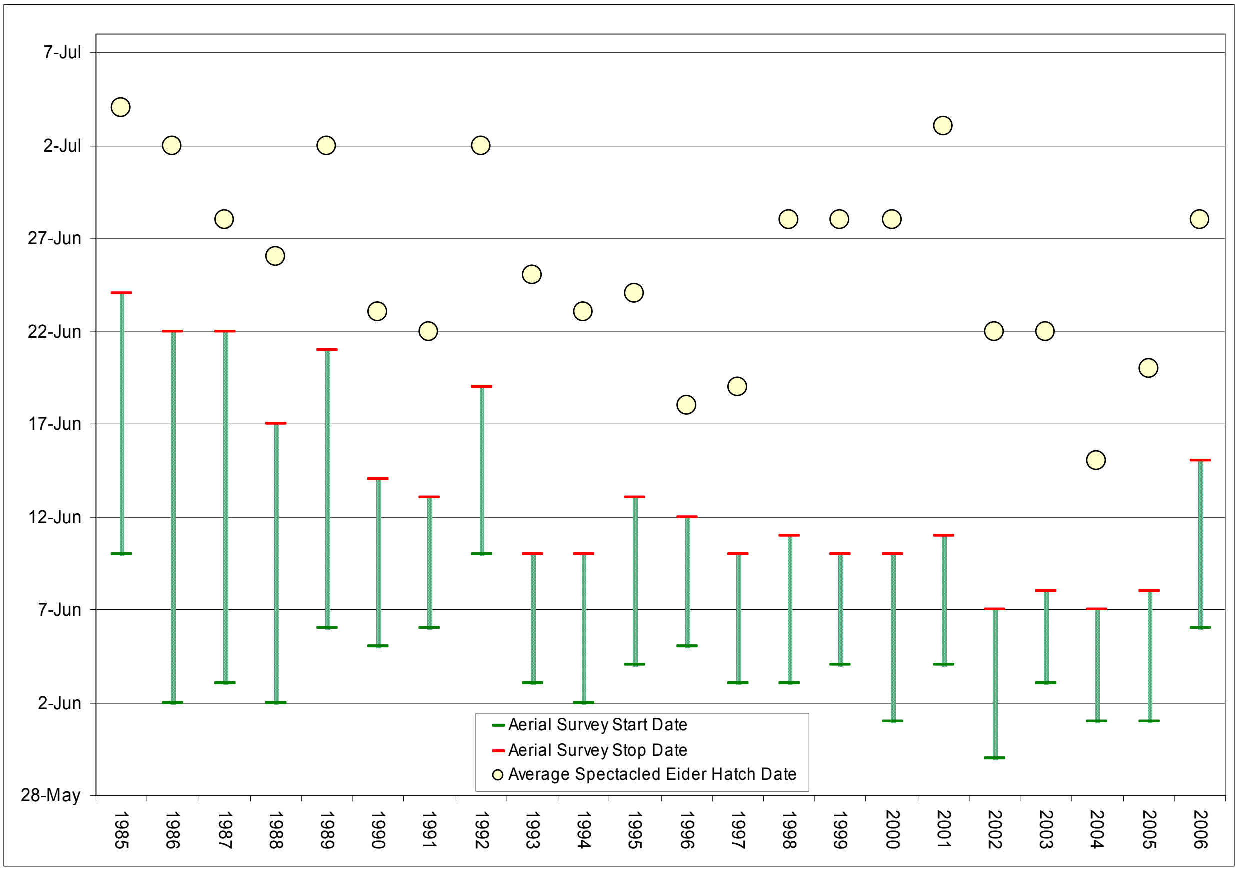



Fig. 2. Timing and duration of the coastal zone aerial survey in relation to average spectacled eider hatch date from ground surveys (Fischer et al. 2006), Yukon-Kuskokwim Delta, Alaska, 1985-2006.

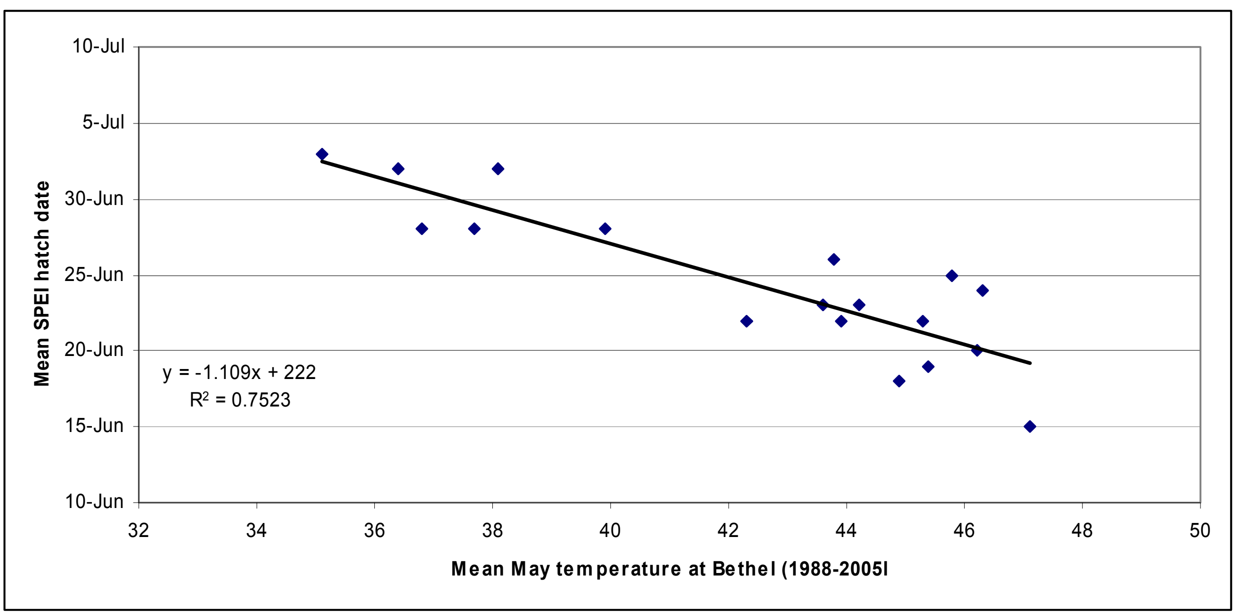



Fig. 3. Relationship between mean May temperatures in Bethel, Alaska and mean spectacled eider hatch dates from nest surveys, 1988-2005, on the central coastal zone of Yukon Delta National Wildlife Refuge.

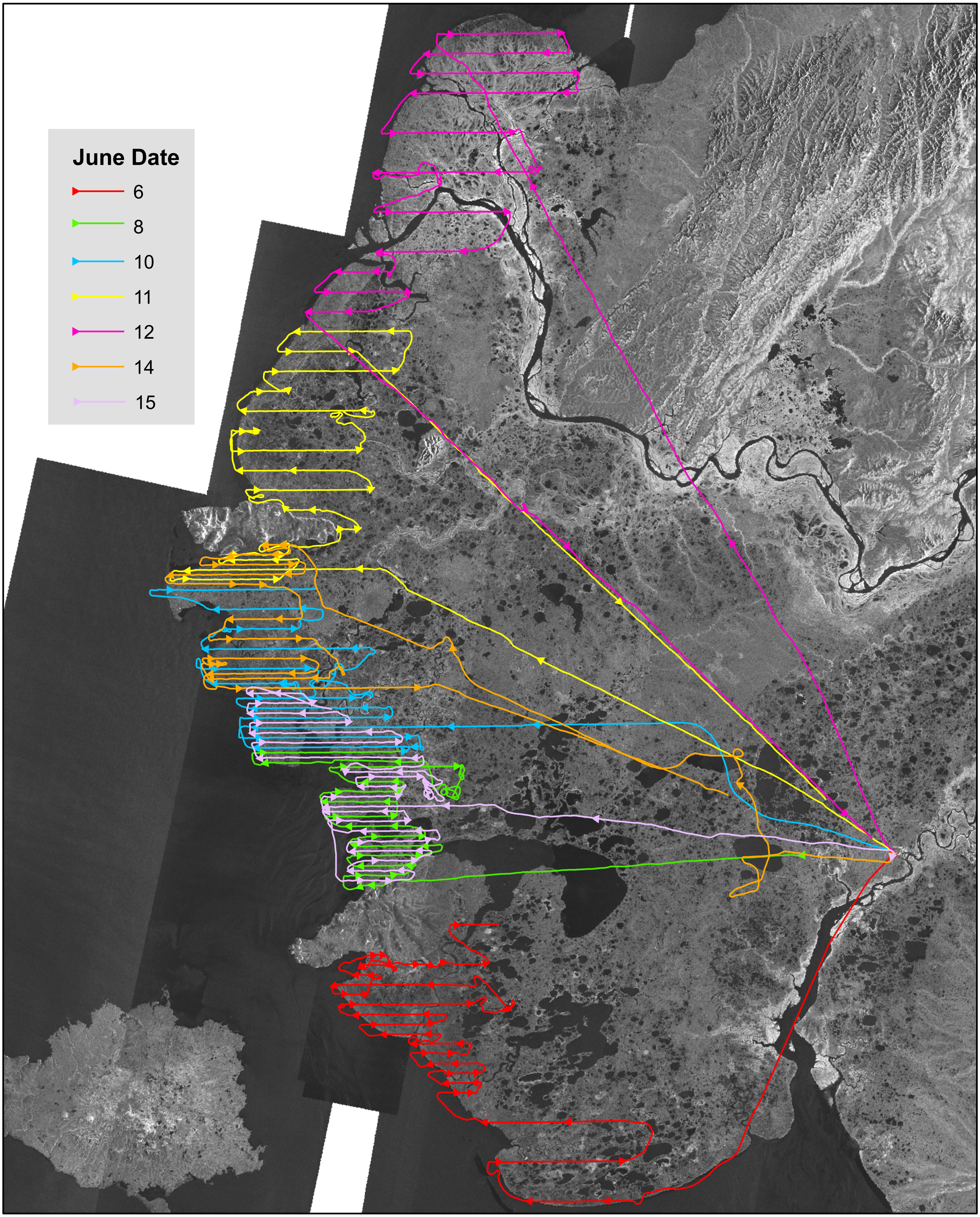



Fig. 4. Transects color-coded by date flown showing typical progression of survey by date. We skip every other transect in 1-mile interval strata so as not to double count flushing birds and to spread the survey temporally.

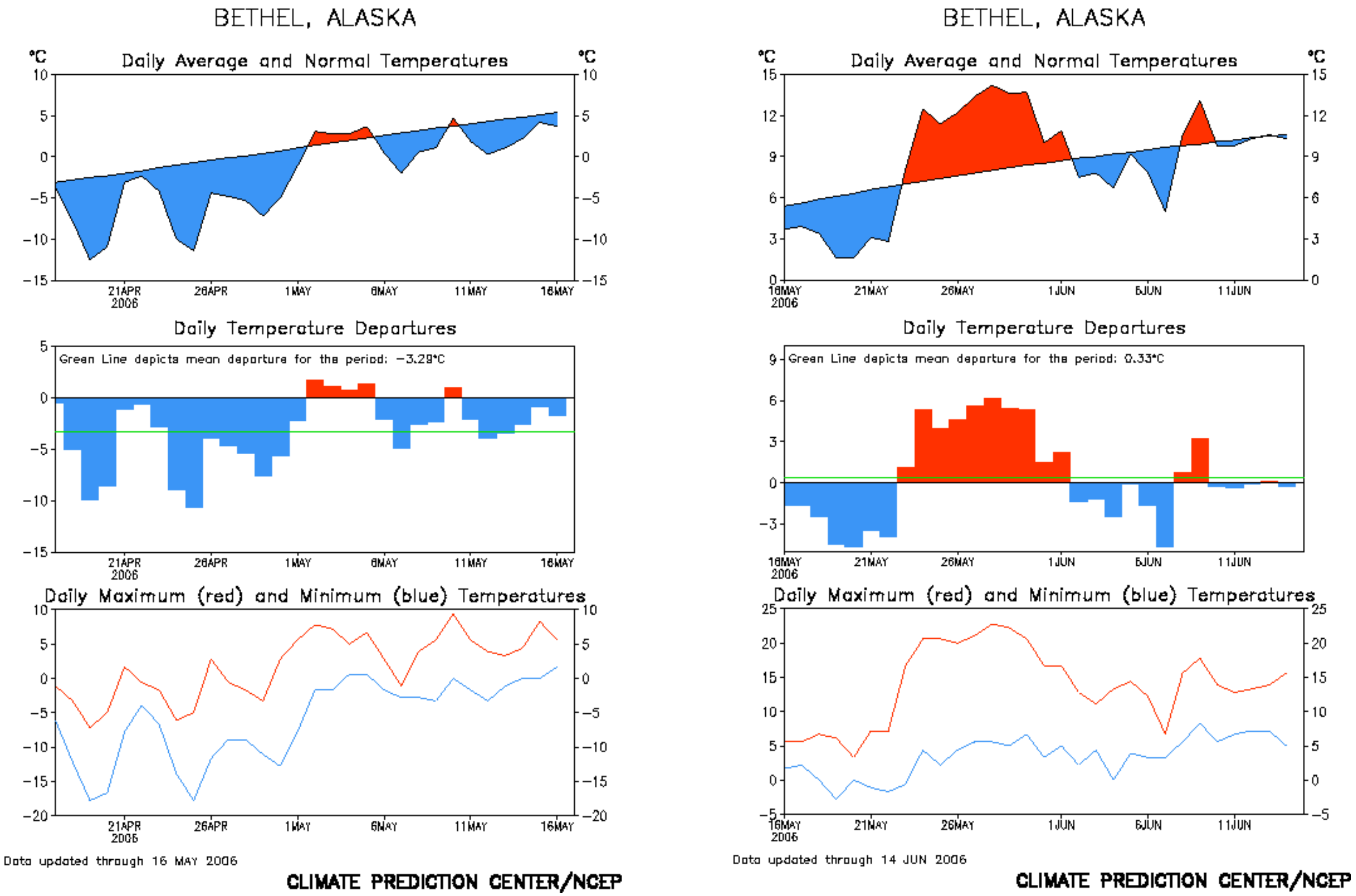



Fig. 5. Temperature information prior to and during the 2006 survey, from Bethel Airport, approximately 140km east of the survey area.

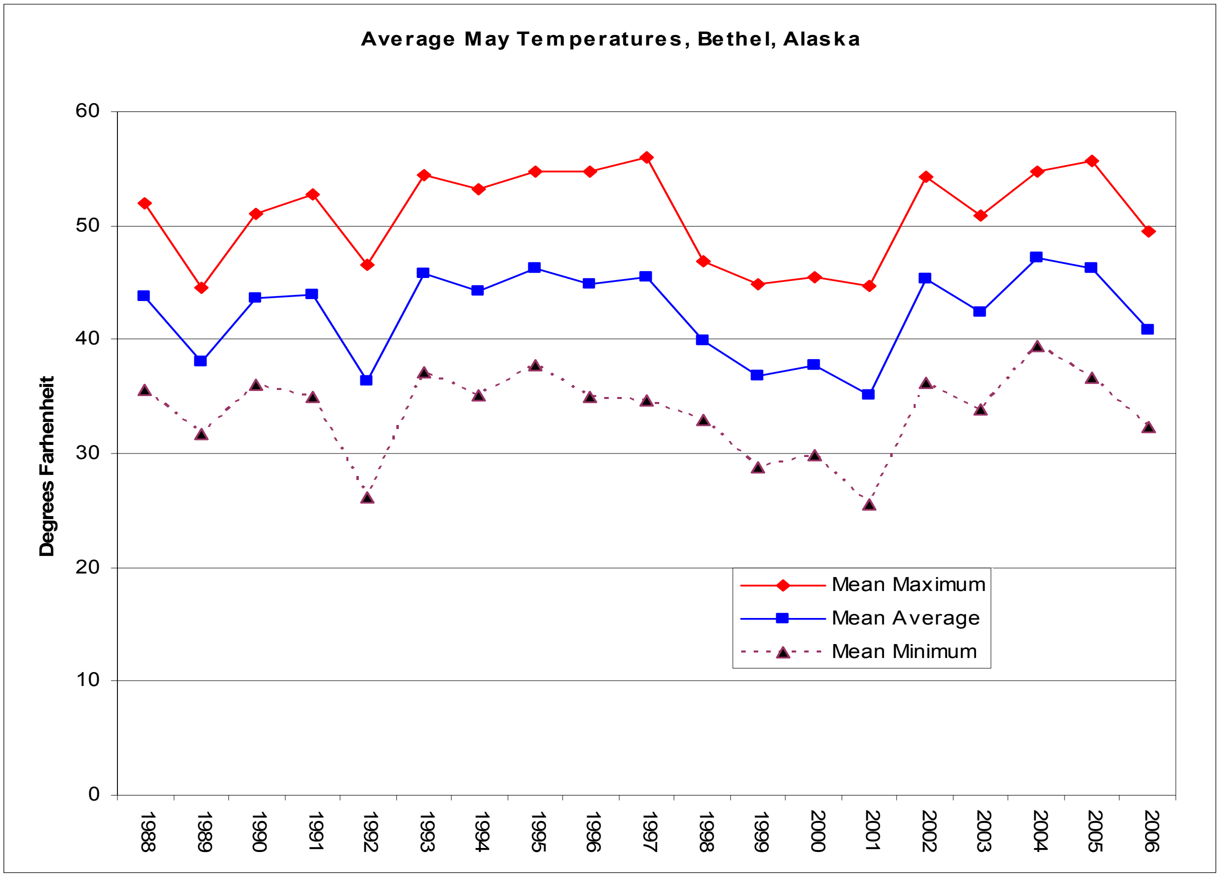


Fig. 6. Mean maximum, mean average, and mean minimum May temperatures from Bethel, Alaska, 1988 – 2006.

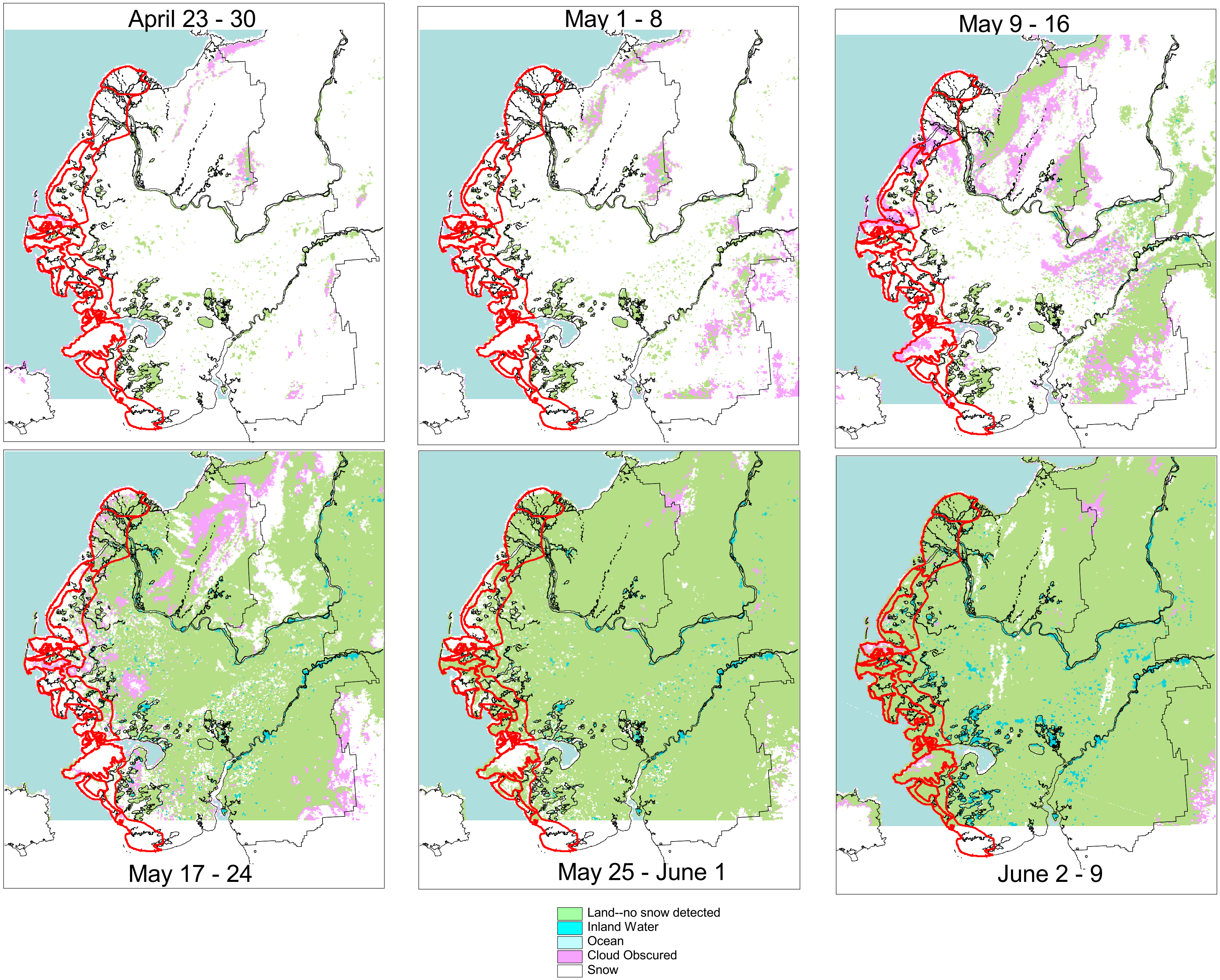
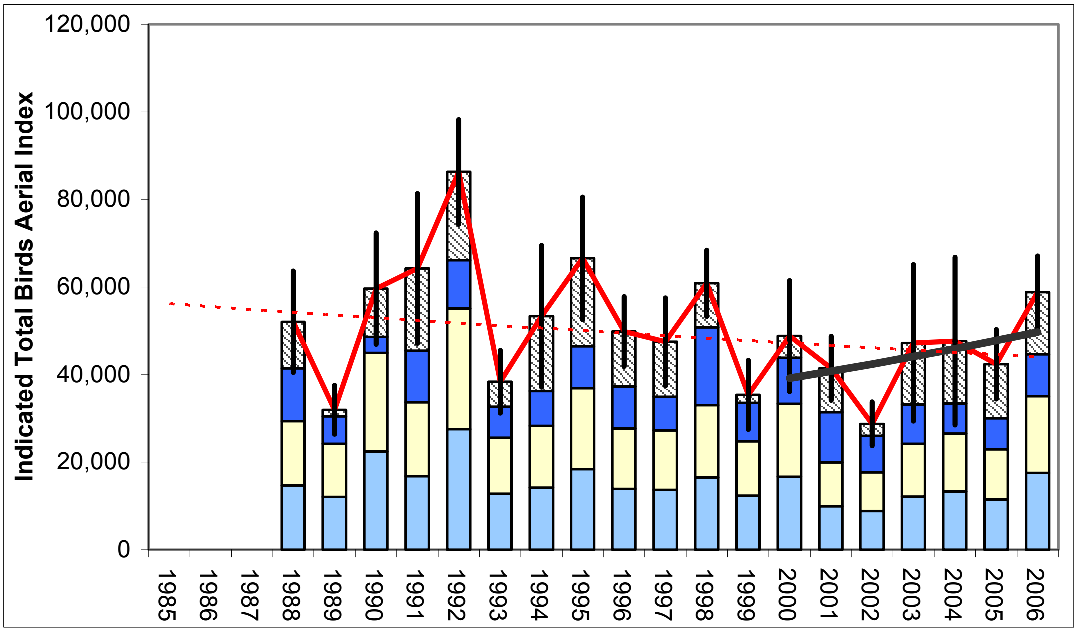



Fig. 7. Snow melt phenology from Terra satellite MODIS 8-day composite maximum snow extent, 2006 Yukon Delta National Wildlife Refuge, Alaska.

## Northern Pintail

Yukon-Kuskokwim Delta coastal survey



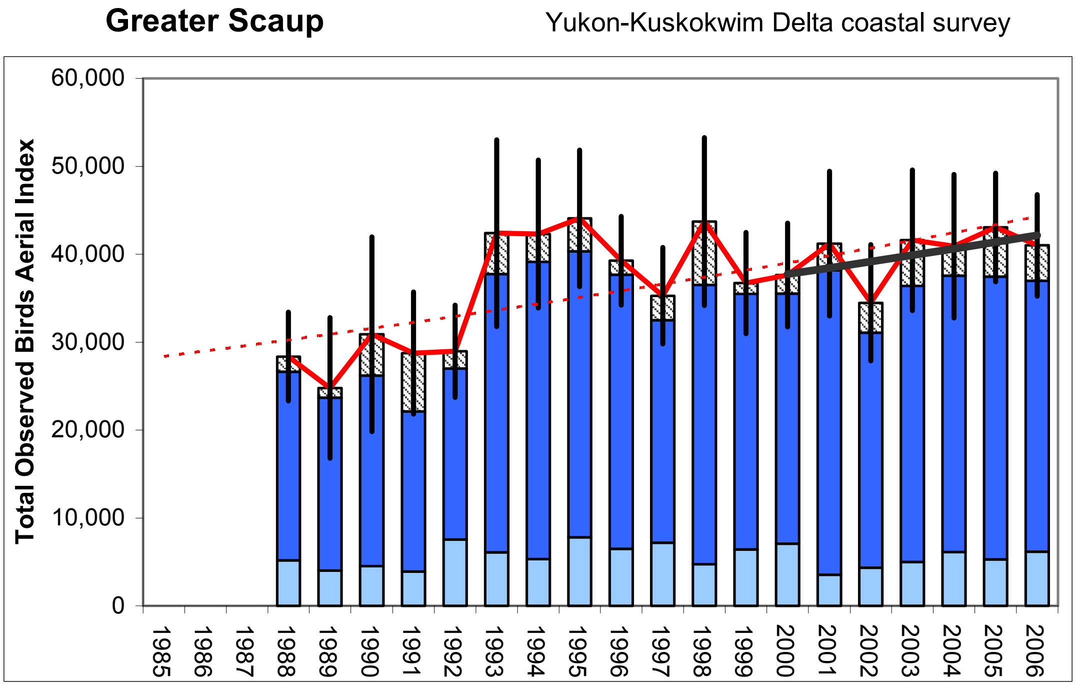

Aerial survey index with 18 strata: Indicated total birds

NOPI

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 29350 | 12110 | 10593 | **52052** | 5916 |
| 1989 | 24168 | 6324 | 1470 | **31962** | 2842 |
| 1990 | 44940 | 3638 | 11085 | **59663** | 6490 |
| 1991 | 33658 | 11812 | 18780 | **64250** | 8719 |
| 1992 | 55086 | 11048 | 20139 | **86273** | 6082 |
| 1993 | 25554 | 7122 | 5703 | **38379** | 3644 |
| 1994 | 28292 | 7988 | 17055 | **53336** | 8254 |
| 1995 | 36894 | 9570 | 20095 | **66559** | 7133 |
| 1996 | 27708 | 9590 | 12549 | **49847** | 4055 |
| 1997 | 27284 | 7670 | 12521 | **47476** | 5128 |
| 1998 | 33010 | 17790 | 10064 | **60863** | 3861 |
| 1999 | 24752 | 8776 | 1855 | **35381** | 4025 |
| 2000 | 33328 | 10490 | 4973 | **48791** | 6474 |
| 2001 | 19950 | 11492 | 10010 | **41452** | 3727 |
| 2002 | 17702 | 8322 | 2725 | **28749** | 2547 |
| 2003 | 24200 | 8980 | 14057 | **47236** | 9108 |
| 2004 | 26546 | 6870 | 14212 | **47628** | 9767 |
| 2005 | 22948 | 7082 | 12330 | **42360** | 4037 |
| 2006 | 35062 | 9620 | 14115 | **58797** | 4245 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **50582** |
| std dev = | 13681 |
| ln linear slope = | -0.0116 |
| SE slope = | 0.0112 |
| Growth Rate = | **0.989** |
| low 90%ci GR = | 0.970 |
| high 90%ci GR = | 1.007 |
| regression resid CV = | 0.269 |
| avg sampling err CV = | 0.111 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 16.6 |
| w/ sample error CV = | 9.2 |
| most recent 7 years : | |
| Growth Rate = | **1.040** |
| low 90%ci GR = | 0.971 |
| high 90%ci GR = | 1.115 |
| %chg (last : avg.prev.yrs) = | 17% |

Figure 8. Population trend for Northern Pintail (*Anas acuta*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.




Aerial survey index with 18 strata: Total birds observed

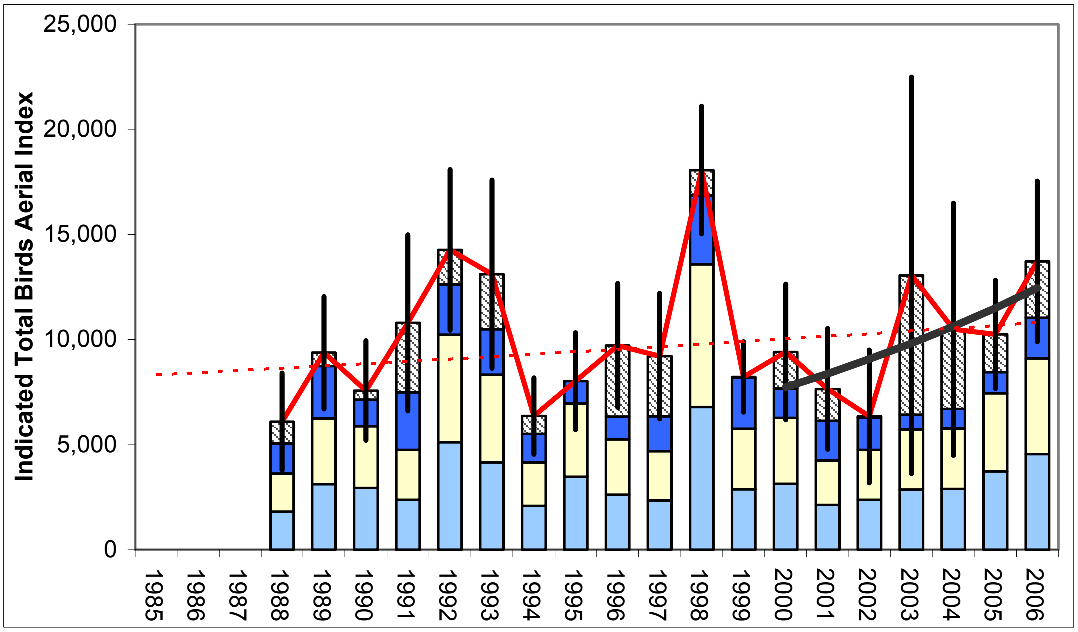
| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 5191 | 21434 | 1722 | **28347** | 2573 |
| 1989 | 3999 | 19674 | 1107 | **24780** | 4076 |
| 1990 | 4500 | 21698 | 4696 | **30895** | 5652 |
| 1991 | 3900 | 18230 | 6623 | **28753** | 3541 |
| 1992 | 7536 | 19474 | 1962 | **28973** | 2673 |
| 1993 | 6074 | 31656 | 4668 | **42398** | 5421 |
| 1994 | 5330 | 33778 | 3196 | **42304** | 4289 |
| 1995 | 7782 | 32556 | 3745 | **44083** | 3965 |
| 1996 | 6500 | 31166 | 1590 | **39256** | 2581 |
| 1997 | 7180 | 25312 | 2788 | **35280** | 2791 |
| 1998 | 4746 | 31766 | 7204 | **43715** | 4863 |
| 1999 | 6400 | 29076 | 1237 | **36712** | 2934 |
| 2000 | 7059 | 28474 | 2099 | **37631** | 3018 |
| 2001 | 3526 | 34638 | 3047 | **41211** | 4203 |
| 2002 | 4333 | 26744 | 3403 | **34481** | 3371 |
| 2003 | 4994 | 31396 | 5196 | **41585** | 4078 |
| 2004 | 6134 | 31424 | 3351 | **40909** | 4170 |
| 2005 | 5270 | 32188 | 5585 | **43044** | 3154 |
| 2006 | 6144 | 30840 | 4030 | **41015** | 2946 |

SCAU

| | |
|---|---|
| n yrs = | 19 |
| mean = | **37125** |
| std dev = | 6091 |
| slope = | 0.0212 |
| SE slope = | 0.0056 |
| Growth Rate = | **1.021** |
| low 90%ci GR = | 1.012 |
| high 90%ci GR = | 1.031 |
| regression resid CV = | 0.134 |
| avg sampling err CV = | 0.102 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 10.4 |
| w/ sample error CV = | 8.7 |
| most recent 7 years : | |
| Growth Rate = | **1.019** |
| low 90%ci GR = | 0.996 |
| high 90%ci GR = | 1.041 |
| %chg (last : avg.prev.yrs) = | 11% |

Figure 9. Population trend for Greater Scaup (*Aythya marila*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

## Northern Shoveler    Yukon-Kuskokwim Delta coastal survey



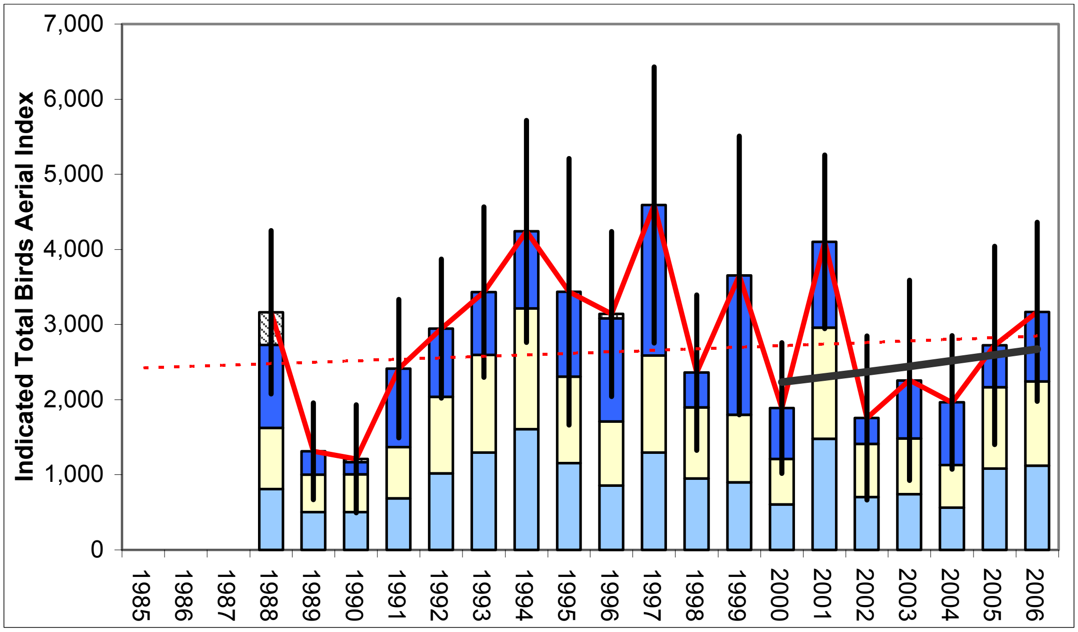

Aerial survey index with 18 strata: Indicated total birds    NSHO

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 3620 | 1442 | 1024 | **6085** | 1180 |
| 1989 | 6250 | 2484 | 639 | **9373** | 1363 |
| 1990 | 5882 | 1260 | 431 | **7574** | 1210 |
| 1991 | 4754 | 2738 | 3298 | **10791** | 2135 |
| 1992 | 10234 | 2388 | 1640 | **14263** | 1951 |
| 1993 | 8326 | 2164 | 2621 | **13112** | 2286 |
| 1994 | 4162 | 1356 | 839 | **6358** | 927 |
| 1995 | 6952 | 1066 | 0 | **8018** | 1174 |
| 1996 | 5250 | 1078 | 3389 | **9716** | 1504 |
| 1997 | 4694 | 1654 | 2866 | **9214** | 1525 |
| 1998 | 13586 | 3270 | 1204 | **18060** | 1551 |
| 1999 | 5756 | 2418 | 48 | **8220** | 853 |
| 2000 | 6274 | 1396 | 1740 | **9409** | 1645 |
| 2001 | 4252 | 1888 | 1510 | **7650** | 1465 |
| 2002 | 4754 | 1540 | 48 | **6342** | 1614 |
| 2003 | 5720 | 704 | 6631 | **13056** | 4810 |
| 2004 | 5776 | 926 | 3792 | **10495** | 3061 |
| 2005 | 7448 | 1006 | 1791 | **10245** | 1310 |
| 2006 | 9112 | 1928 | 2673 | **13713** | 1951 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **10089** |
| std dev = | 3150 |
| ln linear slope = | 0.0124 |
| SE slope = | 0.0126 |
| Growth Rate = | **1.013** |
| low 90%ci GR = | 0.992 |
| high 90%ci GR = | 1.034 |
| regression resid CV = | 0.300 |
| avg sampling err CV = | 0.177 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 17.9 |
| w/ sample error CV = | 12.6 |
| most recent 7 years : | |
| Growth Rate = | **1.082** |
| low 90%ci GR = | 1.006 |
| high 90%ci GR = | 1.165 |
| %chg (last : avg.prev.yrs) = | 39% |

Figure 10. Population trend for Northern Shoveler (*Anas clypeata*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Green-winged Teal** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Indicated total birds

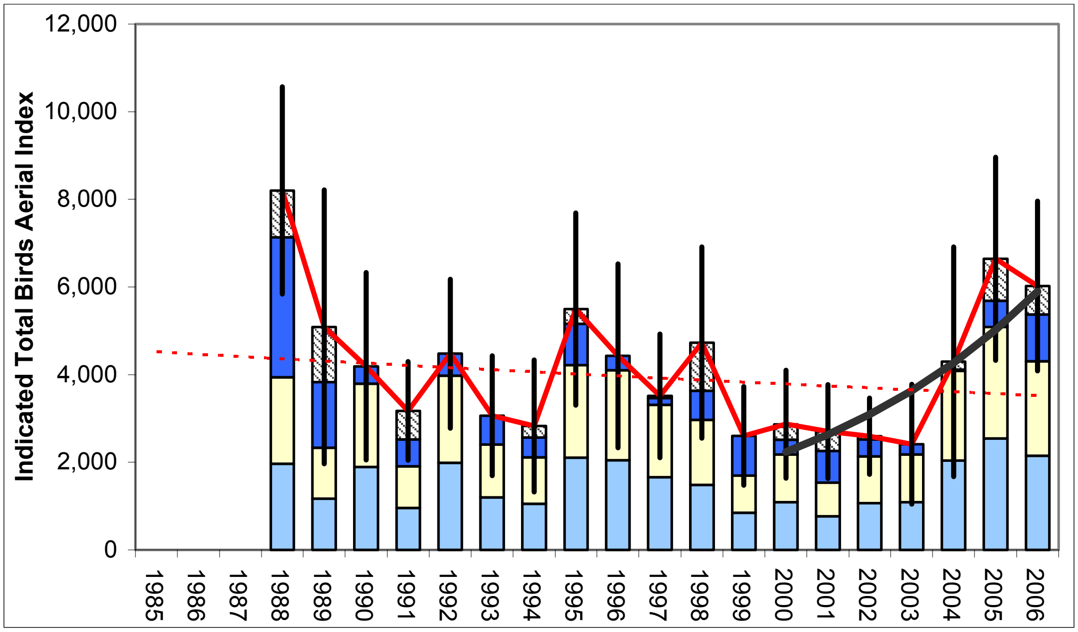
| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 1624 | 1104 | 435 | **3163** | 554 |
| 1989 | 1002 | 312 | 0 | **1313** | 328 |
| 1990 | 1006 | 164 | 41 | **1212** | 367 |
| 1991 | 1370 | 1042 | 0 | **2412** | 470 |
| 1992 | 2038 | 908 | 0 | **2945** | 472 |
| 1993 | 2596 | 836 | 0 | **3431** | 579 |
| 1994 | 3216 | 1024 | 0 | **4240** | 754 |
| 1995 | 2308 | 1128 | 0 | **3436** | 904 |
| 1996 | 1710 | 1372 | 59 | **3140** | 560 |
| 1997 | 2588 | 2004 | 0 | **4592** | 938 |
| 1998 | 1898 | 462 | 0 | **2360** | 528 |
| 1999 | 1798 | 1854 | 0 | **3652** | 946 |
| 2000 | 1212 | 678 | 0 | **1889** | 444 |
| 2001 | 2960 | 1142 | 0 | **4102** | 590 |
| 2002 | 1410 | 348 | 0 | **1758** | 557 |
| 2003 | 1482 | 774 | 0 | **2258** | 680 |
| 2004 | 1128 | 836 | 0 | **1963** | 453 |
| 2005 | 2166 | 556 | 0 | **2722** | 674 |
| 2006 | 2244 | 924 | 0 | **3168** | 608 |

AGWT

| | |
|---|---|
| n yrs = | 19 |
| mean = | **2829** |
| std dev = | 969 |
| ln linear slope = | 0.0077 |
| SE slope = | 0.0162 |
| Growth Rate = | **1.008** |
| low 90%ci GR = | 0.981 |
| high 90%ci GR = | 1.035 |
| regression resid CV = | 0.387 |
| avg sampling err CV = | 0.222 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 21.2 |
| w/ sample error CV = | 14.6 |
| most recent 7 years : | |
| Growth Rate = | **1.031** |
| low 90%ci GR = | 0.929 |
| high 90%ci GR = | 1.143 |
| %chg (last : avg.prev.yrs) = | 13% |

Figure 11. Population trend for American Green-winged Teal (*Anas crecca*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Mallard** Yukon-Kuskokwim Delta coastal survey



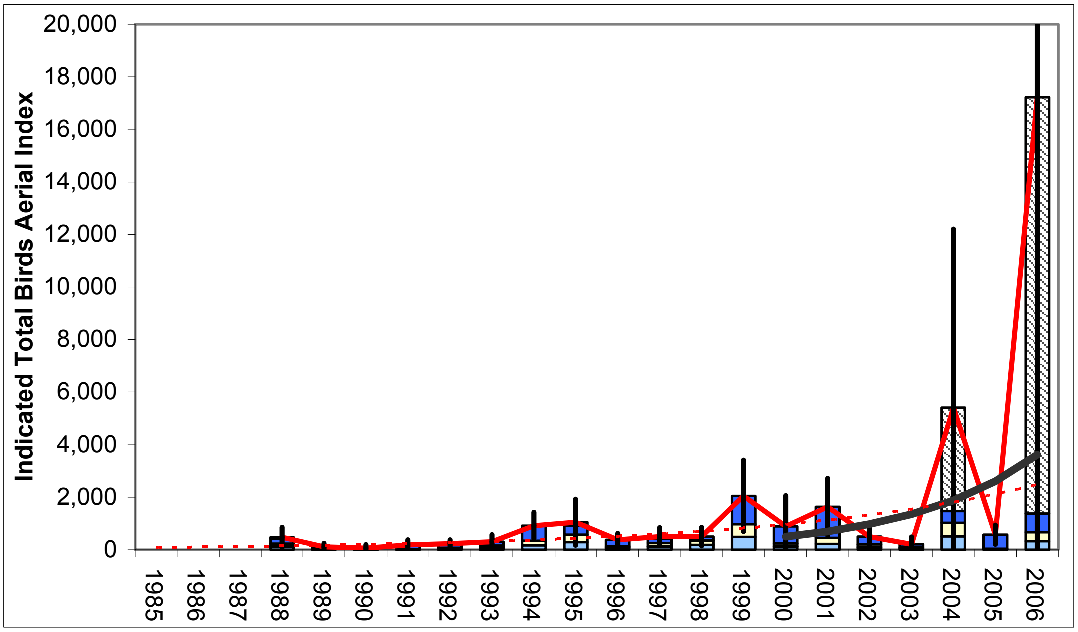

Aerial survey index with 18 strata: Indicated total birds MALL

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 3936 | 3200 | 1066 | **8203** | 1205 |
| 1989 | 2334 | 1498 | 1258 | **5090** | 1593 |
| 1990 | 3790 | 400 | 0 | **4191** | 1091 |
| 1991 | 1908 | 614 | 649 | **3171** | 574 |
| 1992 | 3976 | 502 | 0 | **4477** | 867 |
| 1993 | 2404 | 658 | 0 | **3061** | 698 |
| 1994 | 2112 | 454 | 262 | **2827** | 767 |
| 1995 | 4214 | 946 | 337 | **5496** | 1117 |
| 1996 | 4098 | 334 | 0 | **4432** | 1070 |
| 1997 | 3314 | 152 | 50 | **3517** | 719 |
| 1998 | 2964 | 670 | 1096 | **4731** | 1113 |
| 1999 | 1698 | 904 | 0 | **2602** | 573 |
| 2000 | 2178 | 334 | 356 | **2870** | 628 |
| 2001 | 1538 | 722 | 441 | **2702** | 547 |
| 2002 | 2136 | 384 | 74 | **2593** | 444 |
| 2003 | 2180 | 232 | 0 | **2412** | 697 |
| 2004 | 4082 | 32 | 181 | **4296** | 1337 |
| 2005 | 5086 | 598 | 959 | **6642** | 1182 |
| 2006 | 4304 | 1070 | 647 | **6020** | 988 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **4175** |
| std dev = | 1585 |
| ln linear slope = | -0.0118 |
| SE slope = | 0.0152 |
| Growth Rate = | **0.988** |
| low 90%ci GR = | 0.964 |
| high 90%ci GR = | 1.013 |
| regression resid CV = | 0.362 |
| avg sampling err CV = | 0.223 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 20.2 |
| w/ sample error CV = | 14.7 |
| most recent 7 years : | |
| Growth Rate = | **1.175** |
| low 90%ci GR = | 1.084 |
| high 90%ci GR = | 1.275 |
| %chg (last : avg.prev.yrs) = | 48% |

Figure 12. Population trend for Mallards (*Anas platyrhynchos*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Red-breasted Merganser** Yukon-Kuskokwim Delta coastal survey



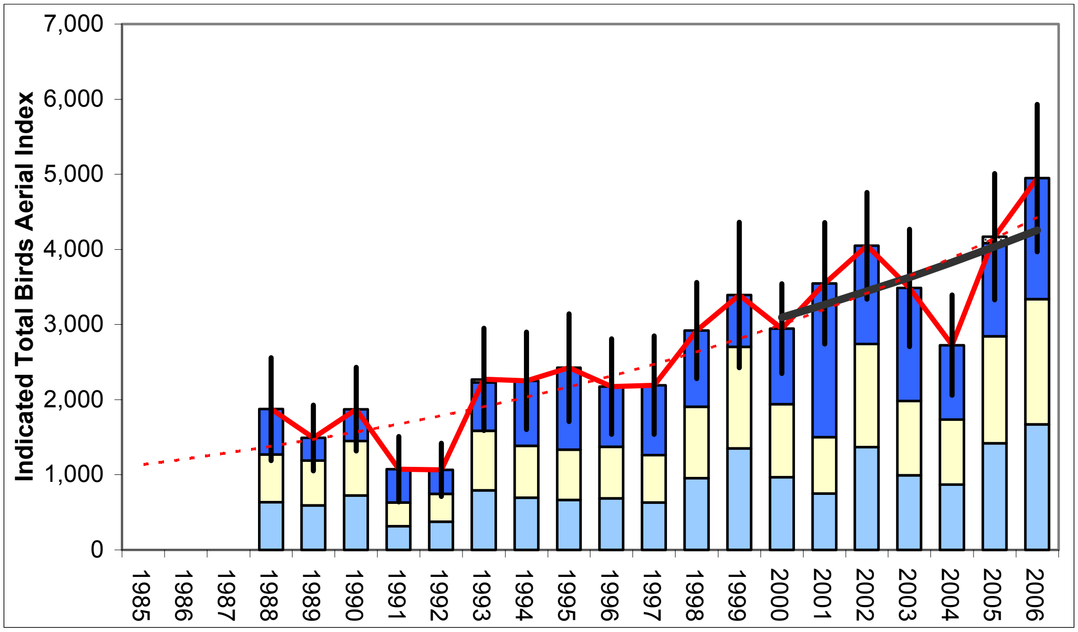

Aerial survey index with 18 strata: Indicated total birds

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 236 | 196 | 41 | **473** | 195 |
| 1989 | 104 | 0 | 0 | **104** | 73 |
| 1990 | 0 | 66 | 0 | **66** | 68 |
| 1991 | 18 | 164 | 0 | **182** | 100 |
| 1992 | 74 | 152 | 0 | **226** | 78 |
| 1993 | 164 | 146 | 0 | **310** | 131 |
| 1994 | 344 | 572 | 0 | **917** | 257 |
| 1995 | 576 | 344 | 127 | **1047** | 450 |
| 1996 | 140 | 240 | 0 | **380** | 120 |
| 1997 | 252 | 166 | 83 | **500** | 175 |
| 1998 | 358 | 146 | 0 | **503** | 180 |
| 1999 | 980 | 1072 | 0 | **2052** | 690 |
| 2000 | 248 | 636 | 0 | **885** | 600 |
| 2001 | 446 | 1184 | 0 | **1630** | 555 |
| 2002 | 206 | 298 | 0 | **504** | 180 |
| 2003 | 80 | 130 | 0 | **209** | 143 |
| 2004 | 1018 | 454 | 3942 | **5414** | 3466 |
| 2005 | 34 | 540 | 0 | **574** | 188 |
| 2006 | 666 | 714 | 15846 | **17227** | 12937 |

| | RBME |
|---|---|
| n yrs = | 19 |
| mean = | **1748** |
| std dev = | 3939 |
| ln linear slope = | 0.1577 |
| SE slope = | 0.0423 |
| Growth Rate = | **1.171** |
| low 90%ci GR = | 1.092 |
| high 90%ci GR = | 1.255 |
| regression resid CV = | 1.011 |
| avg sampling err CV = | 0.490 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 40.1 |
| w/ sample error CV = | 24.8 |
| most recent 7 years : | |
| Growth Rate = | **1.389** |
| low 90%ci GR = | 0.880 |
| high 90%ci GR = | 2.192 |
| %chg (last : avg.prev.yrs) = | 1841% |

Figure 13. Population trend for Red-breasted Merganser (*Mergus serrator*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Spectacled Eider** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Indicated total birds SPEI

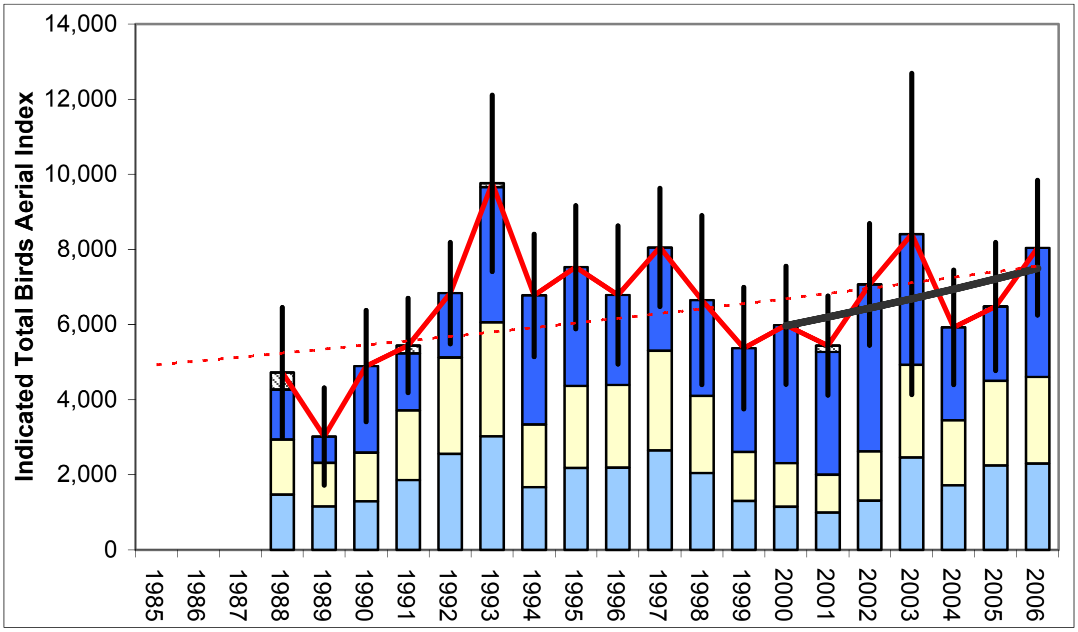
| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 1272 | 602 | 0 | **1874** | 349 |
| 1989 | 1188 | 302 | 0 | **1490** | 222 |
| 1990 | 1450 | 422 | 0 | **1872** | 284 |
| 1991 | 630 | 446 | 0 | **1075** | 222 |
| 1992 | 748 | 318 | 0 | **1066** | 180 |
| 1993 | 1588 | 640 | 42 | **2271** | 347 |
| 1994 | 1386 | 866 | 0 | **2252** | 331 |
| 1995 | 1334 | 1092 | 0 | **2426** | 366 |
| 1996 | 1374 | 802 | 0 | **2176** | 324 |
| 1997 | 1262 | 930 | 0 | **2192** | 334 |
| 1998 | 1906 | 1014 | 0 | **2920** | 326 |
| 1999 | 2702 | 690 | 0 | **3393** | 493 |
| 2000 | 1938 | 1008 | 0 | **2945** | 305 |
| 2001 | 1500 | 2048 | 0 | **3549** | 413 |
| 2002 | 2740 | 1310 | 0 | **4049** | 362 |
| 2003 | 1984 | 1502 | 0 | **3487** | 399 |
| 2004 | 1736 | 990 | 0 | **2727** | 340 |
| 2005 | 2842 | 1244 | 83 | **4170** | 429 |
| 2006 | 3340 | 1608 | 0 | **4949** | 501 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **2678** |
| std dev = | 1057 |
| ln linear slope = | 0.0647 |
| SE slope = | 0.0096 |
| Growth Rate = | **1.067** |
| low 90%ci GR = | 1.050 |
| high 90%ci GR = | 1.084 |
| regression resid CV = | 0.228 |
| avg sampling err CV = | 0.138 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 14.9 |
| w/ sample error CV = | 10.7 |
| most recent 7 years : | |
| Growth Rate = | **1.054** |
| low 90%ci GR = | 0.995 |
| high 90%ci GR = | 1.118 |
| %chg (last : avg.prev.yrs) = | 94% |

Figure 14. Population trend for Spectacled Eiders (*Somateria fischeri*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

## Long-tailed Duck

Yukon-Kuskokwim Delta coastal survey

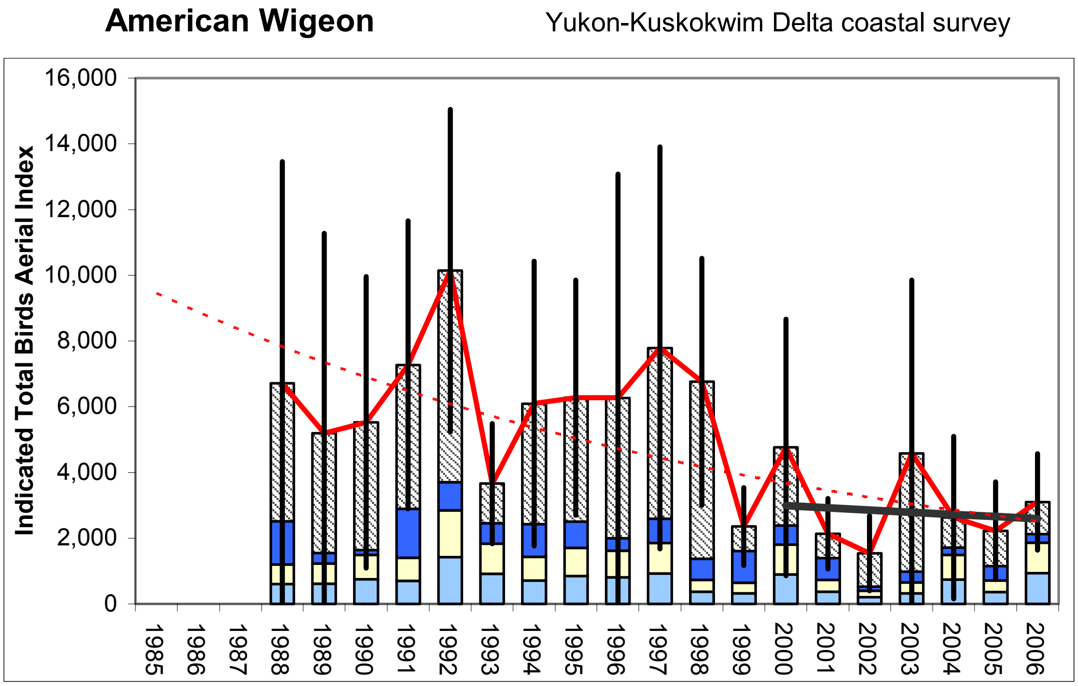



Aerial survey index with 18 strata: Indicated total birds

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 2942 | 1330 | 451 | **4723** | 882 |
| 1989 | 2316 | 704 | 0 | **3020** | 661 |
| 1990 | 2592 | 2304 | 0 | **4897** | 757 |
| 1991 | 3720 | 1512 | 211 | **5443** | 643 |
| 1992 | 5120 | 1714 | 0 | **6834** | 690 |
| 1993 | 6062 | 3598 | 100 | **9759** | 1199 |
| 1994 | 3342 | 3434 | 0 | **6776** | 833 |
| 1995 | 4364 | 3162 | 0 | **7525** | 838 |
| 1996 | 4388 | 2400 | 0 | **6789** | 939 |
| 1997 | 5306 | 2746 | 0 | **8053** | 801 |
| 1998 | 4100 | 2550 | 0 | **6649** | 1148 |
| 1999 | 2608 | 2762 | 0 | **5370** | 827 |
| 2000 | 2310 | 3672 | 0 | **5982** | 801 |
| 2001 | 2002 | 3268 | 169 | **5439** | 675 |
| 2002 | 2622 | 4446 | 0 | **7068** | 825 |
| 2003 | 4926 | 3482 | 0 | **8409** | 2181 |
| 2004 | 3450 | 2474 | 0 | **5924** | 779 |
| 2005 | 4502 | 1980 | 0 | **6481** | 869 |
| 2006 | 4604 | 3440 | 0 | **8044** | 917 |

| | OLDS |
|---|---|
| n yrs = | 19 |
| mean = | **6483** |
| std dev = | 1540 |
| ln linear slope = | 0.0204 |
| SE slope = | 0.0101 |
| Growth Rate = | **1.021** |
| low 90%ci GR = | 1.004 |
| high 90%ci GR = | 1.038 |
| regression resid CV = | 0.241 |
| avg sampling err CV = | 0.143 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 15.4 |
| w/ sample error CV = | 10.9 |
| most recent 7 years : | |
| Growth Rate = | **1.039** |
| low 90%ci GR = | 0.990 |
| high 90%ci GR = | 1.090 |
| %chg (last : avg.prev.yrs) = | 26% |

Figure 15. Population trend for Long-tailed Duck (*Clangula hyamelis*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.




Aerial survey index with 18 strata: Indicated total birds

AMWI

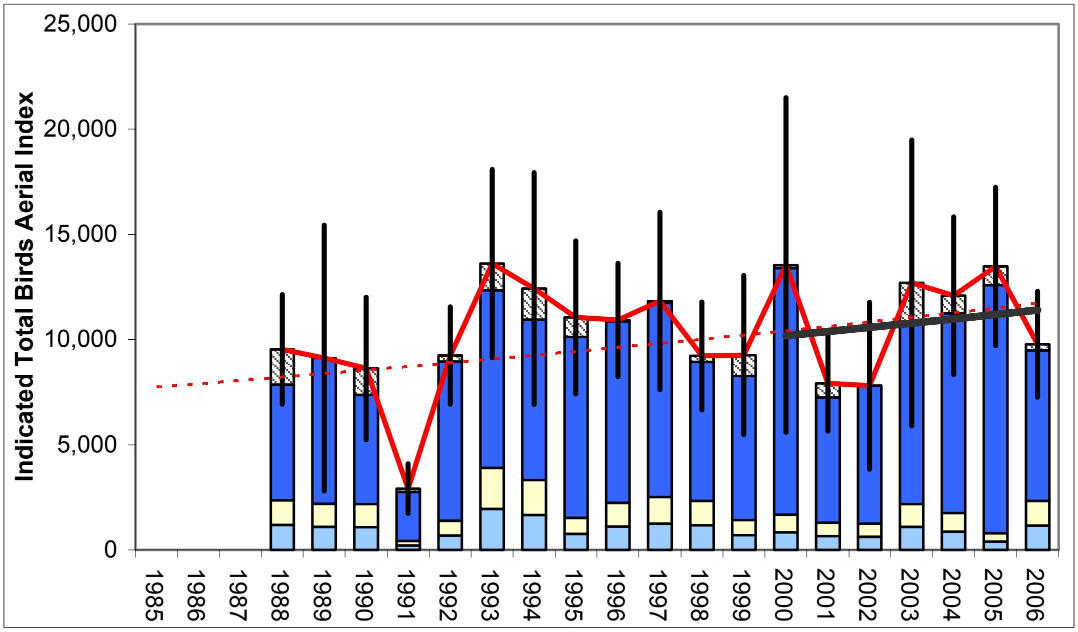
| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 1202 | 1312 | 4196 | **6708** | 3445 |
| 1989 | 1228 | 318 | 3646 | **5192** | 3102 |
| 1990 | 1492 | 142 | 3890 | **5524** | 2261 |
| 1991 | 1404 | 1494 | 4374 | **7270** | 2235 |
| 1992 | 2842 | 864 | 6435 | **10141** | 2503 |
| 1993 | 1830 | 624 | 1205 | **3658** | 932 |
| 1994 | 1430 | 994 | 3670 | **6096** | 2211 |
| 1995 | 1702 | 804 | 3769 | **6275** | 1825 |
| 1996 | 1618 | 384 | 4267 | **6271** | 3470 |
| 1997 | 1854 | 742 | 5193 | **7790** | 3121 |
| 1998 | 732 | 644 | 5385 | **6761** | 1916 |
| 1999 | 640 | 970 | 744 | **2354** | 606 |
| 2000 | 1798 | 592 | 2373 | **4763** | 1992 |
| 2001 | 732 | 666 | 733 | **2133** | 548 |
| 2002 | 402 | 124 | 1014 | **1540** | 581 |
| 2003 | 650 | 330 | 3603 | **4583** | 2690 |
| 2004 | 1488 | 224 | 917 | **2629** | 1261 |
| 2005 | 712 | 436 | 1077 | **2225** | 758 |
| 2006 | 1862 | 260 | 981 | **3104** | 746 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **5001** |
| std dev = | 2313 |
| ln linear slope = | -0.0630 |
| SE slope = | 0.0168 |
| Growth Rate = | **0.939** |
| low 90%ci GR = | 0.913 |
| high 90%ci GR = | 0.965 |
| regression resid CV = | 0.401 |
| avg sampling err CV = | 0.378 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 21.7 |
| w/ sample error CV = | 20.8 |
| most recent 7 years : | |
| Growth Rate = | **0.977** |
| low 90%ci GR = | 0.849 |
| high 90%ci GR = | 1.123 |
| %chg (last : avg.prev.yrs) = | -39% |

Figure 16. Population trend for American Wigeon (*Anas americana*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

## Black Scoter

Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Indicated total birds

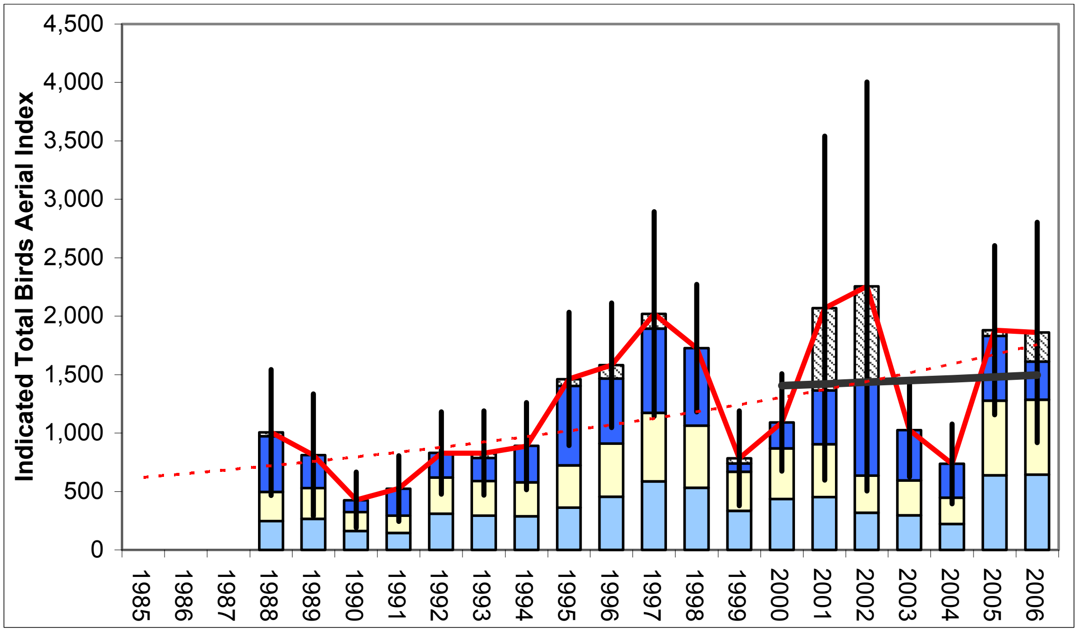
BLSC

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 2364 | 5492 | 1675 | **9531** | 1329 |
| 1989 | 2188 | 6938 | 0 | **9124** | 3225 |
| 1990 | 2172 | 5194 | 1267 | **8631** | 1729 |
| 1991 | 432 | 2318 | 165 | **2915** | 599 |
| 1992 | 1380 | 7574 | 286 | **9240** | 1179 |
| 1993 | 3904 | 8440 | 1269 | **13613** | 2285 |
| 1994 | 3318 | 7628 | 1482 | **12427** | 2810 |
| 1995 | 1516 | 8608 | 934 | **11057** | 1855 |
| 1996 | 2236 | 8638 | 59 | **10934** | 1374 |
| 1997 | 2506 | 9240 | 81 | **11826** | 2150 |
| 1998 | 2332 | 6598 | 291 | **9220** | 1308 |
| 1999 | 1414 | 6850 | 999 | **9264** | 1928 |
| 2000 | 1668 | 11732 | 142 | **13542** | 4062 |
| 2001 | 1296 | 5946 | 676 | **7917** | 1155 |
| 2002 | 1256 | 6548 | 0 | **7804** | 2025 |
| 2003 | 2178 | 8646 | 1868 | **12692** | 3468 |
| 2004 | 1750 | 9500 | 840 | **12090** | 1913 |
| 2005 | 798 | 11790 | 888 | **13475** | 1922 |
| 2006 | 2326 | 7158 | 290 | **9774** | 1281 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **10267** |
| std dev = | 2616 |
| ln linear slope = | 0.0197 |
| SE slope = | 0.0141 |
| Growth Rate = | **1.020** |
| low 90%ci GR = | 0.997 |
| high 90%ci GR = | 1.044 |
| regression resid CV = | 0.336 |
| avg sampling err CV = | 0.192 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 19.3 |
| w/ sample error CV = | 13.3 |
| most recent 7 years : | |
| Growth Rate = | **1.019** |
| low 90%ci GR = | 0.939 |
| high 90%ci GR = | 1.105 |
| %chg (last : avg.prev.yrs) = | -5% |

Figure 17. Population trend for Black Scoter (*Melanitta nigra*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Common Eider** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Indicated total birds

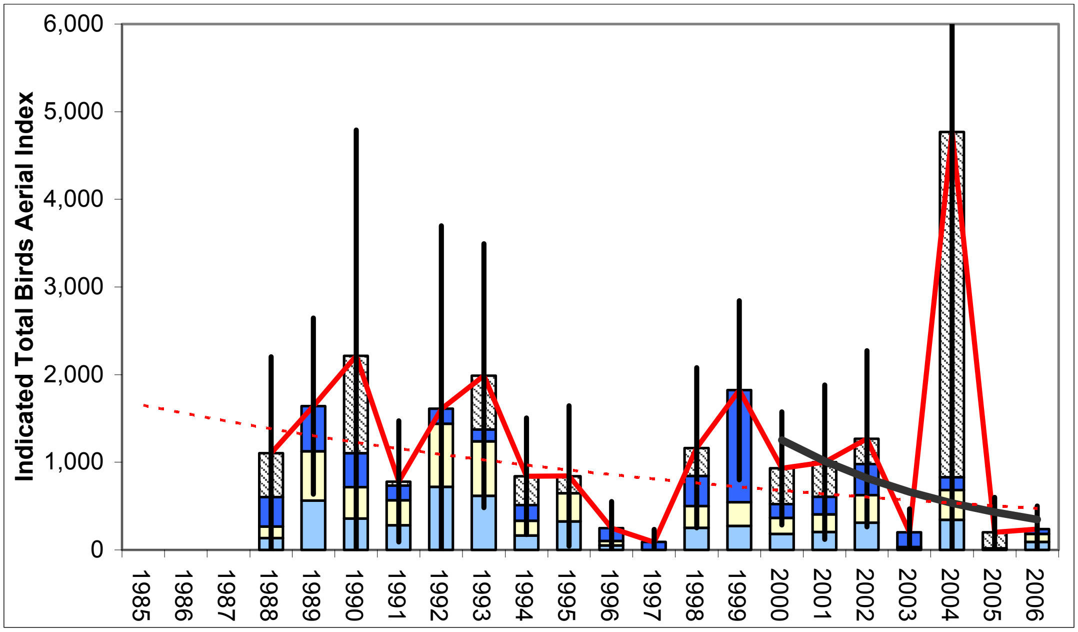
| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 496 | 476 | 33 | **1005** | 275 |
| 1989 | 530 | 280 | 0 | **810** | 267 |
| 1990 | 324 | 102 | 0 | **427** | 122 |
| 1991 | 292 | 232 | 0 | **525** | 143 |
| 1992 | 620 | 210 | 0 | **829** | 180 |
| 1993 | 588 | 198 | 42 | **829** | 184 |
| 1994 | 578 | 312 | 0 | **888** | 190 |
| 1995 | 724 | 680 | 58 | **1463** | 291 |
| 1996 | 910 | 556 | 115 | **1580** | 272 |
| 1997 | 1172 | 722 | 126 | **2019** | 447 |
| 1998 | 1064 | 662 | 0 | **1727** | 278 |
| 1999 | 670 | 70 | 43 | **783** | 207 |
| 2000 | 870 | 222 | 0 | **1091** | 213 |
| 2001 | 904 | 460 | 706 | **2070** | 751 |
| 2002 | 636 | 818 | 801 | **2255** | 893 |
| 2003 | 594 | 432 | 0 | **1026** | 205 |
| 2004 | 446 | 290 | 0 | **736** | 174 |
| 2005 | 1276 | 554 | 51 | **1880** | 369 |
| 2006 | 1286 | 326 | 248 | **1861** | 481 |

COEI

| | |
|---|---|
| n yrs = | 19 |
| mean = | **1253** |
| std dev = | 574 |
| ln linear slope = | 0.0495 |
| SE slope = | 0.0173 |
| Growth Rate = | **1.051** |
| low 90%ci GR = | 1.021 |
| high 90%ci GR = | 1.081 |
| regression resid CV = | 0.412 |
| avg sampling err CV = | 0.246 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 22.1 |
| w/ sample error CV = | 15.7 |
| most recent 7 years : | |
| Growth Rate = | **1.010** |
| low 90%ci GR = | 0.873 |
| high 90%ci GR = | 1.170 |
| %chg (last : avg.prev.yrs) = | 53% |

Figure 18. Population trend for Common Eiders (*Somateria mollissima*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Canvasback** Yukon-Kuskokwim Delta coastal survey



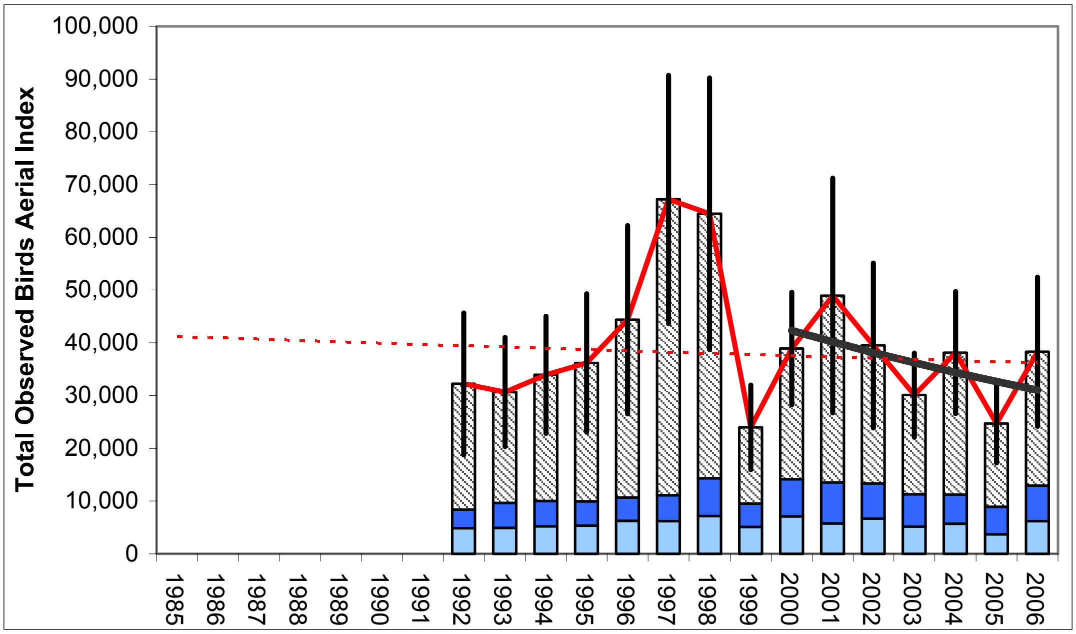

Aerial survey index with 18 strata: Indicated total birds CANV

| year | 2*sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | 268 | 334 | 502 | **1103** | 561 |
| 1989 | 1124 | 516 | 0 | **1641** | 512 |
| 1990 | 718 | 386 | 1111 | **2215** | 1314 |
| 1991 | 566 | 168 | 46 | **781** | 352 |
| 1992 | 1438 | 172 | 0 | **1609** | 1066 |
| 1993 | 1238 | 136 | 614 | **1988** | 768 |
| 1994 | 332 | 178 | 331 | **840** | 340 |
| 1995 | 648 | 0 | 194 | **843** | 408 |
| 1996 | 104 | 144 | 0 | **249** | 154 |
| 1997 | 0 | 90 | 0 | **89** | 73 |
| 1998 | 502 | 342 | 319 | **1164** | 466 |
| 1999 | 546 | 1276 | 0 | **1823** | 521 |
| 2000 | 364 | 158 | 409 | **931** | 329 |
| 2001 | 406 | 200 | 397 | **1002** | 449 |
| 2002 | 624 | 356 | 289 | **1268** | 513 |
| 2003 | 34 | 168 | 0 | **202** | 136 |
| 2004 | 684 | 144 | 3942 | **4771** | 3447 |
| 2005 | 18 | 0 | 184 | **202** | 203 |
| 2006 | 184 | 54 | 0 | **238** | 134 |

| | |
|---|---|
| n yrs = | 19 |
| mean = | **1208** |
| std dev = | 1074 |
| ln linear slope = | -0.0594 |
| SE slope = | 0.0415 |
| Growth Rate = | **0.942** |
| low 90%ci GR = | 0.880 |
| high 90%ci GR = | 1.009 |
| regression resid CV = | 0.993 |
| avg sampling err CV = | 0.531 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 39.7 |
| w/ sample error CV = | 26.1 |
| most recent 7 years : | |
| Growth Rate = | **0.808** |
| low 90%ci GR = | 0.556 |
| high 90%ci GR = | 1.173 |
| %chg (last : avg.prev.yrs) = | -81% |

Figure 19. Population trend for Canvasback (*Aythya valisineria*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Glaucous Gull** Yukon-Kuskokwim Delta coastal survey



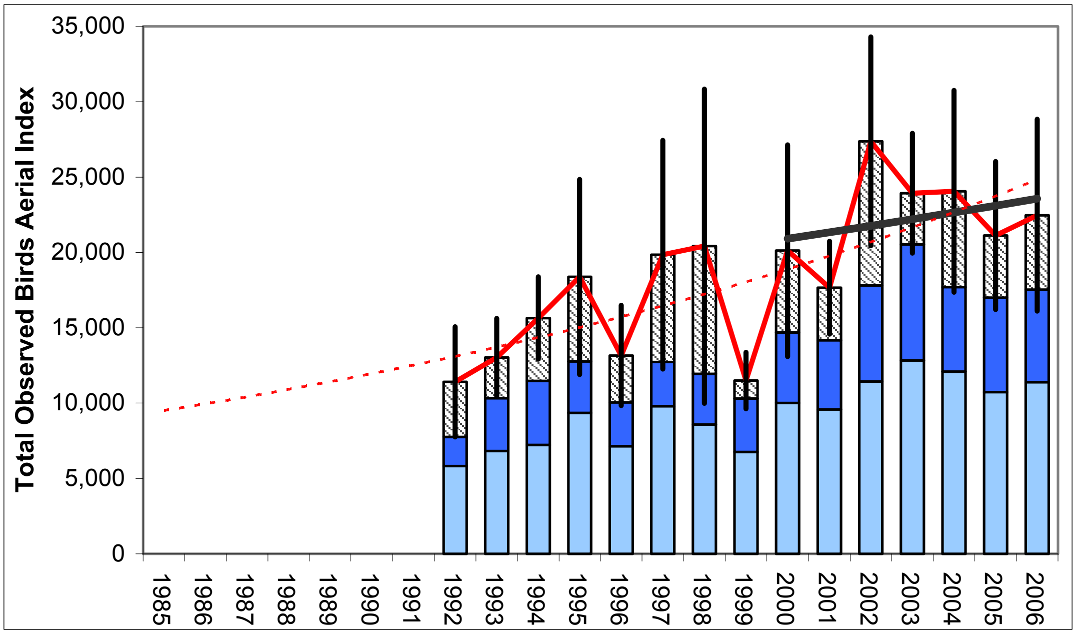

Aerial survey index with 18 strata: Total birds observed GLGU

| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 4881 | 3480 | 23861 | **32221** | 6858 |
| 1993 | 4938 | 4726 | 21023 | **30688** | 5275 |
| 1994 | 5243 | 4790 | 23914 | **33946** | 5663 |
| 1995 | 5336 | 4634 | 26213 | **36183** | 6691 |
| 1996 | 6283 | 4384 | 33718 | **44384** | 9110 |
| 1997 | 6170 | 4960 | 56059 | **67188** | 12002 |
| 1998 | 7180 | 7178 | 50135 | **64492** | 13138 |
| 1999 | 5101 | 4442 | 14448 | **23992** | 4083 |
| 2000 | 7082 | 7042 | 24810 | **38934** | 5455 |
| 2001 | 5797 | 7728 | 35424 | **48950** | 11358 |
| 2002 | 6697 | 6648 | 26178 | **39524** | 7978 |
| 2003 | 5148 | 6158 | 18788 | **30094** | 4064 |
| 2004 | 5734 | 5504 | 26922 | **38158** | 5892 |
| 2005 | 3733 | 5162 | 15799 | **24694** | 3800 |
| 2006 | 6194 | 6732 | 25395 | **38321** | 7207 |

| | |
|---|---|
| n yrs = | 15 |
| mean = | **39451** |
| std dev = | 12617 |
| slope = | -0.0062 |
| SE slope = | 0.0183 |
| Growth Rate = | **0.994** |
| low 90%ci GR = | 0.964 |
| high 90%ci GR = | 1.024 |
| regression resid CV = | 0.307 |
| avg sampling err CV = | 0.180 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 18.1 |
| w/ sample error CV = | 12.7 |
| most recent 7 years : | |
| Growth Rate = | **0.949** |
| low 90%ci GR = | 0.890 |
| high 90%ci GR = | 1.013 |
| %chg (last : avg.prev.yrs) = | -3% |

Figure 20. Population trend for Glaucous Gulls (*Larus hyperboreus*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Arctic Tern** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Total birds observed

| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 5816 | 1936 | 3662 | **11414** | 1865 |
| 1993 | 6820 | 3518 | 2693 | **13031** | 1319 |
| 1994 | 7226 | 4240 | 4181 | **15648** | 1391 |
| 1995 | 9347 | 3424 | 5601 | **18372** | 3301 |
| 1996 | 7133 | 2922 | 3106 | **13161** | 1696 |
| 1997 | 9802 | 2934 | 7112 | **19848** | 3866 |
| 1998 | 8585 | 3348 | 8480 | **20413** | 5317 |
| 1999 | 6757 | 3548 | 1193 | **11497** | 952 |
| 2000 | 10000 | 4680 | 5440 | **20120** | 3584 |
| 2001 | 9592 | 4580 | 3486 | **17659** | 1577 |
| 2002 | 11437 | 6372 | 9563 | **27372** | 3536 |
| 2003 | 12840 | 7694 | 3403 | **23937** | 2027 |
| 2004 | 12085 | 5612 | 6359 | **24055** | 3418 |
| 2005 | 10723 | 6276 | 4121 | **21121** | 2505 |
| 2006 | 11392 | 6144 | 4936 | **22471** | 3248 |

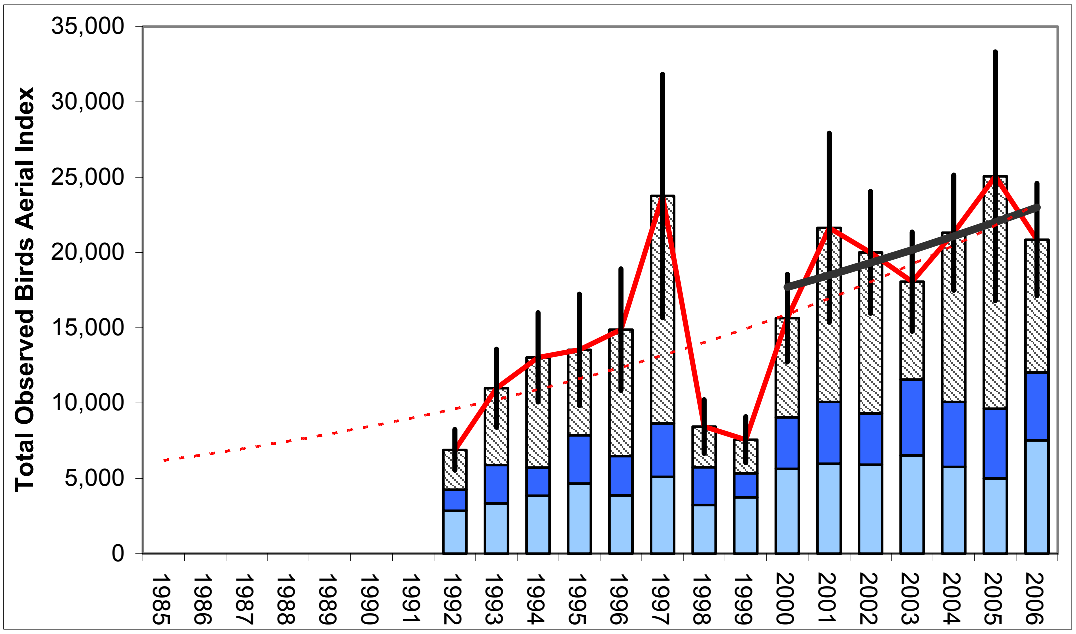
ARTE

| | |
|---|---|
| n yrs = | 15 |
| mean = | **18675** |
| std dev = | 4899 |
| slope = | 0.0457 |
| SE slope = | 0.0117 |
| Growth Rate = | **1.047** |
| low 90%ci GR = | 1.027 |
| high 90%ci GR = | 1.067 |
| regression resid CV = | 0.196 |
| avg sampling err CV = | 0.139 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 13.5 |
| w/ sample error CV = | 10.7 |
| most recent 7 years : | |
| Growth Rate = | **1.020** |
| low 90%ci GR = | 0.974 |
| high 90%ci GR = | 1.068 |
| %chg (last : avg.prev.yrs) = | 22% |

Figure 21. Population trend for Arctic Terns (*Sterna paradisaea*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

## Sabine's Gull

Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Total birds observed

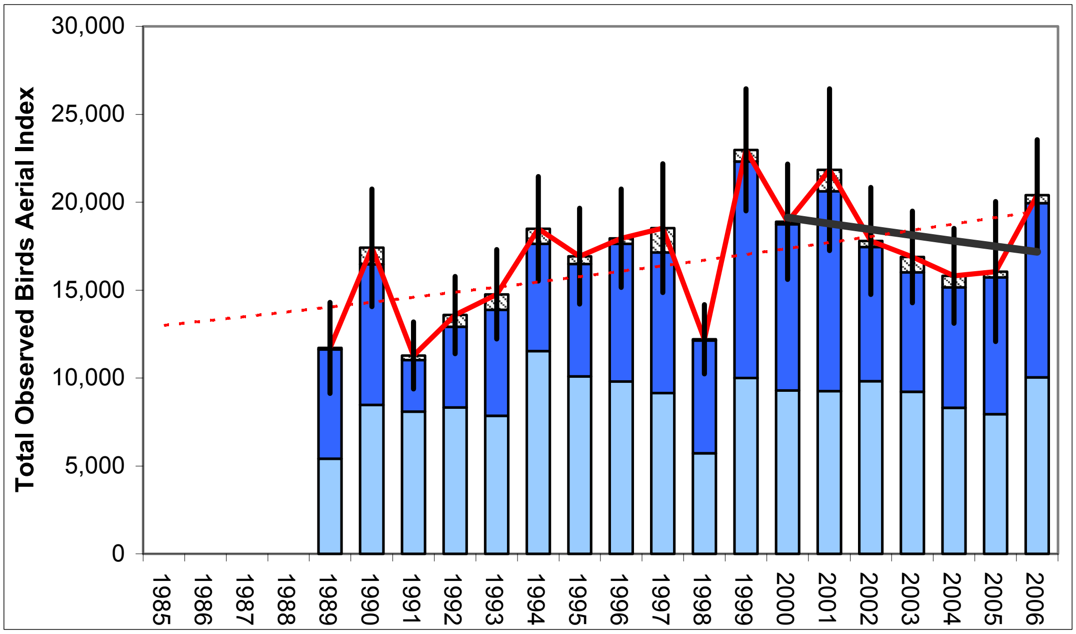
| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 2846 | 1404 | 2642 | **6893** | 688 |
| 1993 | 3327 | 2560 | 5099 | **10986** | 1318 |
| 1994 | 3847 | 1860 | 7330 | **13036** | 1511 |
| 1995 | 4650 | 3212 | 5682 | **13543** | 1887 |
| 1996 | 3863 | 2622 | 8388 | **14874** | 2060 |
| 1997 | 5108 | 3532 | 15113 | **23754** | 4125 |
| 1998 | 3226 | 2502 | 2706 | **8435** | 909 |
| 1999 | 3741 | 1594 | 2235 | **7570** | 778 |
| 2000 | 5642 | 3404 | 6592 | **15638** | 1484 |
| 2001 | 5975 | 4100 | 11560 | **21635** | 3204 |
| 2002 | 5901 | 3416 | 10688 | **20004** | 2064 |
| 2003 | 6514 | 5052 | 6493 | **18058** | 1681 |
| 2004 | 5753 | 4326 | 11238 | **21317** | 1952 |
| 2005 | 4984 | 4652 | 15425 | **25061** | 4213 |
| 2006 | 7524 | 4500 | 8828 | **20852** | 1902 |

SAGU

| | |
|---|---|
| n yrs = | 15 |
| mean = | **16110** |
| std dev = | 5967 |
| slope = | 0.0629 |
| SE slope = | 0.0195 |
| Growth Rate = | **1.065** |
| low 90%ci GR = | 1.031 |
| high 90%ci GR = | 1.100 |
| regression resid CV = | 0.326 |
| avg sampling err CV = | 0.119 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 18.9 |
| w/ sample error CV = | 9.7 |
| most recent 7 years : | |
| Growth Rate = | **1.045** |
| low 90%ci GR = | 1.004 |
| high 90%ci GR = | 1.086 |
| %chg (last : avg.prev.yrs) = | 32% |

Figure 22. Population trend for Sabine's Gulls (*Xema sabini*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Pacific Loon** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Total birds observed

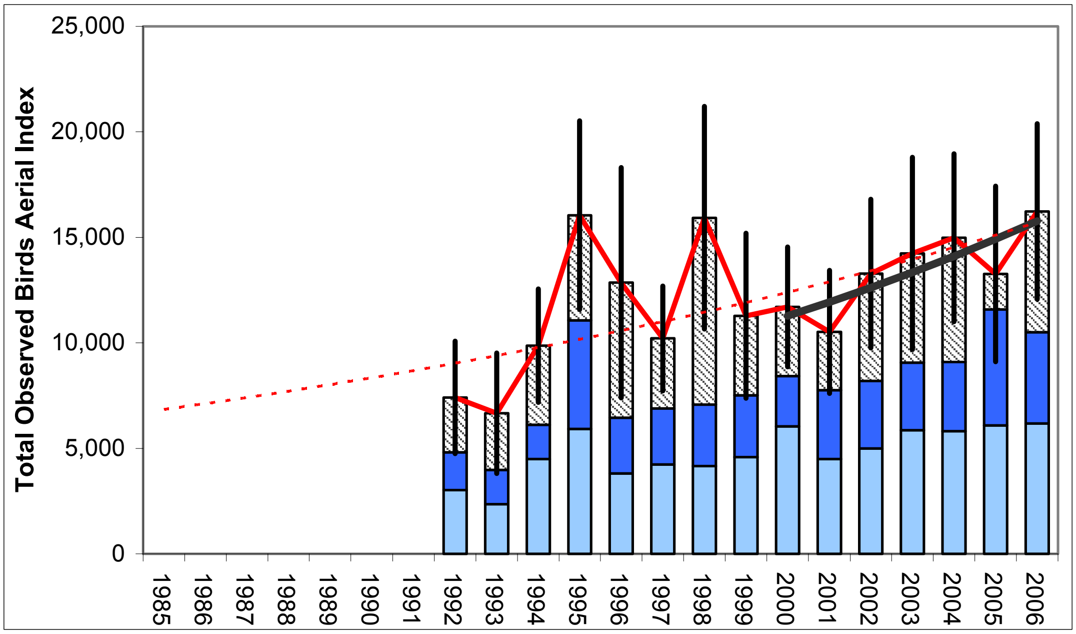
PALO

| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | 5408 | 6216 | 90 | **11712** | 1317 |
| 1990 | 8469 | 7994 | 943 | **17407** | 1703 |
| 1991 | 8096 | 2928 | 257 | **11281** | 969 |
| 1992 | 8317 | 4592 | 671 | **13581** | 1121 |
| 1993 | 7849 | 6036 | 874 | **14759** | 1298 |
| 1994 | 11526 | 6104 | 855 | **18485** | 1517 |
| 1995 | 10087 | 6402 | 440 | **16929** | 1389 |
| 1996 | 9808 | 7820 | 317 | **17945** | 1427 |
| 1997 | 9148 | 7986 | 1389 | **18523** | 1871 |
| 1998 | 5728 | 6402 | 81 | **12212** | 1004 |
| 1999 | 10004 | 12304 | 661 | **22970** | 1770 |
| 2000 | 9295 | 9446 | 151 | **18891** | 1673 |
| 2001 | 9248 | 11366 | 1229 | **21842** | 2346 |
| 2002 | 9826 | 7628 | 337 | **17792** | 1553 |
| 2003 | 9224 | 6778 | 884 | **16886** | 1331 |
| 2004 | 8313 | 6838 | 656 | **15807** | 1373 |
| 2005 | 7938 | 7774 | 340 | **16052** | 2029 |
| 2006 | 10045 | 9908 | 451 | **20403** | 1606 |

| | |
|---|---|
| n yrs = | 18 |
| mean = | **16860** |
| std dev = | 3279 |
| slope = | 0.0193 |
| SE slope = | 0.0082 |
| Growth Rate = | **1.020** |
| low 90%ci GR = | 1.006 |
| high 90%ci GR = | 1.033 |
| regression resid CV = | 0.180 |
| avg sampling err CV = | 0.090 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 12.7 |
| w/ sample error CV = | 8.0 |
| most recent 7 years : | |
| Growth Rate = | **0.982** |
| low 90%ci GR = | 0.944 |
| high 90%ci GR = | 1.022 |
| %chg (last : avg.prev.yrs) = | 23% |

Figure 23. Population trend for Pacific Loons (*Gavia pacifica*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Mew Gull** Yukon-Kuskokwim Delta coastal survey



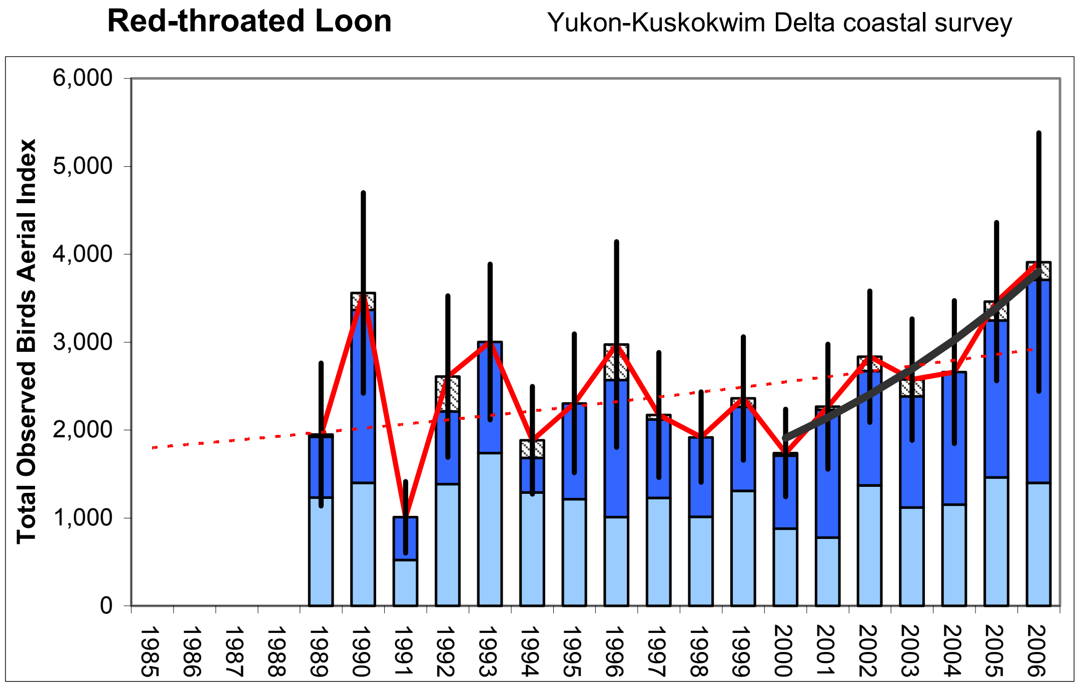

Aerial survey index with 18 strata: Total birds observed

| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | | | | | |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | 3025 | 1792 | 2594 | **7411** | 1359 |
| 1993 | 2349 | 1634 | 2679 | **6663** | 1459 |
| 1994 | 4494 | 1626 | 3746 | **9866** | 1368 |
| 1995 | 5915 | 5146 | 4990 | **16051** | 2279 |
| 1996 | 3806 | 2652 | 6392 | **12849** | 2785 |
| 1997 | 4232 | 2656 | 3326 | **10213** | 1266 |
| 1998 | 4157 | 2914 | 8853 | **15925** | 2691 |
| 1999 | 4588 | 2928 | 3767 | **11284** | 1997 |
| 2000 | 6041 | 2390 | 3272 | **11704** | 1449 |
| 2001 | 4500 | 3252 | 2760 | **10512** | 1487 |
| 2002 | 4997 | 3194 | 5093 | **13283** | 1795 |
| 2003 | 5857 | 3208 | 5180 | **14244** | 2323 |
| 2004 | 5819 | 3266 | 5897 | **14984** | 2030 |
| 2005 | 6082 | 5498 | 1683 | **13262** | 2122 |
| 2006 | 6180 | 4320 | 5731 | **16232** | 2121 |

MEGU

| | |
|---|---|
| n yrs = | 15 |
| mean = | **12299** |
| std dev = | 3005 |
| slope = | 0.0396 |
| SE slope = | 0.0127 |
| Growth Rate = | **1.040** |
| low 90%ci GR = | 1.019 |
| high 90%ci GR = | 1.062 |
| regression resid CV = | 0.212 |
| avg sampling err CV = | 0.157 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 14.2 |
| w/ sample error CV = | 11.6 |
| most recent 7 years : | |
| Growth Rate = | **1.058** |
| low 90%ci GR = | 1.028 |
| high 90%ci GR = | 1.088 |
| %chg (last : avg.prev.yrs) = | 35% |

Figure 24. Population trend for Mew Gulls (*Larus canus*) observed by the right-rear-seat observer on aerial transects sampling 12,832 $km^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.




Aerial survey index with 18 strata: Total birds observed

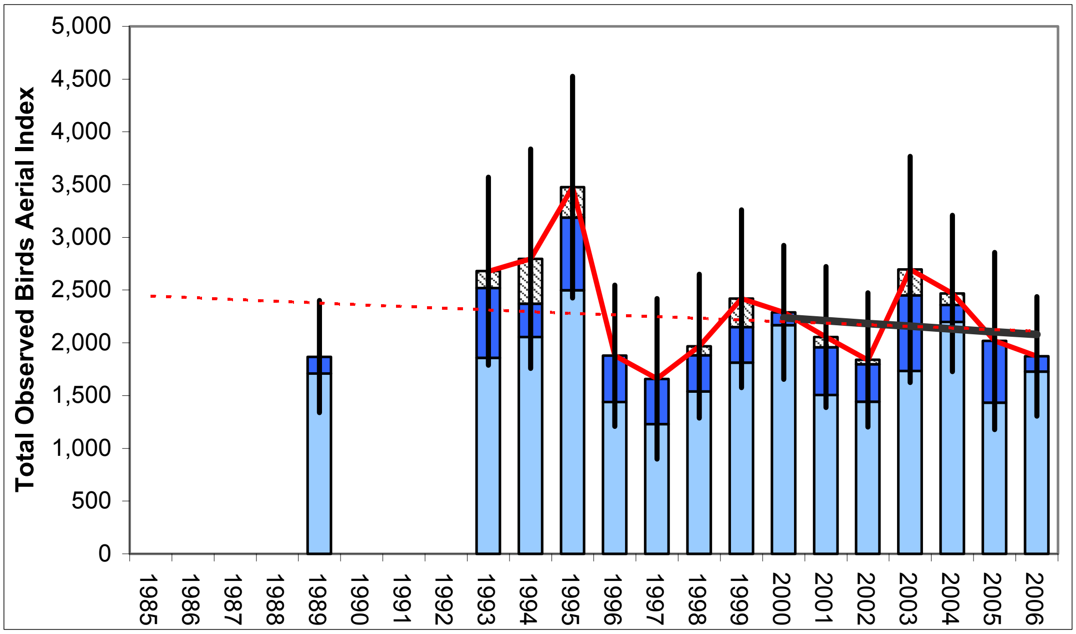
| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | 1231 | 692 | 25 | **1949** | 415 |
| 1990 | 1400 | 1966 | 194 | **3560** | 582 |
| 1991 | 522 | 486 | 0 | **1008** | 207 |
| 1992 | 1385 | 826 | 398 | **2608** | 469 |
| 1993 | 1737 | 1266 | 0 | **3002** | 452 |
| 1994 | 1288 | 394 | 202 | **1884** | 312 |
| 1995 | 1212 | 1092 | 0 | **2304** | 402 |
| 1996 | 1008 | 1560 | 404 | **2972** | 597 |
| 1997 | 1227 | 894 | 51 | **2171** | 363 |
| 1998 | 1014 | 904 | 0 | **1919** | 262 |
| 1999 | 1307 | 954 | 100 | **2360** | 358 |
| 2000 | 879 | 828 | 32 | **1739** | 254 |
| 2001 | 775 | 1456 | 34 | **2265** | 362 |
| 2002 | 1369 | 1302 | 163 | **2834** | 381 |
| 2003 | 1117 | 1264 | 194 | **2575** | 352 |
| 2004 | 1150 | 1510 | 0 | **2659** | 415 |
| 2005 | 1461 | 1784 | 216 | **3462** | 459 |
| 2006 | 1399 | 2310 | 200 | **3909** | 750 |

RTLO

| | |
|---|---|
| n yrs = | 18 |
| mean = | **2510** |
| std dev = | 716 |
| slope = | 0.0231 |
| SE slope = | 0.0136 |
| Growth Rate = | **1.023** |
| low 90%ci GR = | 1.001 |
| high 90%ci GR = | 1.047 |
| regression resid CV = | 0.300 |
| avg sampling err CV = | 0.165 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 17.9 |
| w/ sample error CV = | 12.0 |
| most recent 7 years : | |
| Growth Rate = | **1.122** |
| low 90%ci GR = | 1.084 |
| high 90%ci GR = | 1.160 |
| %chg (last : avg.prev.yrs) = | 61% |

Figure 25. Population trend for Red-throated Loons (*Gavia stellata*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

**Jaeger spp** Yukon-Kuskokwim Delta coastal survey




Aerial survey index with 18 strata: Total birds observed

| year | sg | 2*pr | flocks | Index | Std Err |
|---|---|---|---|---|---|
| 1985 | | | | | |
| 1986 | | | | | |
| 1987 | | | | | |
| 1988 | | | | | |
| 1989 | 1708 | 160 | 0 | **1869** | 271 |
| 1990 | | | | | |
| 1991 | | | | | |
| 1992 | | | | | |
| 1993 | 1857 | 664 | 159 | **2679** | 455 |
| 1994 | 2055 | 316 | 426 | **2797** | 530 |
| 1995 | 2498 | 690 | 289 | **3477** | 536 |
| 1996 | 1438 | 440 | 0 | **1878** | 342 |
| 1997 | 1231 | 428 | 0 | **1660** | 388 |
| 1998 | 1539 | 342 | 87 | **1968** | 348 |
| 1999 | 1812 | 338 | 269 | **2419** | 430 |
| 2000 | 2169 | 120 | 0 | **2289** | 324 |
| 2001 | 1505 | 454 | 97 | **2055** | 341 |
| 2002 | 1443 | 354 | 42 | **1838** | 325 |
| 2003 | 1732 | 718 | 246 | **2696** | 547 |
| 2004 | 2198 | 162 | 108 | **2468** | 378 |
| 2005 | 1434 | 584 | 0 | **2018** | 428 |
| 2006 | 1726 | 146 | 0 | **1872** | 289 |

JAEG

| | |
|---|---|
| n yrs = | 15 |
| mean = | **2266** |
| std dev = | 491 |
| slope = | -0.0070 |
| SE slope = | 0.0115 |
| Growth Rate = | **0.993** |
| low 90%ci GR = | 0.974 |
| high 90%ci GR = | 1.012 |
| regression resid CV = | 0.209 |
| avg sampling err CV = | 0.176 |
| min yrs to detect -50%/20yr rate : | |
| w/ regression resid CV = | 14.0 |
| w/ sample error CV = | 12.5 |
| most recent 7 years : | |
| Growth Rate = | **0.988** |
| low 90%ci GR = | 0.941 |
| high 90%ci GR = | 1.036 |
| %chg (last : avg.prev.yrs) = | -18% |

Figure 26. Population trend for Parasitic Jaegers (*Stercorarius parasiticus*) and Long-tailed Jaegers (*Stercorarius longicaudus*) observed by the right-rear-seat observer on aerial transects sampling 12,832 km$^2$ of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends for each species can be compared using an estimate of the minimum number of years of data needed to detect a significant an annual rate of change of -0.034, a 50% decline in 20 years.

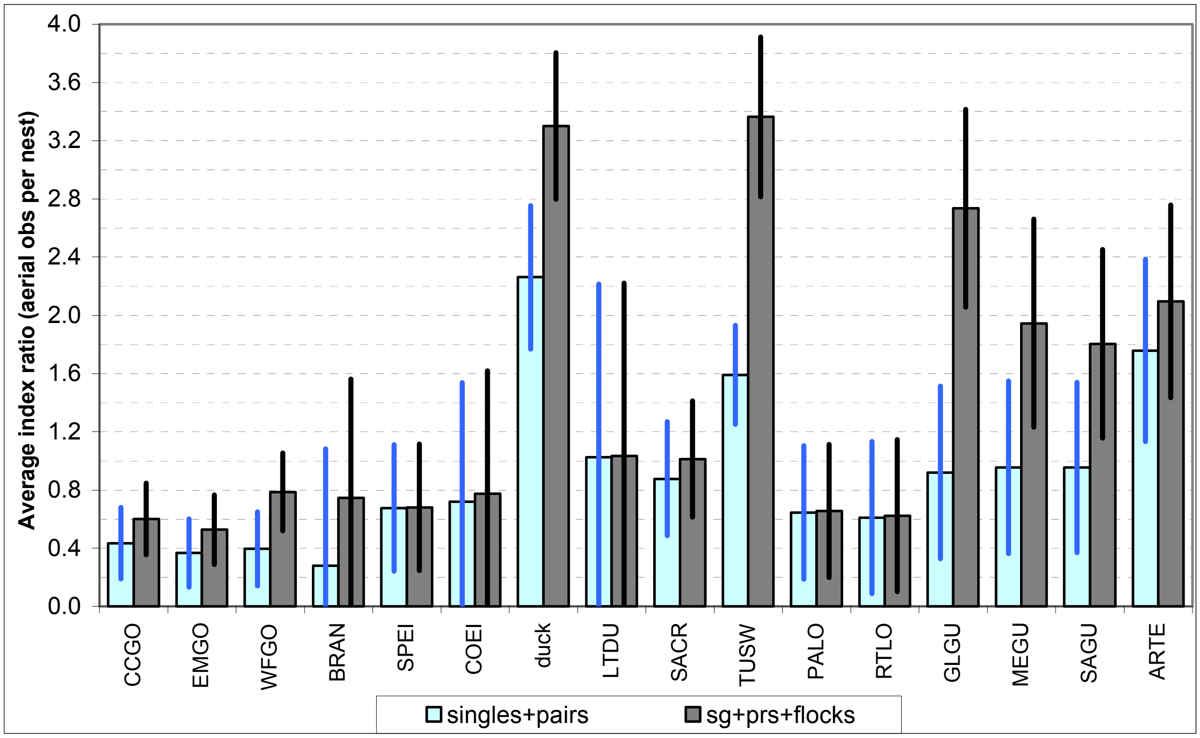



Figure 27. Using all available years of data 1985-2006, columns indicate average and 90% confidence intervals for the index ratios of aerial index population per nest population after correction for nest detection rate. The light blue shaded columns indicate the index ratio of observations to nests excluding flocked birds; the gray columns indicate the ratio including birds in flocks.

Table 1. Number of birds sighted by category and expanded numbers for waterbirds counted by the right-rear-seat observer on the June 2006 Yukon Delta Coastal Zone aerial survey, Alaska. Species sorted in order of decreasing abundance for ducks, then for other species. Survey area = 12,831.5 $km^2$ and sampled area = 479.1 $km^2$. Number of transects (n) = 221. Density was calculated using 18 strata and therefore is not simply the indicated total divided by the sampled area.

| Species | No. of single birds sighted | No. of pairs sighted | No. of grouped birds sighted[a] | Indicated total birds[b] | Sample density Birds/$km^2$ | Population index (No. of birds) | Standard error | Visibility correction factor | Population estimate (No. of birds) |
|---|---|---|---|---|---|---|---|---|---|
| Northern pintail | 1,096 | 298 | 1,331 | 4,119 | 4.582 | 58,797 | 4,245 | 3.05 | **179,331** |
| Greater scaup | 220 | 579 | 76 | 1,454[c] | 3.196 | 41,015 | 2,946 | 1.93 | **79,159** |
| Northern shoveler | 119 | 30 | 88 | 386 | 1.069 | 13,713 | 1,951 | 3.79 | **51,972** |
| American green-winged teal | 33 | 11 | 0 | 88 | 0.247 | 3,168 | 608 | 8.36 | **26,484** |
| Mallard | 97 | 21 | 11 | 247 | 0.469 | 6,020 | 988 | 4.01 | **24,140** |
| Red-breasted merganser | 12 | 18 | 283 | 343 | 1.343 | 17,227 | 12,937 | 1.27 | **21,878** |
| Spectacled eider | 197 | 94 | 0 | 582 | 0.386 | 4,949 | 501 | 3.58 | **17,717** |
| Long-tailed duck | 108 | 79 | 0 | 374 | 0.627 | 8,044 | 917 | 1.87 | **15,042** |
| American wigeon | 37 | 6 | 91 | 177 | 0.242 | 3,104 | 746 | 3.84 | **11,919** |
| Black scoter | 34 | 126 | 27 | 347 | 0.762 | 9,774 | 1,281 | 1.17 | **11,436** |
| Common eider | 75 | 16 | 30 | 212 | 0.145 | 1,861 | 481 | 3.58 | **6,662** |
| Canvasback | 2 | 1 | 0 | 6 | 0.019 | 238 | 134 | 2.43 | **578** |
| Glaucous gull | 421 | 210 | 1,651 | 2,492 | 2.986 | **38,321** | 7,207 | unknown | n/a |
| Arctic tern | 607 | 160 | 268 | 1,195 | 1.751 | **22,471** | 3,248 | unknown | n/a |
| Sabine's gull | 665 | 204 | 778 | 1,851 | 1.625 | **20,852** | 1,902 | unknown | n/a |
| Pacific loon | 425 | 164 | 17 | 770 | 1.590 | **20,403** | 1,606 | unknown | n/a |
| Mew gull | 372 | 133 | 319 | 957 | 1.265 | **16,232** | 2,121 | unknown | n/a |
| Red-throated loon | 76 | 49 | 3 | 177 | 0.305 | **3,909** | 750 | unknown | n/a |
| Jaeger species | 68 | 4 | 0 | 76 | 0.146 | **1,872** | 289 | unknown | n/a |

[a] For ducks, groups are 5 or more birds, for other species, groups are 3 or more birds per sighting.
[b] For ducks, Indicated total birds = 2 * (singles + pairs) + birds in groups, for other species, observed totals = singles + (2 * pairs) + birds in groups.

[c]Greater scaup single drakes are not doubled, scaup number is observed total.

Table 2. Change in population estimates from previous year and from the long-term average, sorted in decreasing order of percent change from long-term average for waterfowl, then other species.

| Species | Population estimate 2005 | Population estimate 2006 | Change between 2005 and 2006 | Long term (1988-2005) average population estimate | Change between 2006 and long term average |
|---|---|---|---|---|---|
| Red-breasted merganser | 729 | 21,878 | 2901% | 1,128 | 1840% |
| Spectacled eider | 14,929 | 17,717 | 19% | 9,136 | 94% |
| Common eider | 6,730 | 6,662 | -1% | 4,364 | 53% |
| Mallard | 26,634 | 24,140 | -9% | 16,333 | 48% |
| Northern shoveler | 38,829 | 51,972 | 34% | 37,476 | 39% |
| Long-tailed duck | 12,119 | 15,042 | 24% | 11,962 | 26% |
| Northern pintail | 129,198 | 179,331 | 39% | 152,881 | 17% |
| Green-winged teal | 22,756 | 26,484 | 16% | 23,492 | 13% |
| Greater scaup | 83,075 | 79,159 | -5% | 71,234 | 11% |
| Black scoter | 15,766 | 11,436 | -27% | 12,045 | -5% |
| American wigeon | 8,544 | 11,919 | 40% | 19,607 | -39% |
| Canvasback | 491 | 578 | 18% | 3,067 | -81% |
| Red-throated loon | 3,462 | 3,909 | 11% | 2,428 | 61% |
| Mew gull | 13,262 | 16,232 | 18% | 12,018 | 35% |
| Sabine's gull | 25,061 | 20,852 | -20% | 15,772 | 32% |
| Pacific loon | 16,052 | 20,403 | 21% | 16,651 | 23% |
| Arctic tern | 21,121 | 22,471 | 6% | 18,403 | 22% |
| Glaucuos gull | 24,694 | 38,321 | 36% | 39,532 | -3% |
| Jaeger spp. | 2,018 | 1,872 | -8% | 2,294 | -18% |

Table 3. Summary of trends for waterbird species counted by the right-rear-seat observer on the Yukon-Kuskokwim Delta coastal zone aerial survey Alaska. Ducks have been counted since 1988. Other species have been added to the survey as indicated. Geographic stratification into 18 regions represents a balance determined by sampling intensity, similar physiographic areas, and reasonable gains in precision for most of the species. Green-shaded cells indicate growth rates significantly above 1.0 and yellow-shaded cells indicate significantly declining trends.

| Fig. # | Species | No. of years | Average pop. Index | Standard deviation pop. Index | Log slope | SE slope | Growth Rate | Low 90%CI GR | High 90%CI GR | CV regress. Resids. | CV sampling error | Yrs. to detect change w/ regress. Resid. CV | Yrs. to detect change w/ sample error CV | Growth rate last 7 yrs. | Low 90%CI GR last 7 yrs. | High 90%CI GR last 7 yrs. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 8 | Northern pintail | 19 | **50582** | 13681 | -0.0116 | 0.0112 | **0.9885** | 0.9704 | 1.0070 | 0.269 | 0.111 | 16.6 | 9.2 | **1.0404** | 0.9707 | 1.1150 |
| 9 | Greater scaup | 19 | **37125** | 6091 | 0.0212 | 0.0056 | **1.0214** | 1.0120 | 1.0309 | 0.134 | 0.102 | 10.4 | 8.7 | **1.0186** | 0.9964 | 1.0413 |
| 10 | Northern Shoveler | 19 | **10089** | 3150 | 0.0124 | 0.0126 | **1.0125** | 0.9918 | 1.0336 | 0.300 | 0.177 | 17.9 | 12.6 | **1.0824** | 1.0059 | 1.1648 |
| 11 | Green-winged teal | 19 | **2829** | 969 | 0.0077 | 0.0162 | **1.0077** | 0.9812 | 1.0349 | 0.387 | 0.222 | 21.2 | 14.6 | **1.0305** | 0.9295 | 1.1425 |
| 12 | Mallard | 19 | **4175** | 1585 | -0.0118 | 0.0152 | **0.9882** | 0.9639 | 1.0132 | 0.362 | 0.223 | 20.2 | 14.7 | **1.1754** | 1.0839 | 1.2747 |
| 13 | Red-breasted merganser | 19 | **1748** | 3939 | 0.1577 | 0.0423 | **1.1708** | 1.0921 | 1.2551 | 1.011 | 0.490 | 40.1 | 24.8 | **1.3886** | 0.8795 | 2.1924 |
| 14 | Spectacled eider | 19 | **2678** | 1057 | 0.0647 | 0.0096 | **1.0669** | 1.0502 | 1.0838 | 0.228 | 0.138 | 14.9 | 10.7 | **1.0544** | 0.9950 | 1.1180 |
| 15 | Long-tailed duck | 19 | **6483** | 1540 | 0.0204 | 0.0101 | **1.0206** | 1.0038 | 1.0376 | 0.241 | 0.143 | 15.4 | 10.9 | **1.0387** | 0.9898 | 1.0899 |
| 16 | American wigeon | 19 | **5001** | 2313 | -0.0630 | 0.0168 | **0.9390** | 0.9134 | 0.9652 | 0.401 | 0.378 | 21.7 | 20.8 | **0.9765** | 0.8493 | 1.1228 |
| 17 | Black scoter | 19 | **10267** | 2616 | 0.0197 | 0.0141 | **1.0199** | 0.9966 | 1.0438 | 0.336 | 0.192 | 19.3 | 13.3 | **1.0189** | 0.9394 | 1.1050 |
| 18 | Common eider | 19 | **1253** | 574 | 0.0495 | 0.0173 | **1.0508** | 1.0214 | 1.0810 | 0.412 | 0.246 | 22.1 | 15.7 | **1.0104** | 0.8730 | 1.1700 |
| 19 | Canvasback | 19 | **1208** | 1074 | -0.0594 | 0.0415 | **0.9424** | 0.8802 | 1.0090 | 0.993 | 0.531 | 39.7 | 26.1 | **0.8080** | 0.5564 | 1.1734 |
| 20 | Glaucous gull | 15 | **39451** | 12617 | -0.0062 | 0.0183 | **0.9938** | 0.9643 | 1.0243 | 0.307 | 0.180 | 18.1 | 12.7 | **0.9495** | 0.8902 | 1.0128 |
| 21 | Arctic tern | 15 | **18675** | 4899 | 0.0457 | 0.0117 | **1.0468** | 1.0268 | 1.0671 | 0.196 | 0.139 | 13.5 | 10.7 | **1.0202** | 0.9744 | 1.0682 |
| 22 | Sabine's gull | 15 | **16110** | 5967 | 0.0629 | 0.0195 | **1.0650** | 1.0314 | 1.0996 | 0.326 | 0.119 | 18.9 | 9.7 | **1.0446** | 1.0043 | 1.0865 |
| 23 | Pacific loon | 18 | **16860** | 3279 | 0.0193 | 0.0082 | **1.0195** | 1.0059 | 1.0333 | 0.180 | 0.090 | 12.7 | 8.0 | **0.9822** | 0.9442 | 1.0217 |
| 24 | Mew gull | 15 | **12299** | 3005 | 0.0396 | 0.0127 | **1.0404** | 1.0189 | 1.0623 | 0.212 | 0.157 | 14.2 | 11.6 | **1.0575** | 1.0276 | 1.0883 |
| 25 | Red-throated loon | 18 | **2510** | 716 | 0.0231 | 0.0136 | **1.0234** | 1.0008 | 1.0466 | 0.2998 | 0.1648 | 17.86 | 11.99 | **1.122** | 1.0845 | 1.1601 |
| 26 | Jaeger spp. | 15 | **2266** | 491 | -0.0070 | 0.0115 | **0.9931** | 0.9745 | 1.0120 | 0.209 | 0.176 | 14.0 | 12.5 | **0.9878** | 0.9414 | 1.0364 |

Table 4. Average and standard error of the index ratio between aerial observation index populations and the corrected nest population based on each year of available data from 1985 to 2006 on a 716-km2 area sampled on the central coast of the Yukon-Kuskokwim Delta.

| Species | Aerial index measure | N years | Average index ratio: singles +pairs per nest | Avg SE Index ratio | Average index ratio: singles +pairs+flocks per nest | Avg SE Index ratio |
|---|---|---|---|---|---|---|
| CCGO | indicated | 22 | 0.435 | 0.064 | 0.601 | 0.089 |
| EMGO | indicated | 22 | 0.367 | 0.051 | 0.528 | 0.075 |
| WFGO | indicated | 22 | 0.396 | 0.064 | 0.787 | 0.131 |
| BRAN | indicated | 21 | 0.279 | 0.131 | 0.747 | 0.368 |
| SPEI | indicated | 19 | 0.675 | 0.166 | 0.681 | 0.168 |
| COEI | indicated | 19 | 0.719 | 0.365 | 0.776 | 0.410 |
| duck | indicated | 19 | 2.262 | 0.725 | 3.300 | 1.083 |
| LTDU | indicated | 17 | 1.027 | 0.785 | 1.034 | 0.790 |
| SACR | indicated | 20 | 0.878 | 0.231 | 1.014 | 0.271 |
| TUSW | observed | 22 | 1.591 | 0.330 | 3.364 | 1.150 |
| PALO | observed | 18 | 0.646 | 0.183 | 0.656 | 0.186 |
| RTLO | observed | 18 | 0.610 | 0.194 | 0.622 | 0.198 |
| GLGU | observed | 15 | 0.921 | 0.320 | 2.736 | 1.120 |
| MEGU | observed | 15 | 0.956 | 0.321 | 1.945 | 0.841 |
| SAGU | observed | 15 | 0.956 | 0.320 | 1.805 | 0.683 |
| ARTE | observed | 15 | 1.759 | 0.716 | 2.096 | 0.887 |