Abundance and Trend of Waterbirds on Alaska's Yukon-Kuskokwim Delta Coast based on 1988 to 2014 Aerial Surveys

Robert M. Platte and Robert A. Stehn,
Waterfowl Management Branch
Division of Migratory Bird Management
U.S. Fish and Wildlife Service
1011 East Tudor Road, Anchorage, Alaska 99503

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Abstract: We summarize 1988 to 2014 (no survey in 2011) aerial survey waterbird sightings that index the abundance and trend of populations in the Yukon-Kuskokwim delta coastal zone. The threatened spectacled eider (*Somateria fischeri*) population index for 2014 was 5,879 birds. Traditionally, a visibility correction factor of 3.58 has been applied for spectacled eiders yielding a population estimate of 21,047 which was 70% above its 1988-2013 long-term average (LTA) size. However, we calculated a new estimate of visibility rate for spectacled eiders in 2010 using the ratio of the aerial index of indicated breeding birds to the estimated population of nests (Fischer et al. 2010). The ratio was 0.425 nests per aerial indicated pair or, expressed as the inverse, 2.351 birds per aerial index. Using this correction, the population estimate for spectacled eiders was 13,822 breeding birds.

In 2014, the three most numerous waterfowl species were northern pintail (*Anas acuta*) with a visibility-corrected estimate of 103,642 birds, greater scaup (*Aythya marila*) with 54,750 birds, and spectacled eider. The estimated population sizes for species of special interest were 7,239 common eiders (*Somateria mollissima*), 8,099 long-tailed ducks (*Clangula hyamelis*), 11,602 black scoters (*Melanitta nigra*), and 2,644 red-throated loons (*Gavia stellata*). The estimated number of common eiders was above the LTA. Numbers of most other duck species were substantially below their LTAs.

Of the non-waterfowl species in 2014, glaucous gulls (*Larus hyperboreus*) were most numerous with an estimated 72,570 birds (90% above LTA), followed by 56,050 Sabine's gulls (*Xema sabini*) (+168%) and 23,147 Arctic terns (*Sterna paradisaea*) (+14%). The index for Sabines' gulls was the highest in the history of the survey. Pacific loons (*Gavia pacifica*) were estimated at 13,720 birds (-17%).

Long term trends based on log-linear regression showed significant population increases ($p<0.10$) for spectacled eider, common eider, greater scaup, red-breasted merganser (*Mergus serrator*), mew gull, Sabine's gull, and arctic tern. Populations declined for American wigeon (*Anas americana*), northern shoveler (*Anas clypeata*), and canvasback (*Aythya valisineria*).

Previous analysis showed a strong correlation between the thaw-degree-day index of spring warming temperatures and average cackling goose (*Branta hutchinsii minima*) clutch initiation date. We used this relationship to predict an appropriate start date for the 2014 survey consistent with average survey timing of the last several years. Due to weather, we were unable to begin the survey till 2 June, 17 days after predicted average nest initiation of 16 May. Later examination of nesting data showed the average cackling goose initiation date was 18 May (MBM unpub data). Therefore, the 2014 survey started 15 days after average nest initiation which is about 6 days late relative to survey timing in recent years. All survey transects were flown in 2014.

We continued to compile individual geographic locations for sightings of 21 major species of waterbirds based on the aircraft global positioning system and now have over 150,000 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 of birds on the Yukon-Kuskokwim delta (YKD) coastal zone in western Alaska provide indices to population abundance, trend, and distribution for many species of breeding waterbirds. This information is 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. The survey was initiated in 1985 to monitor populations of Cackling and White-fronted geese that had shown substantial declines in fall counts. The initial YKD surveys were flown with a pilot/observer in the left front seat and an 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). The high density of geese on the YKD makes it too difficult for front seat observers to also observe and record other species of waterbirds. Therefore, in 1988, an additional observer in the right back seat began to monitor populations of other waterbird 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 for monitoring the threatened population of spectacled eider and other species of concern including common eider, black scoter, long-tailed duck, and red-throated loon. The objective in this report is to present details on the survey methods, and summarize the population estimates and trends for all species recorded from 1988 to 2014 by the back seat observer. No survey data were collected in 2011 due to a shortage of personnel.

METHODS

Survey Design

We modified the survey area and transect design slightly in 2012 to omit areas surrounding villages from the survey excluding a total of 212.7 square kilometers. The survey area originally encompassed 12,832 km^2 of tundra wetlands from Norton Sound to Kuskokwim Bay, extending about 50 km inland from the west coast. The area was divided into 18 strata with generally homogeneous physiographic features visible on an unclassified LANDSAT image mosaic at 1:250,000 scale (Fig. 1). We used custom True BASIC programs and ArcGIS® (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. Strata with higher densities of geese and generally higher variances were allocated transects at 1.61 km spacing. Intervals were expanded to 3.22, 6.44, or 12.88 km spacing for strata with fewer geese. Flight distance in 2014 totaled about 2,350 km on 235 transects with a 200 m wide observed area of 470 km^2. The survey design has changed slightly over the years in the number and placement of transects. In 1998 we started a 4-year rotating panel of transects spaced at 1.6, 3.2, 6.4, or 12.8 km within the various strata. Intermediate transects were flown each year from 1998 to 2001, allowing 50% coverage of the habitat at the 1.6 km intervals by combining samples from four years. We began a second rotation of the same set of transects by replicating the same lines flown in 1998 again in 2002. In 2014, we flew the first year of the fifth replicate set of rotations by flying the same transects as in 2002, 2006, and 2010.

Data Collection

Survey methods followed the standard protocol for waterfowl breeding ground surveys in North America (USFWS and Canadian Wildlife Service 1987). For all surveys prior to 2012, a Cessna 206 amphibious aircraft was used. In 2012, a Quest Kodiak amphibious aircraft was used. In 2013 we used a Cessna 206 float plane. In 2014 we resumed using a Cessna 206 amphibious aircraft. The aircraft was flown at 145-170 km per hour, 30-46 m 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, 1992-2014) to maintain the correct 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). Geographic point locations were interpolated based on the proportion of elapsed time between the start and end coordinates for each transect. Since 1998, the observer used a computerized data collection program called Survey Recording Program written by John Hodges (retired USFWS, Migratory Bird Management, Juneau, Alaska). This system consisted of a notebook computer connected to the aircraft's GPS receiver and a remote microphone/mouse. The observer voice recorded each transect number, transect start and end points, and bird sighted within the 200 m wide strip to the right side of the aircraft to the computer using the remote microphone/mouse (.WAV file format). The observer identified birds to species or species group and recorded group size as a single, pair, or number of birds in flocks. The mouse click for each sighting caused the latitude/longitude coordinates (WGS84 datum) from the GPS to be written to a computer file (.POS). We then used a computer transcription program to replay the .WAV format sound files, enter header information (year, month, day, observer initials, and transect number.), species and group size, and combine these with the geographic coordinates in the .POS position file to produce a final data file.

Leslie Slater was the observer in 1988 and Karen Bollinger observed in 1989 and 1990. Bob Platte has collected the data every year since 1991, except 2011 when he collected geese, swan, and crane sightings from the right front seat and there was no rear seat observer. We now have twenty-six years of counts on duck species. Observations on other waterbird species were added with jaegers recorded in 1989, and 1993 to 2014, loons counted beginning in 1989, and gulls and terns added in 1992.

Due to a variety of circumstances data discrepancies have occurred, but none have greatly altered the observations or data analysis on over 100 transects (not subdivided by strata) flown each year. In 1997, the back seat observer was unable to collect data on 13 transects north of the Askinuk Mountains, therefore, we duplicated the data from the 1996 survey for those transects. Twenty-three transects were not flown in 1999 causing population indices to be calculated with fewer transects in some strata. Because the survey is generally flown without covering every adjacent transect in sequence (some transects were skipped early in the survey and flown later to geographically spread the survey observation effort over time), the completed transects still sampled each stratum at systematic intervals and provided adequate data for analysis. 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, transect numbers 81 and 83 were inadvertently flown twice on different days and transects 82 and 84 were skipped. We included both replicates in the data analysis. In 2007, data were lost for transect 2, most of 15, and some of 16 due to computer malfunction. In 2008, a 10.4 km section of transect 74 in the eastern coastal upland stratum had no data recorded due to a computer malfunction. In 2012, 4 transects (82, 96, 97, and 98) were truncated on the west ends from 0.3 – 1.6 miles due to fog along the coast. In 2013 several transects were not flown due to limited hours on the aircraft and logistics (transects 55, 59, 63, 72, 87, 100, 102-105, 107, and 109). The observer also lost data for Transect 56 and a small portion of the east end of Transect 67 due to computer problems. All transects were flown in 2014, however, a small amount of data was lost on Transect 29 due to computer malfunction.

The survey has been flown 1988 to 2014 (except no duck survey in 2011) within a maximum range of dates from 29 May to 24 June. The average annual dates ranged from 2 June to 16 June. The goal for timing the survey was to coincide with laying and early incubation of nesting geese because geese are the primary focus of the survey. Prior to 1993, the average survey date was 10 June or later, and surveys were of slightly longer duration, however in those years the timing of nesting was later as well. We considered that consistent survey timing relative to nesting would reduce variation in visibility rate linked to normal shifts in nesting behaviors such as constancy of nest attendance, departure of males in some species, and the flocking and departure of failed breeders. In 2010, we set an objective for beginning the survey each year at about 9 days after average clutch initiation for cackling geese, corresponding to survey timing in 2007-2009.

We examined ways to predict average clutch initiation date for cackling geese because nesting data from the present year are not available until after the aerial survey is completed. A nesting survey has been conducted each spring on a portion of the central coastal zone since 1982 (Fischer et al. 2014). Clutch initiation date has been determined each year by backdating from the stage of incubation indicated by egg floatation angle, adding a laying period equal to clutch size minus one, and averaging all nests found on plots searched by ground crews. The 1993-2011, 19-year average cackling goose clutch initiation date was 24 May (SD=+-4.1 days). This date would correspond to a start for the aerial survey on 2 June, nine days later.

However, the weather conditions in the current year also affect nesting phenology. We downloaded from the Weather Underground web site (http://www.wunderground.com/) all years of available Meteorological Terminal Air Report (METAR) temperature data for Bethel, Cape Romanzof, Emmonak, Hooper Bay, Mekoryuk, and St Marys. We found a good correlation between clutch initiation date and day-of-year (DOY = Julian date) when warming temperatures measured by thaw-degree-days (TDD) reached 25. Thaw-degree-days are the daily accumulation of degrees of daily mean temperature above 32F. The average anomaly, defined as the departure in days from the 1993-2013 average date at TDD >25, was calculated for 6 weather stations (Fig. 3) and showed a high correlation ($r = 0.78$) with clutch initiation date. In 2014, the 6-station average anomaly for TDD warming was about 2 days earlier than the average date over all years and predicted clutch initiation was DOY = 136, 16 May. The target survey start date was around 25 May. However, we began the survey on 2 June due to weather-related delays in flying the aircraft to Bethel.

In addition to temperature data, we obtained satellite imagery data after the survey to determine the approximate timing of snowmelt over the survey area as a general indicator of timing of nest site availability. We obtained sequential 8-day mosaics (mid-April to June) of snow extent from the Terra satellite's Moderate Resolution Imaging Spectroradiometer (MODIS) sensor with a 500m grid cell resolution (Hall et al. 2008).

Data Analysis

With unequal length transect units sampling each strata, we used a ratio estimator (Cochran 1977) to calculate the mean density of observations for each species. The stratum population index total (= density * stratum area) and variance were added across all 18 strata. Duck population indices were based on indicated total birds, 2 * (nsg + npr) + bflk, where nsg = number of single birds, npr = number of pairs, and bflk = number of birds in flocks. A flock was defined as a group of 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. For these species the aerial population index was the total birds sighted, nsg + 2*npr + bflk.

We plotted the species population index for each year as a column shaded to indicate single, indicated single, pair, and flock components. The standard error of the total population divided by the total was the coefficient of variation (CV). The average of all annual CVs provided a measure of survey precision. For nearly all species, the data analysis with 18 strata had a smaller CV compared to analysis using the minimum of only four sampling intensity strata.

Log-linear least squares regression determined the average slope of annual population indices across years. By exponentiation, we converted the log-linear slope to the rate of annual change or the population growth rate. Annual % change is the (growth rate-1)*100. The estimated standard error of growth rate is the residual mean square error in the log scale multiplied by the growth rate (Taylor series approximation, see Bart et al. 1998).

The residuals around the log-linear regression line provided another estimate related to the precision of the survey. The CV of the residuals after regression included components of both the regression model lack-of-fit error and the sampling error, and it was usually larger than the estimated sampling error CV based only on variation among transects within strata. We calculated a standardized measure of power to detect trend for each species using the approximate formula of Gerrodette (1987) that links sample size, slope, CV, and probabilities for Type 1 and Type 2 errors. The number of years needed to detect a slope significantly different from zero was calculated for each species. Under standard conditions (alpha set at 0.10, beta at 0.20, population change with a slope of 0.0341 equating to 50% change in 20 years), the expected number of data years necessary to show a significant slope provided a useful way to compare species. Each species had estimates using both observed sampling error CV and regression residual error CV. We also calculated the growth rates for each species using only the last 10 years of data.

RESULTS

Spring phenology and survey conditions

The Yukon Delta coast was warmer than normal with an extremely early breakup during the spring of 2014. Thawing degree days at Bethel were 244% of normal on 27 May, 2014. The April 1 snow pack analysis by the Natural Resources Conservation Service indicated a snowpack less than 50% of normal in the Kuskokwim Basin and the lower Yukon River. Most of the low elevation snow in southwest Alaska melted off in April due to warmer than normal temperatures. April ice thickness data indicated below normal ice thickness in western Alaska. The Kuskokwim River at Bethel broke up on 2 May, 10 days earlier than the 33-year average of 12 May (National Weather Service Pacific River Forecast Center, Anchorage, Alaska). Yukon River breakup at Alakanuk/Emmonak in 2014 was on 10 May, 13 days earlier than the 29-year average of 23 May.

The predicted average Cackling goose clutch initiation date of 16 May based on thaw-degree-days was 2 days earlier than 18 May, the date based on the 2014 nest plot data. Thus the aerial survey start should have been around 27 May to be consistent with previous years survey timing. This indicated that the 2 June aerial survey start date was about 6 days late relative to previous years timing and could have had substantial effects on population indices.

The 2014 survey transects (Fig. 2) were flown on a total of 6 survey days from 2 June to 8 June (no survey on 7 June due to pilot flight rules). Weather conditions recorded during the 2014 survey at the village of Chevak, centered in the survey area, are given in Figure 4.

Satellite imagery indicated 2014 snowmelt began around the third week of April on the coastal zone and was completed by about the first week of May (Fig. 5). The date when the coastal zone became snow-free has varied by as much as 5 weeks (Fig. 6) based on 15 years of MODIS satellite data. The 2014 snowmelt was the earliest in the 15 years between 2000-2014.

Relative abundance and distribution

Number of birds sighted, the area observed, and the sampling effort in each strata provided the data to calculate total aerial population indices for each species. Indices for 2014, and where available, the visibility-corrected population estimates are tabulated (Table 1). The aerial population indices, with no correction for visibility bias, showed the relative contribution by group size category for all survey years (Figs. 7 to 25). Caution in interpretation is necessary for species with relatively low numbers of sightings such as canvasbacks and red-breasted mergansers because sampling error alone may cause the apparently large fluctuations in estimated population size.

The spectacled eider population index for 2014 was 5,879 indicated total birds. To convert the aerial indices 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). The spectacled eider population estimate of 21,047 birds was less than the 2013 estimate but up 70% from the LTA (Table 2). This estimate was calculated using a visibility correction factor of 3.58 which may be too large. If a new ratio of 2.35 is used, derived as twice the number of nests per indicated birds aerial index in the plot-sampled area of 716 km^2, the estimate would be 13,822 spectacled eiders. Pintails

(103,642 birds), scaup (54,750), and spectacled eiders were the most numerous waterfowl species in 2014.

The estimates for common eiders was also higher than the long-term average (Table 2). All other duck species estimates were below their LTAs. Population indices for American wigeon and green-winged teal were the lowest in the history of the survey. Sabine’s gulls, glaucous gulls, mew gulls, arctic terns, and red-throated loons were above their LTAs whereas Pacific loons and jaegers were below their LTAs.

The geographic locations of over 150,000 sightings of 21 species of waterbirds have been collected in 26 years of surveys. Average location accuracy of the observations when the surveys were flown using LORAN for navigation was estimated as 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 are incorporated into a GIS database for potential use in research or management.

Population trends

American wigeon, northern shoveler, and canvasback showed decreasing trends (Figs. 12, 16, and 21 and Table 3) over all years of the survey. Increasing trends over all years occurred for spectacled eider, common eider, greater scaup, red-breasted merganser, mew gull, Sabine’s gull, and arctic tern. Trends were significantly increasing over the last 10 years for spectacled eider, glaucous gull, mew gull, and Sabine’s gull. Mallard, green-winged teal, northern shoveler, canvasback, scaup, and long-tailed duck showed significant declines over the past 10 years. The rest of the species showed relatively stable trends over the history of the survey and during the last 10 years.

For spectacled eiders, the population growth rate from 1988 to 2014 for the aerial indicated total bird index was 1.065 (Fig. 7) The 2005-2014 growth rate of 1.040 was less than 2 times higher than the nest population growth rate of 1.026 from the ground studies 2005-2014 (MBM unpub data). However the overlap in the 90% confidence intervals for these estimated growth rates indicated no real difference.

DISCUSSION

Three different observers have collected data for this survey, although the same observer has collected 23 years of data. All observers were experienced at identifying and counting birds from aircraft, however especially for the less common species, a "learning curve" effect is likely 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 account for the relatively lower counts in the first years of this survey, however, because a single observer completed 22 years of surveys, 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 multi-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 back-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-back seat observer was 68%. 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.

Timing of snowmelt and warming temperatures can affect the breeding chronology of waterfowl (Batt et al. 1992) and this variation, in combination with differences in survey timing, may influence observed population indices. Different stages of nesting may correlate with changes in the flocking behavior, single:pair ratio, and tendency to hide or flush from the aircraft. To get the best population trend information, surveys should be timed consistently relative to nesting chronology. The intended survey timing was within the first half of incubation for nesting geese. Better prediction of nesting chronology by using the correlation with warming temperatures will help standardize timing, although 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 eider, the more visible male eiders depart from the breeding grounds returning to marine foraging habitat shortly after hens begin incubation. Depending on survey timing, a variable portion of the males may have already departed and thus are not available for observation. Late survey timing is expected to lower the population index for eiders. An example of possible timing effect occurred when both spring chronology and nesting were very early in 2004 yet the survey was flown close to average timing, possibly causing the eider index to be lower. Conversely, in 2006, the survey was flown earlier relative to average hatch date and this may have caused a larger population index for eiders that year. Earlier reports analyze and discuss these influences (Platte et al. 1999, Stehn et al. 2006). It is possible the late timing of the 2014 survey relative to nesting chronology resulted in the lower population index for spectacled eiders.

In this report, we include additional data on survey timing and nesting chronology, however further analysis remains necessary to best account for the confounding between timing, nesting, index ratios, and other changes in detection rate that may contribute to bias in trend from aerial population indices. When completed, this work will be reported separately. Similarly, further details and exploration of relationships among various measures of spring warming and timing of nest initiation, snowmelt, and river breakup will be presented in a separate report.

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 to expand the nest population to the entire YKD coast. The combined data provide unique and detailed information at two scales of geographic extent and intensity of coverage. Both are better than either one alone for monitoring the spectacled eider and other populations.

The aerial survey also provides information on many other species of interest, although caution in generalization is needed 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 had low sampling fractions and these species occur even further inland where we did not sample at all. For better information on seaduck species, we could expand coverage and add transects in inland areas. Because we base the survey aircraft from Bethel, much of this area must be crossed 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 would cause only a minimal decrease in precision for geese and eiders.

The geographic point locations of birds collected over the 26 years of this survey have been used for a number of purposes. Interpolated density polygons have been developed for most species as one method to show species distribution. These can be used as baseline to detect future changes in distribution due to such factors as alteration of habitat, disturbance, or climate change. Distribution information was essential in evaluation of YKD coastal zone areas for delineation as critical habitat for spectacled eiders. Relative density distribution maps have been used to illustrate and evaluate patterns of land ownership and impacts of potential land exchanges. 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.

Although originally justified and designed just to monitor geese, this survey has expanded to a multi-species effort to collect accurate data on distribution, trend, and abundance for all large waterbird species. This broader ecological or community-based approach not only provides information on these other species but it also provides essential data for understanding the population dynamics of geese. For example, depredation on goose nests and broods has been related to Glaucous gull population size and distribution. The multi-species data collection approach proactively provided five years of population data on spectacled eider even before there was direct support or recognition of the need to monitor eiders. This survey provides continuing annual data for USFWS focal species and species of special concern including common eider, black brant, emperor geese, black scoter, long-tailed duck, and red-throated loon.

The extensive coverage with the aerial transect survey allows an objective procedure for expansion of the ground-based sampling by nest plots. Conversely, the data from the more intensive plot sampling contributes to understanding the aerial observation process.

We calculated index ratios between the aerial indices and the population of nests and evaluated confounding factors such as survey timing, observer experience, visibility rate, availability, nesting success, and nesting chronology. Although it was feasible to collect sufficient data on such factors for only certain species, these variables may influence all species and appropriate adjustments will improve the monitoring process.

A good example of linking aerial and ground sampling is the ongoing work on black brant that has used plot estimates of nesting density to validate that the aerial index accurately monitors nesting brant, indicates a shifting distribution of nesting birds, and shows stability in total number of brant nests (Stehn et al. 2011). Multi-species, multi-scale, designed sampling surveys also provide unique and important data essential to detect and quantify population level responses among species. For example, such data are needed to establish if Cackling geese are a buffer prey species key to increasing nest success for spectacled eider, common eider, and other ducks, or if numbers of cackling geese are beneficial to goslings in emperor geese and brant perhaps due to expansion of grazing-lawn habitat. Extensive, long-term, multi-species surveys provide the data to link population change to variation in species habitat, a key precursor for landscape-level conservation practices and management to preserve species abundance and diversity. The North American Waterfowl Breeding Pair and Habitat Survey also has some similar attributes and objectives, but it is designed for duck species and flyway-scale harvest management. As such, it does not need high statistical precision in both aerial and ground estimates, it does not directly estimate nests, and therefore cannot hope to resolve such issues as are mentioned above. To our knowledge, the YKD survey initiated in 1985 for geese, has grown to provide the longest duration, most precise, multi-species, multi-scale monitoring survey for nesting waterfowl and other waterbirds in North America.

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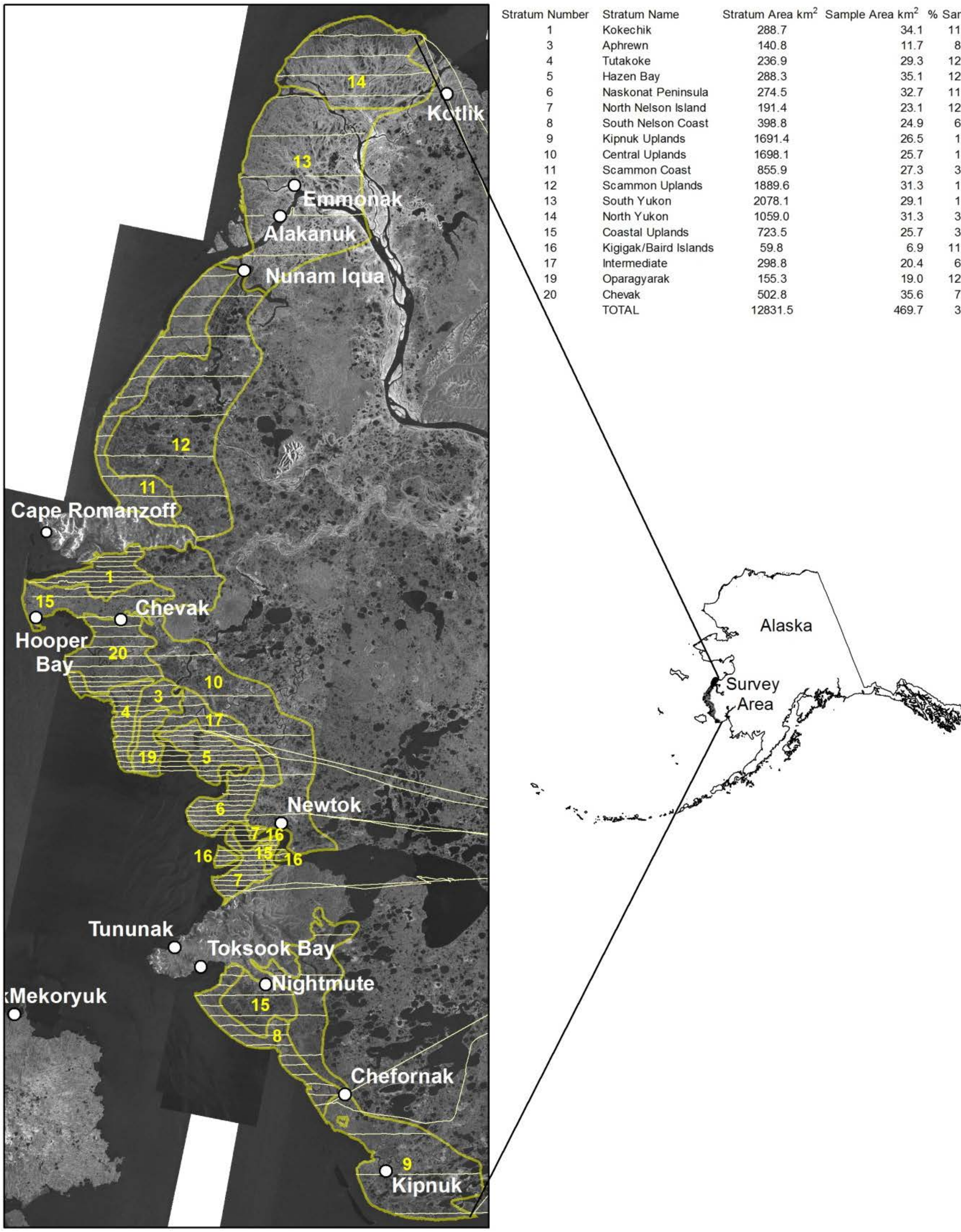
U.S. FISH AND WILDLIFE SERVICE AND CANADIAN WILDLIFE SERVICE. 1987. Standard operating procedures for aerial breeding ground population and habitat surveys in North America. Unpub. Manual. U.S. Fish and Wildl. Serv. & Canadian Wildl. Serv., Laurel, MD, 103pp.



Stratum Number	Stratum Name	Stratum Area km^2	Sample Area km^2	% Sample
1	Kokechik	288.7	34.1	11.8%
3	Aphrewn	140.8	11.7	8.3%
4	Tutakoke	236.9	29.3	12.4%
5	Hazen Bay	288.3	35.1	12.2%
6	Naskonat Peninsula	274.5	32.7	11.9%
7	North Nelson Island	191.4	23.1	12.1%
8	South Nelson Coast	398.8	24.9	6.2%
9	Kipnuk Uplands	1691.4	26.5	1.6%
10	Central Uplands	1698.1	25.7	1.5%
11	Scammon Coast	855.9	27.3	3.2%
12	Scammon Uplands	1889.6	31.3	1.7%
13	South Yukon	2078.1	29.1	1.4%
14	North Yukon	1059.0	31.3	3.0%
15	Coastal Uplands	723.5	25.7	3.6%
16	Kigigak/Baird Islands	59.8	6.9	11.6%
17	Intermediate	298.8	20.4	6.8%
19	Oparagyarak	155.3	19.0	12.2%
20	Chevak	502.8	35.6	7.1%
	TOTAL	12831.5	469.7	3.7%

Figure 1. Transects and strata for aerial waterbird survey, June 2-8, 2014, Yukon Delta coastal zone, Alaska. Transects were spaced at 1-mile intervals in strata 1, 4, 5, 6, 7, 16, and 19; 2-mile intervals in strata 3, 8, 17, and 20; 4-mile intervals in strata 11, 14, and 15; and 8-mile intervals in strata 9, 10, 12, and 13.

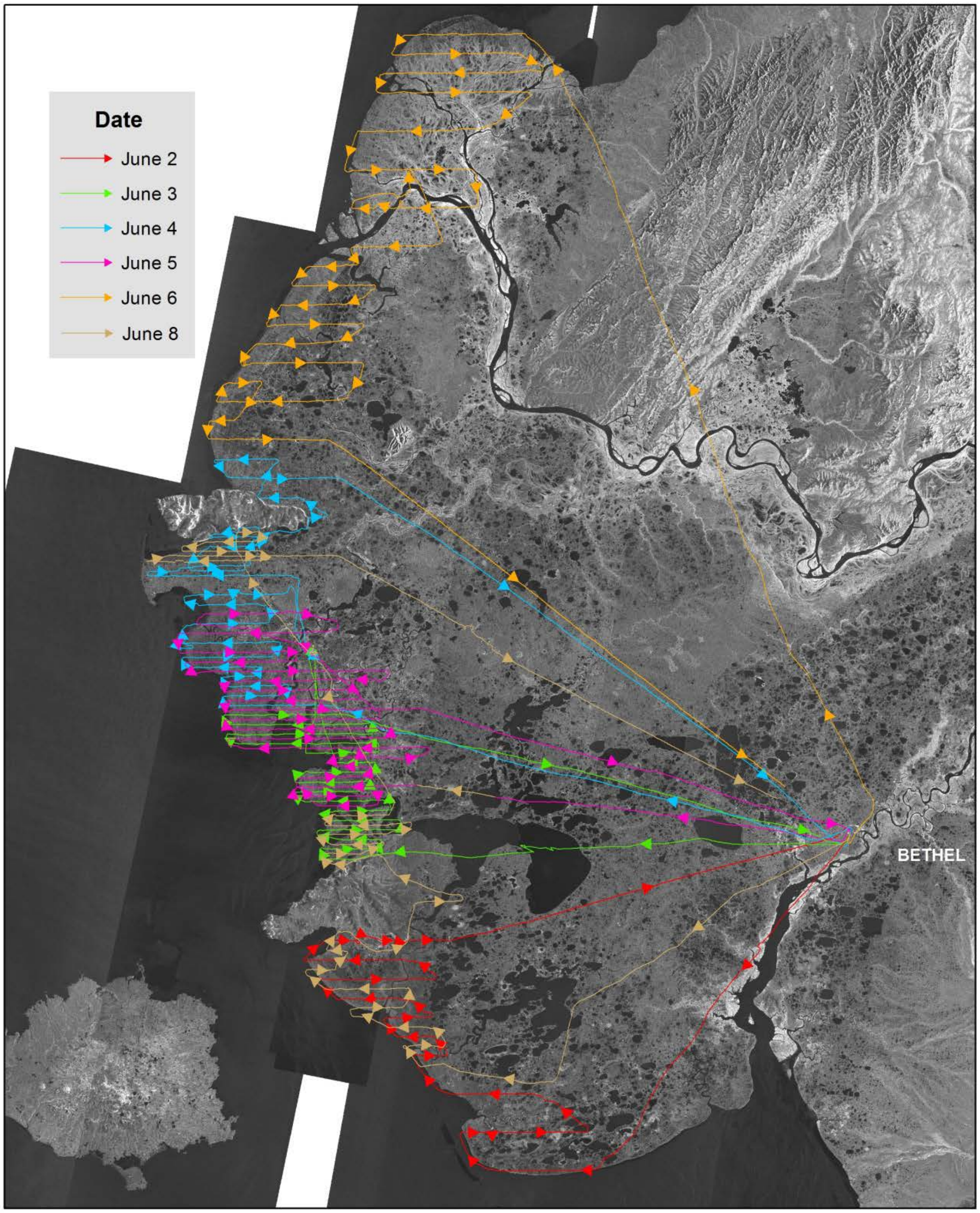


Figure 2. Transects color-coded by date flown in 2014 showing progression of survey by date. We skip every other transect in the 1-mile strata so as not to double-count flushing birds and to spread the sample temporally.

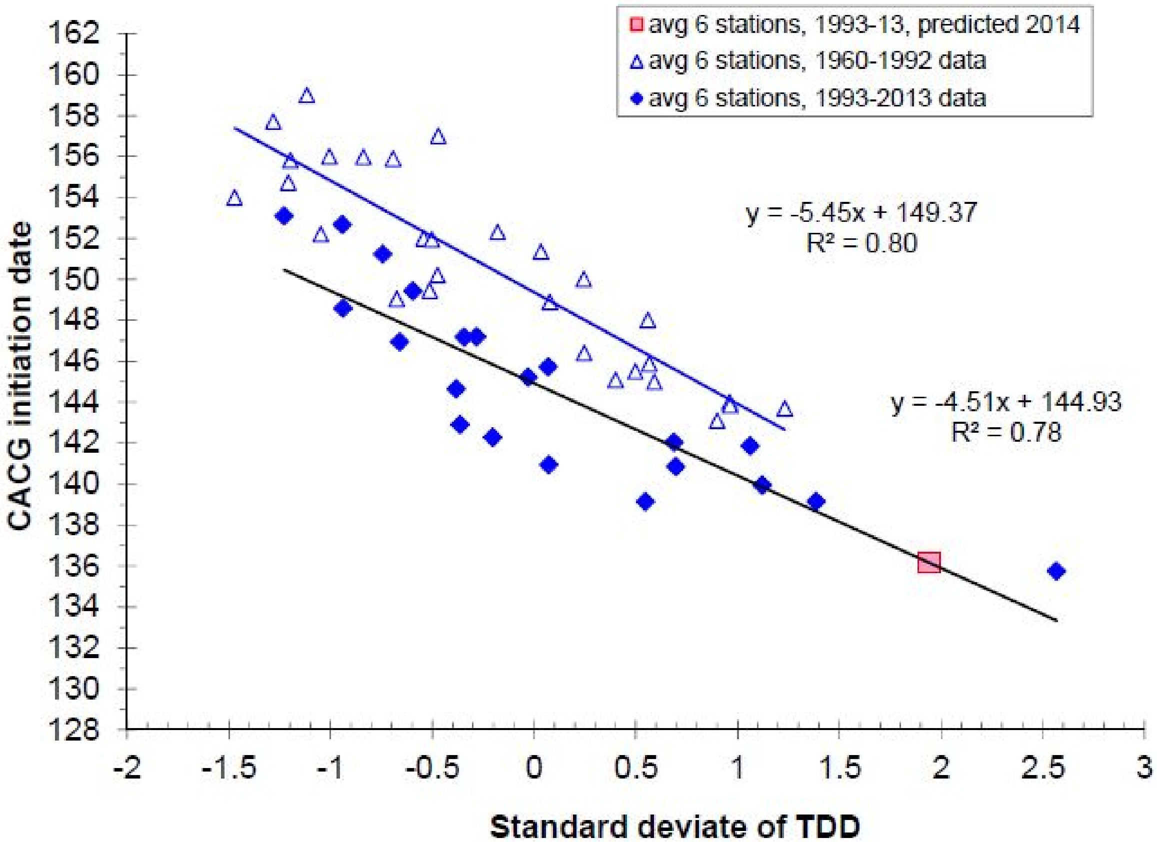


Figure 3. 2014 predicted cackling goose average clutch initiation date based on the linear regression relationship of the standard deviates from 6-station average date at thaw-degree-days>25 criterion. Analysis conducted on May 15, 2014 and predicted initiation on 16 May.

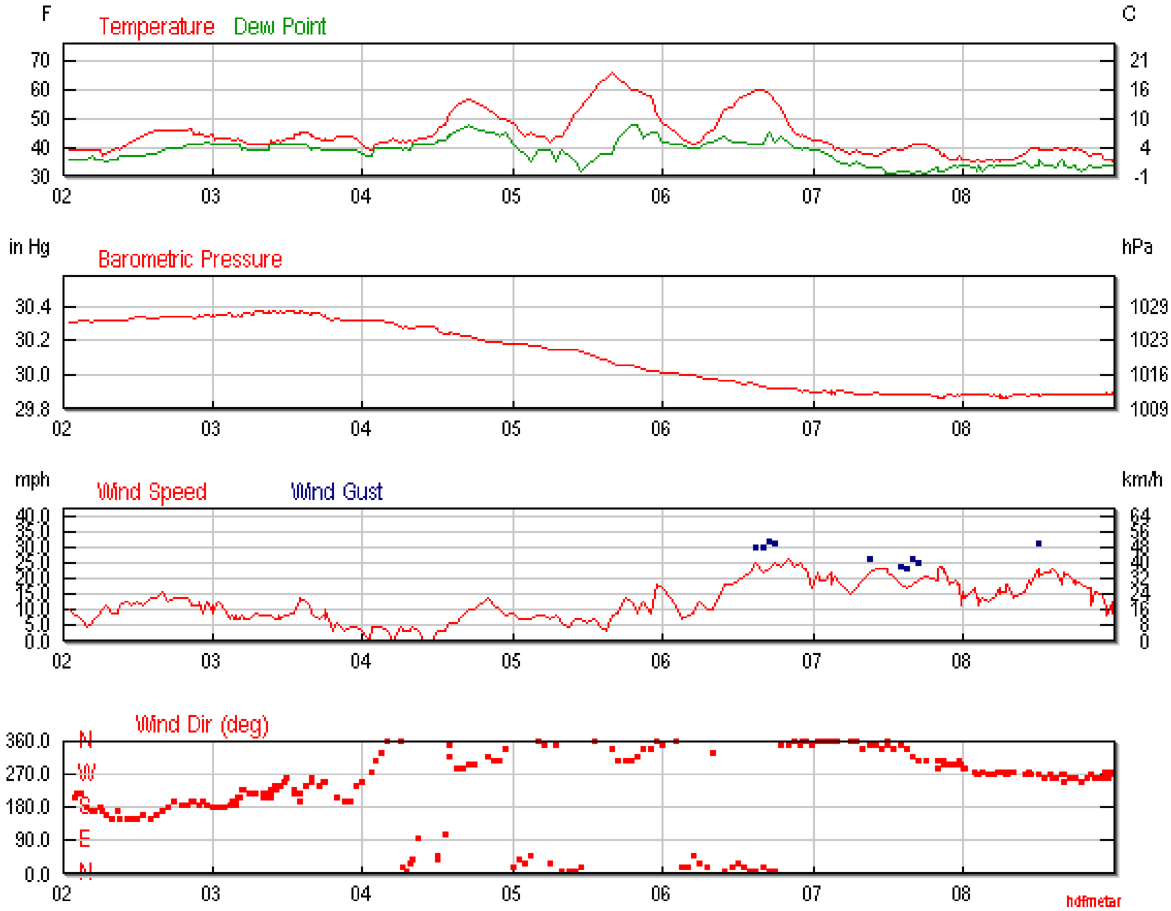


Figure 4. Weather data during the aerial survey, June 2-8, 2014 from Chevak in the central coastal zone (from http://www.wunderground.com/history/airport/PAVA/2014/6/2/CustomHistory.html).

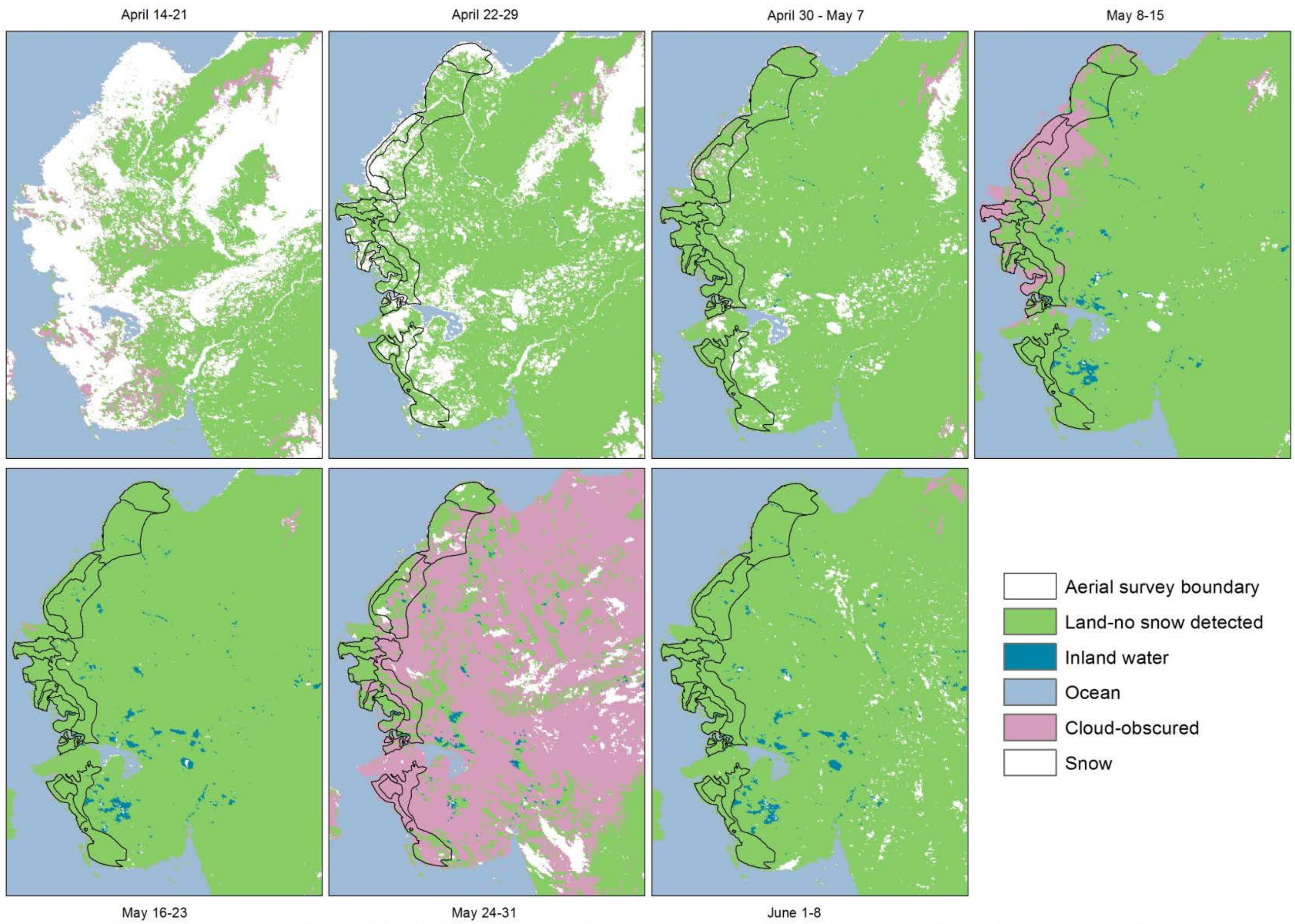


Figure 5. Snow melt chronology from Terra satellite MODIS 8-day composite maximum snow extent, 2014, Yukon Delta National Wildlife Refuge, Alaska. Data from Hall, D.K., G.A. Riggs, and V.V. Salomonson. 2014, updated daily. MODIS/Terra Snow Cover Daily L3 Global 500m Grid V005, April to June 2014. Boulder, CO, USA: National Snow and Ice Data Center. Digital media

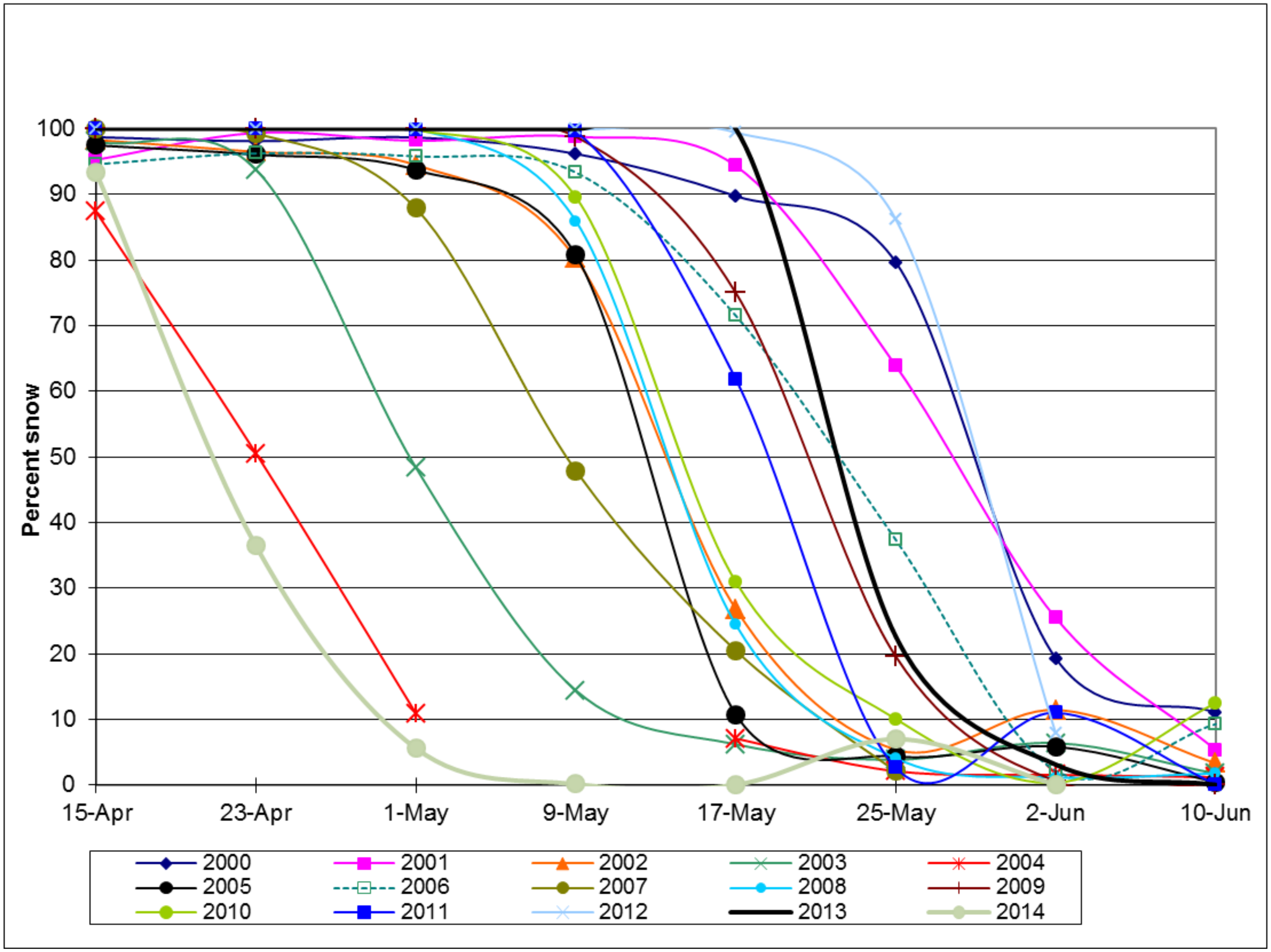
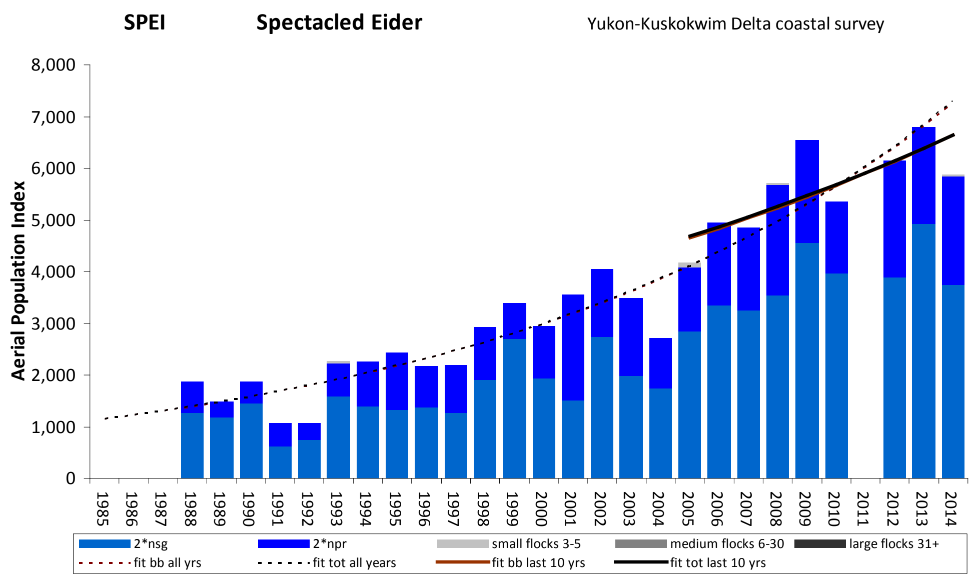


Figure 6. Percent snow cover for coastal zone survey area in spring from MODIS imagery (Hall et al. 2014) .

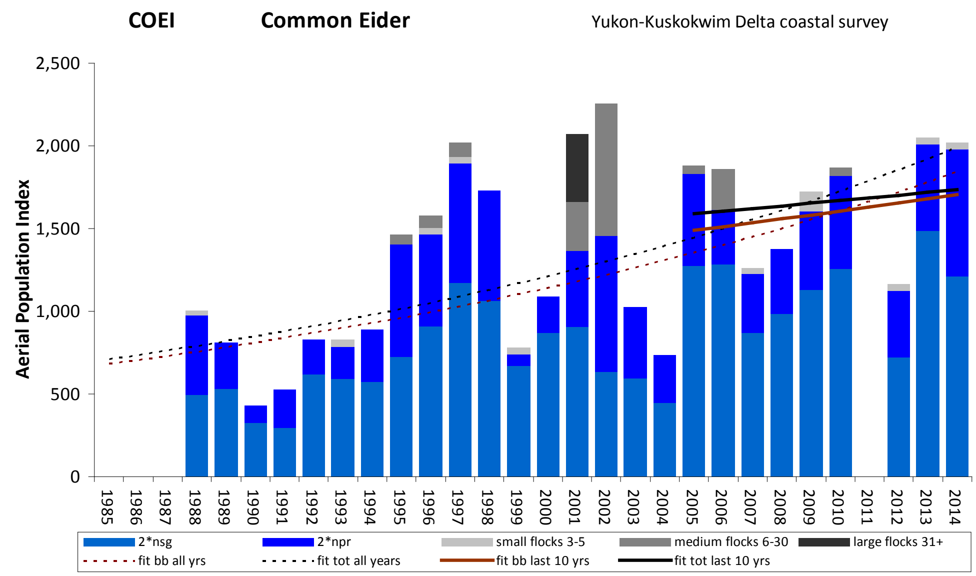


18 strata = 12,832 km² **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**1272**	**603**	**0**	**0**	**0**	**1874**	*349*	**1874**	*349*
1989	**1187**	**303**	**0**	**0**	**0**	**1490**	*222*	**1490**	*222*
1990	**1451**	**421**	**0**	**0**	**0**	**1872**	*284*	**1872**	*284*
1991	**629**	**446**	**0**	**0**	**0**	**1075**	*222*	**1075**	*222*
1992	**747**	**319**	**0**	**0**	**0**	**1066**	*180*	**1066**	*180*
1993	**1589**	**640**	**42**	**0**	**0**	**2229**	*347*	**2272**	*347*
1994	**1387**	**865**	**0**	**0**	**0**	**2252**	*331*	**2252**	*331*
1995	**1334**	**1092**	**0**	**0**	**0**	**2426**	*366*	**2426**	*366*
1996	**1373**	**803**	**0**	**0**	**0**	**2176**	*324*	**2176**	*324*
1997	**1262**	**930**	**0**	**0**	**0**	**2192**	*334*	**2192**	*334*
1998	**1907**	**1014**	**0**	**0**	**0**	**2921**	*326*	**2921**	*326*
1999	**2703**	**690**	**0**	**0**	**0**	**3393**	*493*	**3393**	*493*
2000	**1937**	**1008**	**0**	**0**	**0**	**2945**	*305*	**2945**	*305*
2001	**1500**	**2048**	**0**	**0**	**0**	**3549**	*413*	**3549**	*413*
2002	**2739**	**1310**	**0**	**0**	**0**	**4049**	*362*	**4049**	*362*
2003	**1985**	**1502**	**0**	**0**	**0**	**3487**	*399*	**3487**	*399*
2004	**1737**	**991**	**0**	**0**	**0**	**2728**	*340*	**2728**	*340*
2005	**2843**	**1244**	**83**	**0**	**0**	**4087**	*421*	**4170**	*429*
2006	**3340**	**1609**	**0**	**0**	**0**	**4949**	*501*	**4949**	*501*
2007	**3248**	**1601**	**0**	**0**	**0**	**4849**	*516*	**4849**	*516*
2008	**3534**	**2139**	**39**	**0**	**0**	**5673**	*546*	**5713**	*548*
2009	**4568**	**1969**	**0**	**0**	**0**	**6537**	*527*	**6537**	*527*
2010	**3976**	**1386**	**0**	**0**	**0**	**5362**	*527*	**5362**	*527*
2011									
2012	**3892**	**2246**	**0**	**0**	**0**	**6138**	*504*	**6138**	*504*
2013	**4936**	**1872**	**0**	**0**	**0**	**6808**	*576*	**6808**	*576*
2014	**3739**	**2098**	**41**	**0**	**0**	**5838**	*538*	**5879**	*541*

	SPEI bb	total
over all years :		
n yrs =	26	26
average index =	**3537**	**3545**
std dev =	1738	1742
std err mean =	341	342
lo 90% ci mean=	2977	2983
hi 90% ci mean=	4098	4107
loglinear slope =	0.063	0.063
SE ln slope =	0.005	0.005
Growth Rate =	**1.065**	**1.065**
lo 90% ci GR =	1.056	1.056
hi 90% ci GR =	1.075	1.075
regr resid CV =	0.204	0.204
sampl err CV =	0.126	0.126
nyrs to detect -.034 =	10.0	10.0
last 10 years:		
n yrs =	9	9
average index =	**5582**	**5601**
std dev =	867	852
std err mean =	289	284
lo 90% ci mean=	5107	5133
hi 90% ci mean=	6058	6068
loglinear slope =	0.040	0.039
SE ln slope =	0.012	0.012
Growth Rate =	**1.040**	**1.040**
lo 90% ci GR =	1.020	1.020
hi 90% ci GR =	1.061	1.060
regr resid CV =	0.108	0.105
sampl err CV =	0.094	0.094
nyrs to detect -.034 =	8.2	8.2

Figure 7. Population trend for Spectacled Eiders (*Somateria fischeri*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

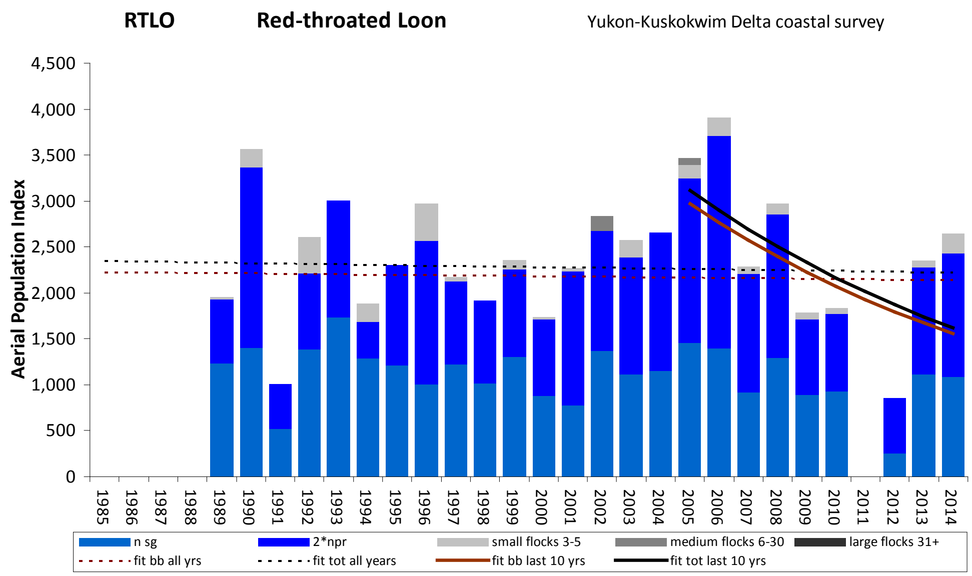


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**497**	**476**	**33**	**0**	**0**	**972**	*272*	**1005**	*275*
1989	**530**	**280**	**0**	**0**	**0**	**810**	*267*	**810**	*267*
1990	**325**	**103**	**0**	**0**	**0**	**428**	*122*	**428**	*122*
1991	**293**	**232**	**0**	**0**	**0**	**525**	*143*	**525**	*143*
1992	**619**	**209**	**0**	**0**	**0**	**829**	*180*	**829**	*180*
1993	**588**	**198**	**42**	**0**	**0**	**787**	*173*	**829**	*184*
1994	**577**	**311**	**0**	**0**	**0**	**888**	*190*	**888**	*190*
1995	**725**	**680**	**0**	**58**	**0**	**1404**	*271*	**1463**	*291*
1996	**910**	**555**	**41**	**74**	**0**	**1465**	*264*	**1580**	*272*
1997	**1172**	**721**	**42**	**85**	**0**	**1893**	*437*	**2019**	*447*
1998	**1065**	**663**	**0**	**0**	**0**	**1728**	*278*	**1728**	*278*
1999	**670**	**69**	**43**	**0**	**0**	**739**	*195*	**783**	*207*
2000	**869**	**222**	**0**	**0**	**0**	**1091**	*213*	**1091**	*213*
2001	**905**	**459**	**0**	**297**	**410**	**1364**	*262*	**2070**	*751*
2002	**637**	**818**	**0**	**801**	**0**	**1455**	*322*	**2255**	*893*
2003	**594**	**432**	**0**	**0**	**0**	**1026**	*205*	**1026**	*205*
2004	**447**	**289**	**0**	**0**	**0**	**736**	*174*	**736**	*174*
2005	**1275**	**554**	**0**	**51**	**0**	**1829**	*346*	**1880**	*369*
2006	**1287**	**327**	**0**	**248**	**0**	**1613**	*420*	**1861**	*481*
2007	**869**	**354**	**39**	**0**	**0**	**1222**	*231*	**1261**	*227*
2008	**985**	**389**	**0**	**0**	**0**	**1374**	*248*	**1374**	*248*
2009	**1131**	**474**	**122**	**0**	**0**	**1606**	*265*	**1728**	*275*
2010	**1255**	**564**	**0**	**50**	**0**	**1819**	*458*	**1869**	*464*
2011									
2012	**719**	**406**	**41**	**0**	**0**	**1125**	*206*	**1166**	*211*
2013	**1485**	**524**	**43**	**0**	**0**	**2008**	*336*	**2051**	*340*
2014	**1212**	**767**	**42**	**0**	**0**	**1979**	*496*	**2022**	*499*

	COEI bb	total
over all years :		
n yrs =	26	26
average index =	**1258**	**1357**
std dev =	465	548
std err mean =	91	107
lo 90% ci mean=	1108	1180
hi 90% ci mean=	1408	1534
loglinear slope =	0.034	0.035
SE ln slope =	0.008	0.009
Growth Rate =	**1.035**	**1.036**
lo 90% ci GR =	1.021	1.020
hi 90% ci GR =	1.049	1.052
regr resid CV =	0.327	0.372
sampl err CV =	0.220	0.232
nyrs to detect -.034 =	14.5	15.1
last 10 years:		
n yrs =	9	9
average index =	**1619**	**1690**
std dev =	321	335
std err mean =	107	112
lo 90% ci mean=	1443	1507
hi 90% ci mean=	1796	1874
loglinear slope =	0.015	0.010
SE ln slope =	0.024	0.025
Growth Rate =	**1.015**	**1.010**
lo 90% ci GR =	0.975	0.969
hi 90% ci GR =	1.057	1.053
regr resid CV =	0.218	0.226
sampl err CV =	0.204	0.202
nyrs to detect -.034 =	13.8	13.7

Figure 8. Population trend for Common Eiders (*Somateria mollissima*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at *p*=0.10, beta set at *p*=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

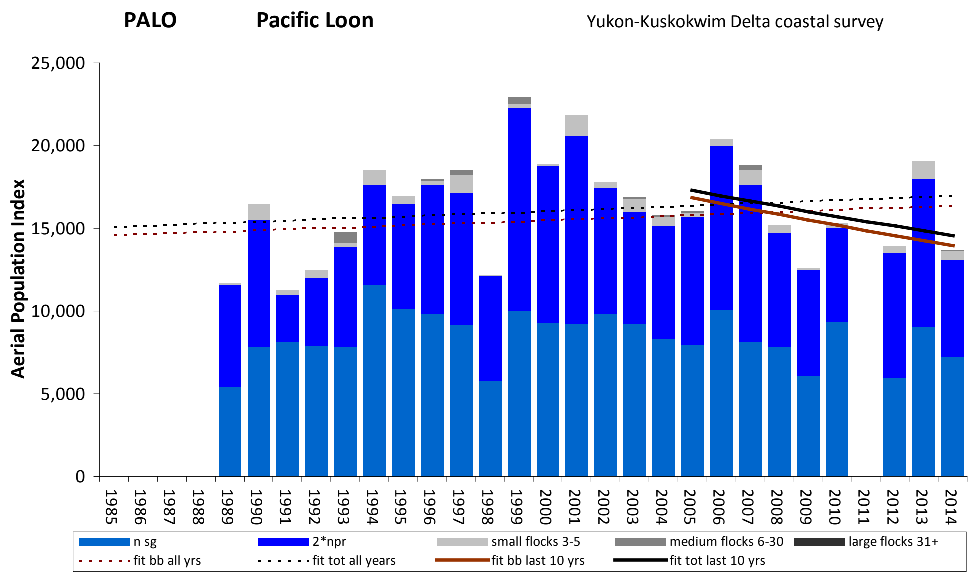


18 strata = 12,832 km² — **Aerial Index with singles =1**

0	n sg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988									
1989	**1231**	**693**	**26**	**0**	**0**	**1923**	*414*	**1949**	*415*
1990	**1400**	**1967**	**194**	**0**	**0**	**3367**	*548*	**3560**	*582*
1991	**522**	**486**	**0**	**0**	**0**	**1008**	*207*	**1008**	*207*
1992	**1385**	**825**	**398**	**0**	**0**	**2210**	*332*	**2608**	*469*
1993	**1737**	**1266**	**0**	**0**	**0**	**3002**	*452*	**3002**	*452*
1994	**1288**	**394**	**202**	**0**	**0**	**1682**	*234*	**1884**	*312*
1995	**1212**	**1092**	**0**	**0**	**0**	**2304**	*402*	**2304**	*402*
1996	**1008**	**1560**	**404**	**0**	**0**	**2568**	*544*	**2972**	*597*
1997	**1227**	**893**	**51**	**0**	**0**	**2121**	*361*	**2171**	*363*
1998	**1014**	**904**	**0**	**0**	**0**	**1919**	*262*	**1919**	*262*
1999	**1307**	**953**	**100**	**0**	**0**	**2260**	*345*	**2360**	*358*
2000	**879**	**828**	**32**	**0**	**0**	**1707**	*253*	**1739**	*254*
2001	**775**	**1456**	**34**	**0**	**0**	**2231**	*359*	**2265**	*362*
2002	**1369**	**1302**	**0**	**163**	**0**	**2671**	*347*	**2834**	*381*
2003	**1117**	**1264**	**194**	**0**	**0**	**2381**	*342*	**2575**	*352*
2004	**1150**	**1509**	**0**	**0**	**0**	**2659**	*415*	**2659**	*415*
2005	**1461**	**1785**	**151**	**65**	**0**	**3246**	*448*	**3462**	*459*
2006	**1399**	**2311**	**200**	**0**	**0**	**3709**	*710*	**3909**	*750*
2007	**921**	**1280**	**81**	**0**	**0**	**2201**	*329*	**2282**	*328*
2008	**1295**	**1555**	**122**	**0**	**0**	**2850**	*395*	**2971**	*399*
2009	**888**	**818**	**79**	**0**	**0**	**1706**	*252*	**1785**	*247*
2010	**931**	**842**	**67**	**0**	**0**	**1773**	*253*	**1839**	*260*
2011									
2012	**250**	**609**	**0**	**0**	**0**	**860**	*211*	**860**	*211*
2013	**1113**	**1162**	**76**	**0**	**0**	**2276**	*522*	**2352**	*523*
2014	**1088**	**1343**	**213**	**0**	**0**	**2431**	*421*	**2644**	*428*

	RTLO bb	total
over all years :		
n yrs =	25	25
average index =	**2283**	**2397**
std dev =	665	719
std err mean =	133	144
lo 90% ci mean=	2064	2160
hi 90% ci mean=	2501	2633
loglinear slope =	-0.001	-0.002
SE ln slope =	0.009	0.010
Growth Rate =	**0.999**	**0.998**
lo 90% ci GR =	0.984	0.983
hi 90% ci GR =	1.014	1.014
regr resid CV =	0.340	0.355
sampl err CV =	0.167	0.166
nyrs to detect -.034 =	12.1	12.1
last 10 years:		
n yrs =	9	9
average index =	**2339**	**2456**
std dev =	859	925
std err mean =	286	308
lo 90% ci mean=	1868	1949
hi 90% ci mean=	2810	2963
loglinear slope =	-0.072	-0.073
SE ln slope =	0.044	0.046
Growth Rate =	**0.931**	**0.930**
lo 90% ci GR =	0.866	0.862
hi 90% ci GR =	1.000	1.003
regr resid CV =	0.393	0.413
sampl err CV =	0.173	0.168
nyrs to detect -.034 =	12.4	12.1

Figure 9. Population trend for Red-throated Loon (*Gavia stellata*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

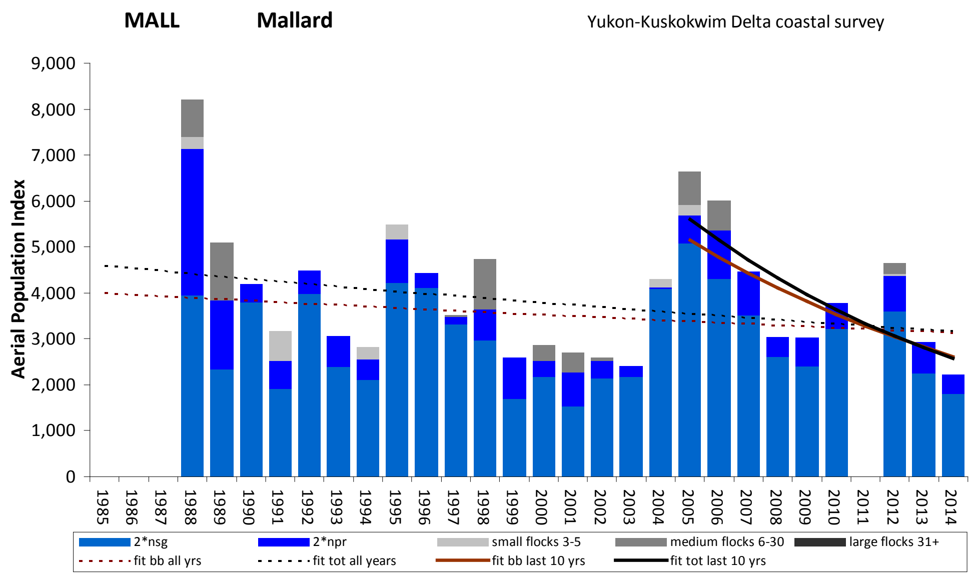


18 strata = 12,832 km² — **Aerial Index with singles =1**

0	n sg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988									
1989	**5408**	**6215**	**90**	**0**	**0**	**11623**	*1313*	**11712**	*1317*
1990	**7861**	**7628**	**943**	**0**	**0**	**15489**	*1593*	**16432**	*1710*
1991	**8096**	**2928**	**257**	**0**	**0**	**11024**	*887*	**11281**	*969*
1992	**7925**	**4069**	**500**	**0**	**0**	**11994**	*918*	**12495**	*979*
1993	**7849**	**6037**	**222**	**652**	**0**	**13886**	*1027*	**14759**	*1298*
1994	**11527**	**6104**	**855**	**0**	**0**	**17630**	*1467*	**18485**	*1517*
1995	**10088**	**6402**	**440**	**0**	**0**	**16489**	*1380*	**16929**	*1389*
1996	**9808**	**7820**	**220**	**98**	**0**	**17628**	*1419*	**17945**	*1427*
1997	**9148**	**7986**	**1088**	**301**	**0**	**17134**	*1592*	**18523**	*1871*
1998	**5728**	**6403**	**82**	**0**	**0**	**12130**	*984*	**12212**	*1004*
1999	**10004**	**12304**	**219**	**443**	**0**	**22308**	*1711*	**22970**	*1770*
2000	**9295**	**9445**	**151**	**0**	**0**	**18741**	*1656*	**18891**	*1673*
2001	**9248**	**11366**	**1229**	**0**	**0**	**20614**	*2346*	**21842**	*2346*
2002	**9826**	**7628**	**337**	**0**	**0**	**17455**	*1533*	**17792**	*1553*
2003	**9224**	**6779**	**751**	**133**	**0**	**16003**	*1181*	**16886**	*1331*
2004	**8313**	**6837**	**568**	**88**	**0**	**15150**	*1202*	**15807**	*1373*
2005	**7938**	**7774**	**192**	**148**	**0**	**15712**	*2008*	**16052**	*2029*
2006	**10045**	**9908**	**451**	**0**	**0**	**19953**	*1485*	**20403**	*1606*
2007	**8148**	**9429**	**957**	**292**	**0**	**17576**	*1504*	**18825**	*1731*
2008	**7832**	**6877**	**471**	**0**	**0**	**14710**	*1283*	**15181**	*1299*
2009	**6107**	**6371**	**142**	**0**	**0**	**12478**	*936*	**12620**	*939*
2010	**9364**	**5642**	**280**	**0**	**0**	**15006**	*1271*	**15286**	*1317*
2011									
2012	**5954**	**7600**	**392**	**0**	**0**	**13554**	*1336*	**13946**	*1311*
2013	**9026**	**8980**	**1037**	**0**	**0**	**18006**	*1514*	**19043**	*1609*
2014	**7269**	**5823**	**577**	**51**	**0**	**13092**	*1211*	**13720**	*1268*

PALO	bb	total
over all years :		
n yrs =	25	25
average index =	**15815**	**16401**
std dev =	2950	3135
std err mean =	590	627
lo 90% ci mean=	14845	15370
hi 90% ci mean=	16786	17433
loglinear slope =	0.004	0.004
SE ln slope =	0.005	0.005
Growth Rate =	**1.004**	**1.004**
lo 90% ci GR =	0.996	0.995
hi 90% ci GR =	1.013	1.013
regr resid CV =	0.190	0.196
sampl err CV =	0.088	0.089
nyrs to detect -.034 =	7.9	8.0
last 10 years:		
n yrs =	9	9
average index =	**15565**	**16120**
std dev =	2500	2705
std err mean =	833	902
lo 90% ci mean=	14194	14636
hi 90% ci mean=	16936	17603
loglinear slope =	-0.021	-0.019
SE ln slope =	0.017	0.018
Growth Rate =	**0.979**	**0.981**
lo 90% ci GR =	0.952	0.952
hi 90% ci GR =	1.007	1.011
regr resid CV =	0.153	0.165
sampl err CV =	0.090	0.090
nyrs to detect -.034 =	8.0	8.0

Figure 10. Population trend for Pacific Loon (*Gavia pacifica*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

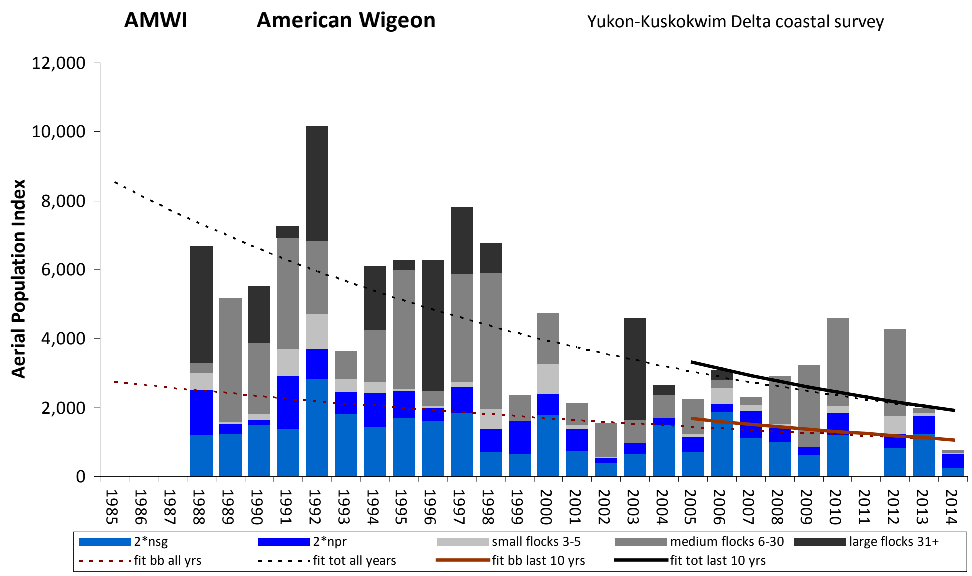


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**3936**	**3200**	**266**	**800**	**0**	**7136**	*784*	**8202**	*1205*
1989	**2334**	**1498**	**0**	**1258**	**0**	**3832**	*995*	**5090**	*1593*
1990	**3790**	**401**	**0**	**0**	**0**	**4191**	*1091*	**4191**	*1091*
1991	**1907**	**615**	**649**	**0**	**0**	**2522**	*492*	**3171**	*574*
1992	**3976**	**501**	**0**	**0**	**0**	**4477**	*867*	**4477**	*867*
1993	**2403**	**658**	**0**	**0**	**0**	**3061**	*698*	**3061**	*698*
1994	**2111**	**453**	**262**	**0**	**0**	**2565**	*637*	**2827**	*767*
1995	**4214**	**946**	**337**	**0**	**0**	**5160**	*1030*	**5496**	*1117*
1996	**4098**	**334**	**0**	**0**	**0**	**4432**	*1070*	**4432**	*1070*
1997	**3313**	**153**	**0**	**50**	**0**	**3467**	*718*	**3517**	*719*
1998	**2965**	**671**	**0**	**1096**	**0**	**3635**	*831*	**4731**	*1113*
1999	**1697**	**904**	**0**	**0**	**0**	**2602**	*573*	**2602**	*573*
2000	**2179**	**335**	**0**	**356**	**0**	**2513**	*556*	**2870**	*628*
2001	**1538**	**723**	**0**	**441**	**0**	**2261**	*489*	**2702**	*547*
2002	**2136**	**384**	**0**	**74**	**0**	**2520**	*439*	**2593**	*444*
2003	**2179**	**233**	**0**	**0**	**0**	**2412**	*697*	**2412**	*697*
2004	**4083**	**32**	**181**	**0**	**0**	**4115**	*1151*	**4296**	*1337*
2005	**5085**	**598**	**232**	**727**	**0**	**5683**	*994*	**6642**	*1182*
2006	**4304**	**1069**	**0**	**647**	**0**	**5373**	*722*	**6020**	*988*
2007	**3518**	**951**	**0**	**0**	**0**	**4470**	*642*	**4470**	*642*
2008	**2607**	**441**	**0**	**0**	**0**	**3047**	*562*	**3047**	*562*
2009	**2386**	**641**	**0**	**0**	**0**	**3028**	*740*	**3028**	*740*
2010	**3231**	**545**	**0**	**0**	**0**	**3776**	*688*	**3776**	*688*
2011									
2012	**3592**	**780**	**41**	**231**	**0**	**4372**	*1073*	**4644**	*1073*
2013	**2257**	**674**	**0**	**0**	**0**	**2931**	*697*	**2931**	*697*
2014	**1803**	**404**	**0**	**0**	**0**	**2207**	*425*	**2207**	*425*

	MALL bb	total
over all years :		
n yrs =	26	26
average index =	**3684**	**3978**
std dev =	1231	1452
std err mean =	241	285
lo 90% ci mean=	3287	3510
hi 90% ci mean=	4081	4447
loglinear slope =	-0.008	-0.013
SE ln slope =	0.008	0.008
Growth Rate =	**0.992**	**0.987**
lo 90% ci GR =	0.979	0.974
hi 90% ci GR =	1.005	1.001
regr resid CV =	0.317	0.329
sampl err CV =	0.212	0.217
nyrs to detect -.034 =	14.2	14.4
last 10 years:		
n yrs =	9	9
average index =	**3876**	**4085**
std dev =	1183	1495
std err mean =	394	498
lo 90% ci mean=	3228	3265
hi 90% ci mean=	4525	4905
loglinear slope =	-0.075	-0.086
SE ln slope =	0.024	0.028
Growth Rate =	**0.927**	**0.917**
lo 90% ci GR =	0.891	0.875
hi 90% ci GR =	0.965	0.961
regr resid CV =	0.218	0.254
sampl err CV =	0.193	0.195
nyrs to detect -.034 =	13.3	13.4

Figure 11. Population trend for Mallard (*Anas platyrhynchos*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

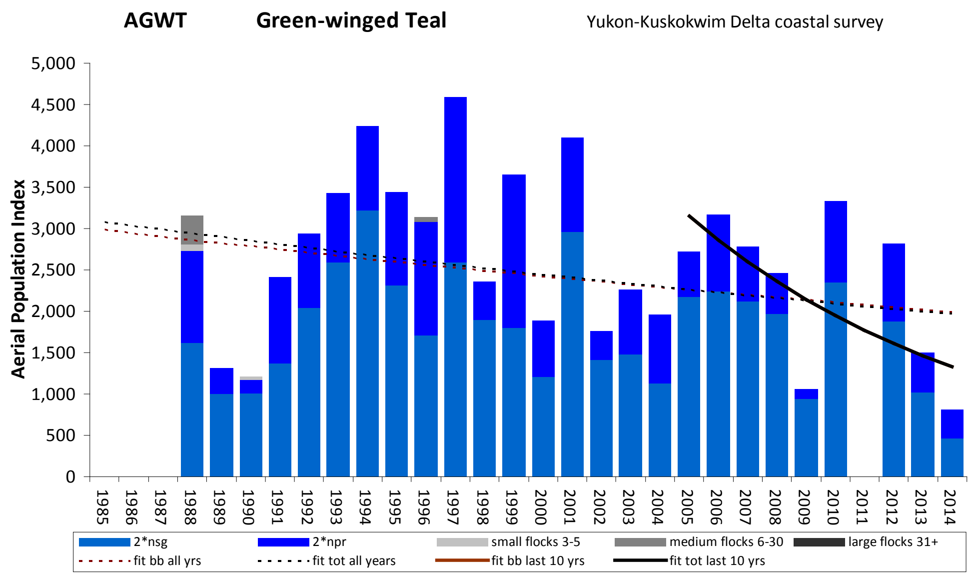


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	1201	1311	480	297	3419	2512	*501*	6709	*3445*
1989	1229	318	41	3605	0	1546	*529*	5192	*3102*
1990	1493	141	171	2075	1644	1634	*354*	5524	*2261*
1991	1403	1493	794	3211	369	2897	*532*	7270	*2235*
1992	2841	864	1032	2111	3293	3706	*457*	10141	*2503*
1993	1830	624	382	823	0	2454	*813*	3658	*932*
1994	1431	995	305	1516	1850	2425	*727*	6096	*2211*
1995	1702	803	42	3442	285	2506	*560*	6275	*1825*
1996	1619	384	42	432	3794	2003	*506*	6271	*3470*
1997	1854	743	163	3124	1907	2597	*592*	7790	*3121*
1998	732	644	599	3924	862	1376	*300*	6761	*1916*
1999	640	970	0	744	0	1610	*428*	2354	*606*
2000	1798	592	877	1496	0	2390	*601*	4763	*1992*
2001	733	666	80	653	0	1400	*473*	2133	*548*
2002	401	125	40	973	0	526	*211*	1540	*581*
2003	649	331	0	648	2955	980	*420*	4583	*2690*
2004	1488	224	0	634	283	1712	*741*	2629	*1261*
2005	712	436	82	995	0	1149	*298*	2225	*758*
2006	1862	261	437	254	290	2123	*585*	3104	*746*
2007	1137	755	162	258	0	1892	*535*	2312	*571*
2008	1009	406	120	1371	0	1415	*354*	2906	*856*
2009	616	247	0	2375	0	863	*266*	3238	*1124*
2010	1203	650	190	2575	0	1853	*383*	4619	*1513*
2011									
2012	814	440	495	2520	0	1254	*530*	4268	*1941*
2013	1242	521	82	122	0	1762	*484*	1966	*508*
2014	252	385	42	101	0	637	*297*	780	*314*

	AMWI bb	total
over all years :		
n yrs =	26	26
average index =	**1816**	**4427**
std dev =	739	2282
std err mean =	145	447
lo 90% ci mean=	1578	3691
hi 90% ci mean=	2055	5163
loglinear slope =	-0.032	-0.052
SE ln slope =	0.010	0.011
Growth Rate =	**0.968**	**0.950**
lo 90% ci GR =	0.952	0.932
hi 90% ci GR =	0.984	0.967
regr resid CV =	0.393	0.442
sampl err CV =	0.288	0.366
nyrs to detect -.034 =	17.4	20.4
last 10 years:		
n yrs =	9	9
average index =	**1439**	**2824**
std dev =	505	1178
std err mean =	168	393
lo 90% ci mean=	1162	2178
hi 90% ci mean=	1716	3470
loglinear slope =	-0.050	-0.060
SE ln slope =	0.044	0.059
Growth Rate =	**0.951**	**0.942**
lo 90% ci GR =	0.884	0.855
hi 90% ci GR =	1.022	1.038
regr resid CV =	0.394	0.527
sampl err CV =	0.305	0.324
nyrs to detect -.034 =	18.1	18.8

Figure 12. Population trend for American Wigeon (*Anas americana*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

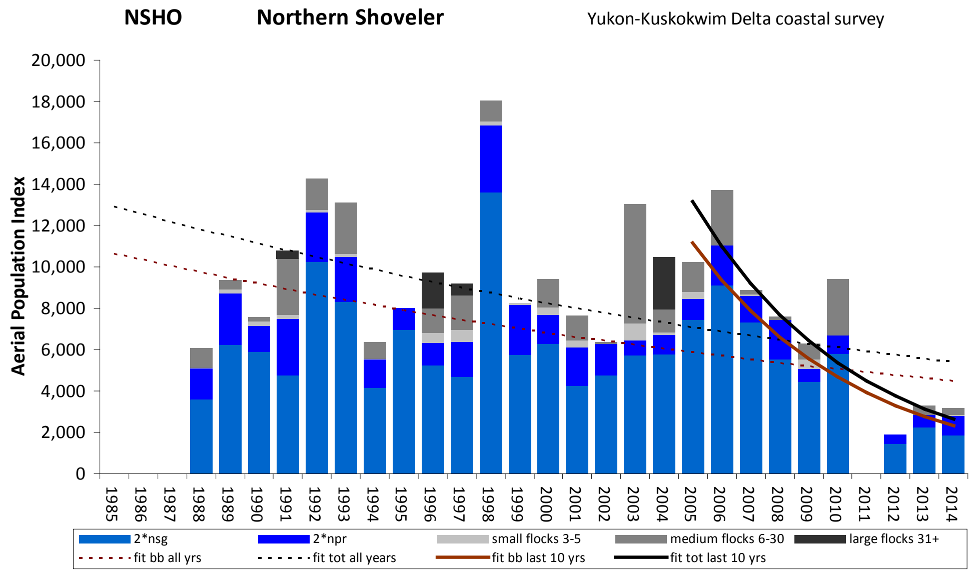


18 strata = 12,832 km² **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	1623	1105	82	354	0	2728	*465*	3163	*554*
1989	1002	312	0	0	0	1313	*328*	1313	*328*
1990	1007	164	41	0	0	1171	*365*	1212	*367*
1991	1370	1042	0	0	0	2412	*470*	2412	*470*
1992	2037	908	0	0	0	2945	*472*	2945	*472*
1993	2595	836	0	0	0	3431	*579*	3431	*579*
1994	3216	1023	0	0	0	4240	*754*	4240	*754*
1995	2308	1128	0	0	0	3436	*904*	3436	*904*
1996	1709	1371	0	59	0	3081	*555*	3140	*560*
1997	2589	2003	0	0	0	4592	*938*	4592	*938*
1998	1898	462	0	0	0	2360	*528*	2360	*528*
1999	1798	1853	0	0	0	3652	*946*	3652	*946*
2000	1211	678	0	0	0	1889	*444*	1889	*444*
2001	2960	1142	0	0	0	4102	*590*	4102	*590*
2002	1410	347	0	0	0	1758	*557*	1758	*557*
2003	1483	775	0	0	0	2258	*680*	2258	*680*
2004	1127	836	0	0	0	1963	*453*	1963	*453*
2005	2166	557	0	0	0	2722	*674*	2722	*674*
2006	2244	924	0	0	0	3168	*608*	3168	*608*
2007	2119	658	0	0	0	2778	*717*	2778	*717*
2008	1970	491	0	0	0	2460	*590*	2460	*590*
2009	945	117	0	0	0	1061	*287*	1061	*287*
2010	2353	975	0	0	0	3328	*620*	3328	*620*
2011									
2012	1880	937	0	0	0	2818	*686*	2818	*686*
2013	1025	480	0	0	0	1505	*460*	1505	*460*
2014	460	354	0	0	0	814	*339*	814	*339*

AGWT	bb	total
over all years :		
n yrs =	26	26
average index =	**2615**	**2635**
std dev =	1000	1005
std err mean =	196	197
lo 90% ci mean=	2292	2311
hi 90% ci mean=	2938	2960
loglinear slope =	-0.014	-0.015
SE ln slope =	0.011	0.011
Growth Rate =	**0.986**	**0.985**
lo 90% ci GR =	0.968	0.967
hi 90% ci GR =	1.005	1.003
regr resid CV =	0.441	0.439
sampl err CV =	0.237	0.236
nyrs to detect -.034 =	15.3	15.2
last 10 years:		
n yrs =	9	9
average index =	**2295**	**2295**
std dev =	928	928
std err mean =	309	309
lo 90% ci mean=	1786	1786
hi 90% ci mean=	2804	2804
loglinear slope =	-0.096	-0.096
SE ln slope =	0.050	0.050
Growth Rate =	**0.908**	**0.908**
lo 90% ci GR =	0.837	0.837
hi 90% ci GR =	0.986	0.986
regr resid CV =	0.443	0.443
sampl err CV =	0.262	0.262
nyrs to detect -.034 =	16.3	16.3

Figure 13. Population trend for Green-winged Teal (A*nas crecca*)observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

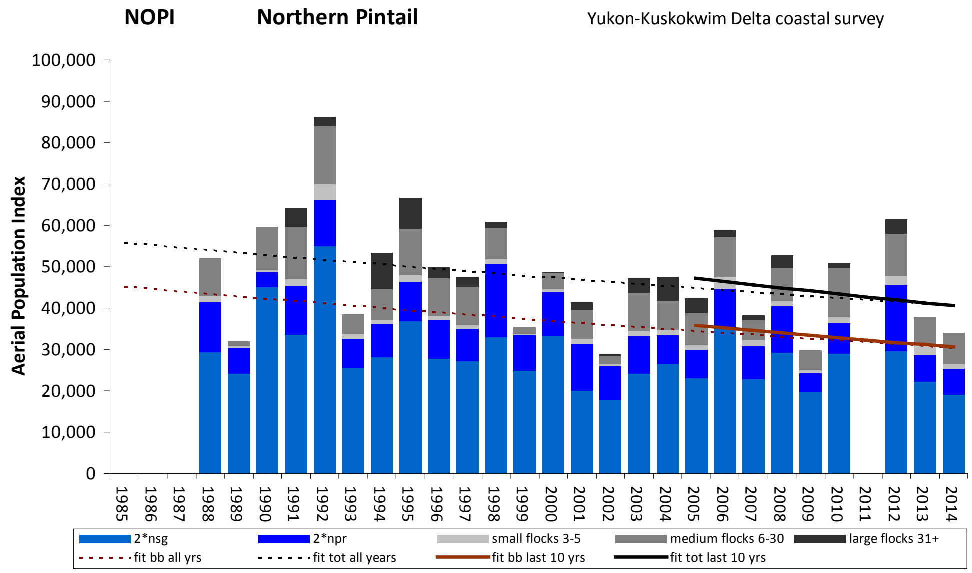


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	3620	1442	42	982	0	5061	*730*	6085	*1180*
1989	6250	2485	205	434	0	8735	*1228*	9374	*1363*
1990	5883	1260	205	226	0	7143	*1179*	7574	*1210*
1991	4755	2739	184	2704	410	7494	*1015*	10791	*2136*
1992	10233	2389	138	1502	0	12622	*1593*	14263	*1951*
1993	8326	2164	164	2458	0	10491	*1875*	13112	*2286*
1994	4162	1357	42	797	0	5519	*836*	6358	*927*
1995	6952	1066	0	0	0	8018	*1174*	8018	*1174*
1996	5249	1078	480	1205	1703	6327	*793*	9716	*1504*
1997	4695	1653	602	1693	571	6348	*1130*	9213	*1525*
1998	13586	3270	166	1038	0	16856	*1494*	18060	*1551*
1999	5755	2418	48	0	0	8173	*850*	8221	*853*
2000	6273	1396	373	1367	0	7669	*1479*	9409	*1644*
2001	4252	1888	320	1190	0	6140	*1210*	7650	*1464*
2002	4753	1541	0	48	0	6294	*1613*	6342	*1614*
2003	5721	704	869	5762	0	6425	*1682*	13056	*4810*
2004	5776	927	119	1146	2527	6703	*1183*	10495	*3061*
2005	7447	1007	348	1443	0	8454	*1074*	10245	*1310*
2006	9112	1929	0	2673	0	11041	*1659*	13713	*1951*
2007	7329	1277	81	200	0	8606	*1222*	8887	*1239*
2008	5522	1911	0	187	0	7433	*1395*	7620	*1403*
2009	4421	675	433	747	0	5097	*941*	6277	*1032*
2010	5814	856	0	2716	0	6670	*996*	9386	*1808*
2011									
2012	1445	422	0	0	0	1867	*495*	1867	*495*
2013	2259	565	0	466	0	2823	*661*	3289	*598*
2014	1860	942	42	314	0	2802	*680*	3158	*848*

NSHO	bb	total
over all years :		
n yrs =	26	26
average index =	**7339**	**8930**
std dev =	3091	3623
std err mean =	606	711
lo 90% ci mean=	6342	7761
hi 90% ci mean=	8336	10099
loglinear slope =	-0.030	-0.030
SE ln slope =	0.010	0.011
Growth Rate =	**0.971**	**0.970**
lo 90% ci GR =	0.954	0.952
hi 90% ci GR =	0.987	0.989
regr resid CV =	0.408	0.446
sampl err CV =	0.171	0.183
nyrs to detect -.034 =	12.3	12.9
last 10 years:		
n yrs =	9	9
average index =	**6088**	**7160**
std dev =	3140	3880
std err mean =	1047	1293
lo 90% ci mean=	4366	5033
hi 90% ci mean=	7810	9287
loglinear slope =	-0.174	-0.179
SE ln slope =	0.033	0.041
Growth Rate =	**0.840**	**0.836**
lo 90% ci GR =	0.795	0.781
hi 90% ci GR =	0.887	0.894
regr resid CV =	0.297	0.368
sampl err CV =	0.187	0.185
nyrs to detect -.034 =	13.0	13.0

Figure 14. Population trend for Northern Shoveler (*Anas clypeata*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.



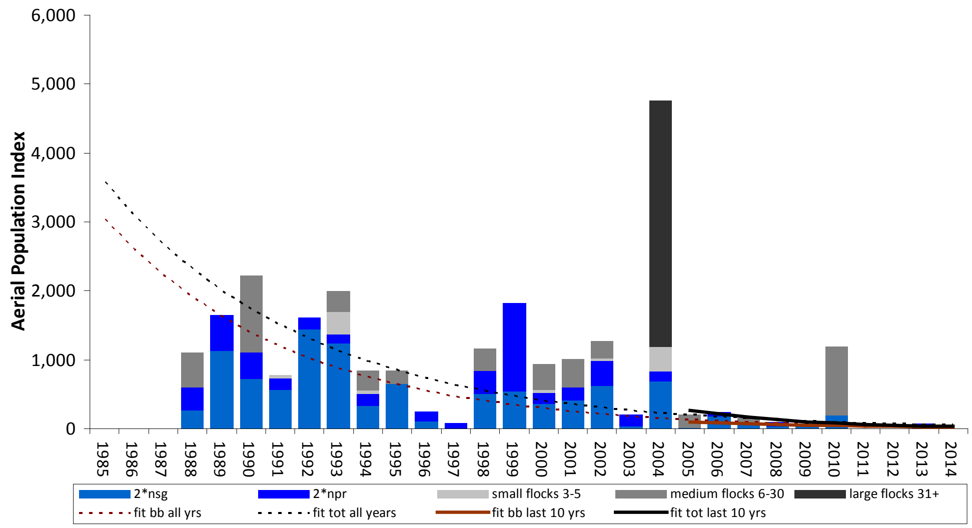
18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**29350**	**12109**	**1621**	**8972**	**0**	**41459**	*3072*	**52052**	*5916*
1989	**24168**	**6325**	**322**	**1148**	**0**	**30492**	*2751*	**31962**	*2842*
1990	**44941**	**3638**	**708**	**10377**	**0**	**48578**	*3895*	**59663**	*6490*
1991	**33658**	**11813**	**1486**	**12570**	**4724**	**45470**	*3632*	**64250**	*8719*
1992	**55085**	**11049**	**3819**	**14084**	**2235**	**66134**	*3420*	**86272**	*6082*
1993	**25554**	**7122**	**1167**	**4537**	**0**	**32676**	*2440*	**38379**	*3644*
1994	**28293**	**7989**	**1012**	**7361**	**8682**	**36281**	*3005*	**53336**	*8254*
1995	**36893**	**9571**	**1547**	**11223**	**7325**	**46464**	*3802*	**66560**	*7133*
1996	**27708**	**9591**	**876**	**8947**	**2726**	**37299**	*2600*	**49847**	*4055*
1997	**27284**	**7671**	**899**	**9386**	**2236**	**34955**	*3069*	**47476**	*5128*
1998	**33010**	**17789**	**1010**	**7686**	**1369**	**50799**	*2995*	**60863**	*3861*
1999	**24751**	**8775**	**288**	**1567**	**0**	**33527**	*3944*	**35382**	*4025*
2000	**33328**	**10489**	**852**	**3843**	**278**	**43817**	*4836*	**48790**	*6474*
2001	**19949**	**11493**	**1256**	**6888**	**1866**	**31442**	*2394*	**41452**	*3727*
2002	**17703**	**8322**	**444**	**1879**	**402**	**26025**	*2260*	**28750**	*2547*
2003	**24199**	**8980**	**1324**	**9220**	**3513**	**33179**	*3437*	**47236**	*9108*
2004	**26546**	**6870**	**1365**	**7043**	**5804**	**33417**	*2898*	**47628**	*9766*
2005	**22948**	**7081**	**935**	**7921**	**3474**	**30030**	*2059*	**42360**	*4037*
2006	**35063**	**9619**	**2898**	**9679**	**1538**	**44682**	*3478*	**58797**	*4245*
2007	**22749**	**8144**	**1227**	**4974**	**1136**	**30893**	*2944*	**38230**	*3978*
2008	**29119**	**11243**	**1225**	**8173**	**3137**	**40361**	*3096*	**52896**	*5159*
2009	**19829**	**4293**	**889**	**4838**	**0**	**24122**	*1948*	**29849**	*2901*
2010	**29079**	**7333**	**1484**	**11957**	**1029**	**36411**	*4058*	**50880**	*5962*
2011									
2012	**29526**	**16091**	**2158**	**10295**	**3237**	**45618**	*4305*	**61307**	*11225*
2013	**22184**	**6505**	**2311**	**6861**	**0**	**28689**	*2582*	**37862**	*3923*
2014	**19097**	**6397**	**886**	**7600**	**0**	**25495**	*2374*	**33981**	*4016*

NOPI	bb	total
over all years :		
n yrs =	26	26
average index =	**37628**	**48695**
std dev =	9477	13291
std err mean =	1859	2607
lo 90% ci mean=	34570	44407
hi 90% ci mean=	40685	52983
loglinear slope =	-0.014	-0.011
SE ln slope =	0.006	0.007
Growth Rate =	**0.986**	**0.989**
lo 90% ci GR =	0.977	0.978
hi 90% ci GR =	0.996	1.000
regr resid CV =	0.219	0.261
sampl err CV =	0.085	0.113
nyrs to detect -.034 =	7.7	9.3
last 10 years:		
n yrs =	9	9
average index =	**34033**	**45129**
std dev =	8054	11224
std err mean =	2685	3741
lo 90% ci mean=	29617	38975
hi 90% ci mean=	38449	51283
loglinear slope =	-0.017	-0.017
SE ln slope =	0.027	0.029
Growth Rate =	**0.983**	**0.983**
lo 90% ci GR =	0.939	0.937
hi 90% ci GR =	1.028	1.032
regr resid CV =	0.245	0.264
sampl err CV =	0.088	0.110
nyrs to detect -.034 =	7.9	9.1

Figure 15. Population trend for Northern Pintail (*Anas acuta*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

CANV **Canvasback** Yukon-Kuskokwim Delta coastal survey



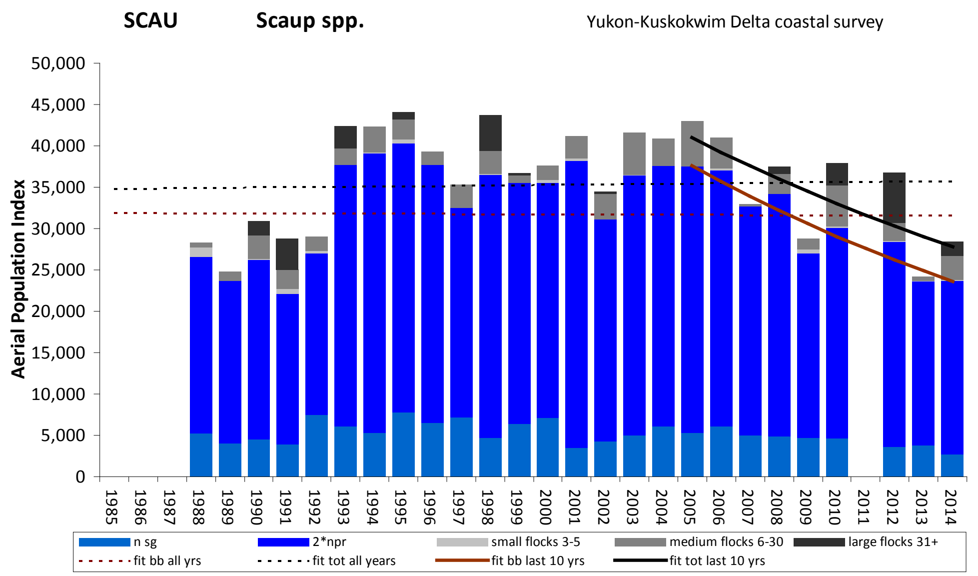
18 strata = 12,832 km²

Aerial Index with singles doubled

0	**2*nsg**	**2*npr**	**s flks**	**m flks**	**l flks**	**bb**	*SE bb*	**total**	*SE tot*
1985									
1986									
1987									
1988	**268**	**333**	**0**	**502**	**0**	**601**	*215*	**1103**	*561*
1989	**1124**	**517**	**0**	**0**	**0**	**1641**	*512*	**1641**	*512*
1990	**719**	**386**	**0**	**1111**	**0**	**1105**	*382*	**2215**	*1314*
1991	**567**	**169**	**46**	**0**	**0**	**735**	*350*	**781**	*352*
1992	**1437**	**172**	**0**	**0**	**0**	**1609**	*1066*	**1609**	*1066*
1993	**1237**	**136**	**325**	**289**	**0**	**1374**	*681*	**1988**	*768*
1994	**332**	**178**	**42**	**289**	**0**	**510**	*212*	**841**	*340*
1995	**649**	**0**	**0**	**194**	**0**	**649**	*337*	**843**	*408*
1996	**104**	**144**	**0**	**0**	**0**	**249**	*153*	**249**	*153*
1997	**0**	**89**	**0**	**0**	**0**	**89**	*73*	**89**	*73*
1998	**503**	**341**	**0**	**320**	**0**	**844**	*327*	**1164**	*466*
1999	**546**	**1276**	**0**	**0**	**0**	**1823**	*521*	**1823**	*521*
2000	**363**	**159**	**40**	**369**	**0**	**522**	*180*	**931**	*329*
2001	**407**	**199**	**0**	**397**	**0**	**606**	*258*	**1002**	*449*
2002	**623**	**356**	**41**	**248**	**0**	**979**	*365*	**1268**	*513*
2003	**33**	**169**	**0**	**0**	**0**	**202**	*136*	**202**	*136*
2004	**684**	**144**	**361**	**0**	**3581**	**829**	*440*	**4771**	*3447*
2005	**18**	**0**	**0**	**184**	**0**	**18**	*18*	**202**	*203*
2006	**184**	**53**	**0**	**0**	**0**	**238**	*134*	**238**	*134*
2007	**98**	**0**	**0**	**57**	**0**	**98**	*73*	**155**	*113*
2008	**31**	**66**	**0**	**0**	**0**	**97**	*51*	**97**	*51*
2009	**34**	**0**	**0**	**0**	**0**	**34**	*37*	**34**	*37*
2010	**187**	**0**	**0**	**1001**	**0**	**187**	*130*	**1187**	*966*
2011									
2012	**0**	**0**	**0**	**0**	**0**	**0**	*0*	**0**	*0*
2013	**0**	**68**	**0**	**0**	**0**	**68**	*68*	**68**	*68*
2014	**0**	**0**	**0**	**0**	**0**	**0**	*0*	**0**	*0*

	CANV bb	total
over all years :		
n yrs =	26	26
average index =	**581**	**942**
std dev =	557	1037
std err mean =	109	203
lo 90% ci mean=	401	608
hi 90% ci mean=	761	1277
loglinear slope =	-0.155	-0.144
SE ln slope =	0.027	0.035
Growth Rate =	**0.856**	**0.866**
lo 90% ci GR =	0.820	0.818
hi 90% ci GR =	0.895	0.917
regr resid CV =	1.044	1.361
sampl err CV =	0.569	0.594
nyrs to detect -.034 =	27.4	28.2
last 10 years:		
n yrs =	9	9
average index =	**82**	**220**
std dev =	84	372
std err mean =	28	124
lo 90% ci mean=	36	16
hi 90% ci mean=	128	424
loglinear slope =	-0.171	-0.241
SE ln slope =	0.133	0.137
Growth Rate =	**0.843**	**0.785**
lo 90% ci GR =	0.677	0.627
hi 90% ci GR =	1.049	0.983
regr resid CV =	1.191	1.225
sampl err CV =	0.802	0.818
nyrs to detect -.034 =	34.4	34.8

Figure 16. Population trend for Canvasback (*Aythya valisineria*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

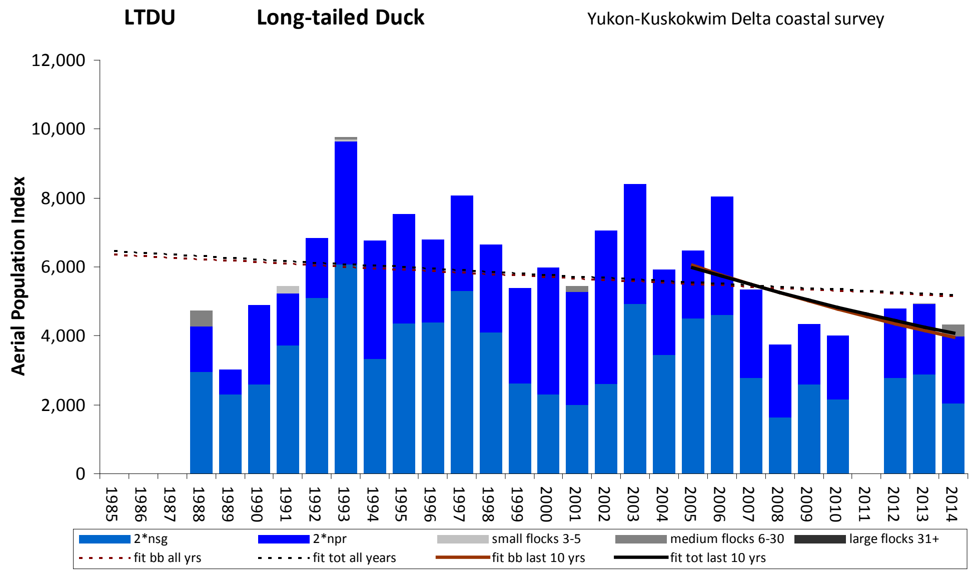


18 strata = 12,832 km² **Aerial Index with singles =1**

0	n sg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**5191**	**21435**	**1035**	**688**	**0**	**26625**	*2584*	**28348**	*2573*
1989	**3999**	**19673**	**0**	**1108**	**0**	**23673**	*3238*	**24780**	*4076*
1990	**4500**	**21698**	**72**	**2980**	**1644**	**26199**	*3942*	**30895**	*5652*
1991	**3900**	**18230**	**579**	**2304**	**3740**	**22130**	*1886*	**28753**	*3541*
1992	**7536**	**19475**	**339**	**1623**	**0**	**27010**	*2197*	**28973**	*2673*
1993	**6074**	**31655**	**0**	**1933**	**2735**	**37730**	*3560*	**42398**	*5421*
1994	**5330**	**33779**	**82**	**3113**	**0**	**39109**	*3401*	**42304**	*4289*
1995	**7782**	**32557**	**462**	**2428**	**854**	**40339**	*3335*	**44084**	*3965*
1996	**6500**	**31167**	**0**	**1590**	**0**	**37667**	*2340*	**39256**	*2581*
1997	**7180**	**25313**	**0**	**2788**	**0**	**32493**	*2322*	**35280**	*2791*
1998	**4746**	**31765**	**83**	**2777**	**4345**	**36511**	*3660*	**43715**	*4863*
1999	**6400**	**29075**	**0**	**936**	**301**	**35475**	*2672*	**36712**	*2934*
2000	**7059**	**28473**	**404**	**1695**	**0**	**35533**	*2673*	**37631**	*3018*
2001	**3526**	**34639**	**317**	**2730**	**0**	**38164**	*3975*	**41211**	*4203*
2002	**4333**	**26745**	**0**	**3123**	**280**	**31078**	*2851*	**34481**	*3371*
2003	**4993**	**31396**	**83**	**5113**	**0**	**36390**	*4075*	**41585**	*4078*
2004	**6134**	**31424**	**0**	**3351**	**0**	**37558**	*3298*	**40909**	*4170*
2005	**5270**	**32188**	**0**	**5586**	**0**	**37459**	*4736*	**43044**	*3154*
2006	**6144**	**30841**	**333**	**3697**	**0**	**36985**	*2728*	**41015**	*2946*
2007	**5047**	**27630**	**40**	**258**	**0**	**32677**	*3958*	**32975**	*3963*
2008	**4909**	**29336**	**0**	**2388**	**833**	**34245**	*2578*	**37465**	*3366*
2009	**4705**	**22321**	**443**	**1345**	**0**	**27026**	*2433*	**28814**	*2607*
2010	**4608**	**25493**	**160**	**4928**	**2712**	**30102**	*2345*	**37902**	*4635*
2011									
2012	**3566**	**24855**	**82**	**2226**	**6036**	**28421**	*2482*	**36764**	*5451*
2013	**3802**	**19807**	**80**	**533**	**0**	**23610**	*2349*	**24223**	*2375*
2014	**2714**	**20972**	**115**	**2879**	**1689**	**23686**	*2056*	**28368**	*2820*

	SCAU bb	total
over all years :		
n yrs =	26	26
average index =	**32227**	**35842**
std dev =	5702	6181
std err mean =	1118	1212
lo 90% ci mean=	30387	33848
hi 90% ci mean=	34066	37836
loglinear slope =	0.000	0.001
SE ln slope =	0.005	0.005
Growth Rate =	**1.000**	**1.001**
lo 90% ci GR =	0.992	0.993
hi 90% ci GR =	1.008	1.009
regr resid CV =	0.190	0.186
sampl err CV =	0.094	0.104
nyrs to detect -.034 =	8.2	8.8
last 10 years:		
n yrs =	9	9
average index =	**30468**	**34508**
std dev =	5240	6313
std err mean =	1747	2104
lo 90% ci mean=	27594	31046
hi 90% ci mean=	33341	37969
loglinear slope =	-0.052	-0.043
SE ln slope =	0.008	0.016
Growth Rate =	**0.950**	**0.958**
lo 90% ci GR =	0.938	0.933
hi 90% ci GR =	0.962	0.983
regr resid CV =	0.068	0.144
sampl err CV =	0.093	0.102
nyrs to detect -.034 =	8.2	8.7

Figure 17. Population trend for Unidentified Scaup, predominantly Greater Scaup (*Aythya marila*), observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

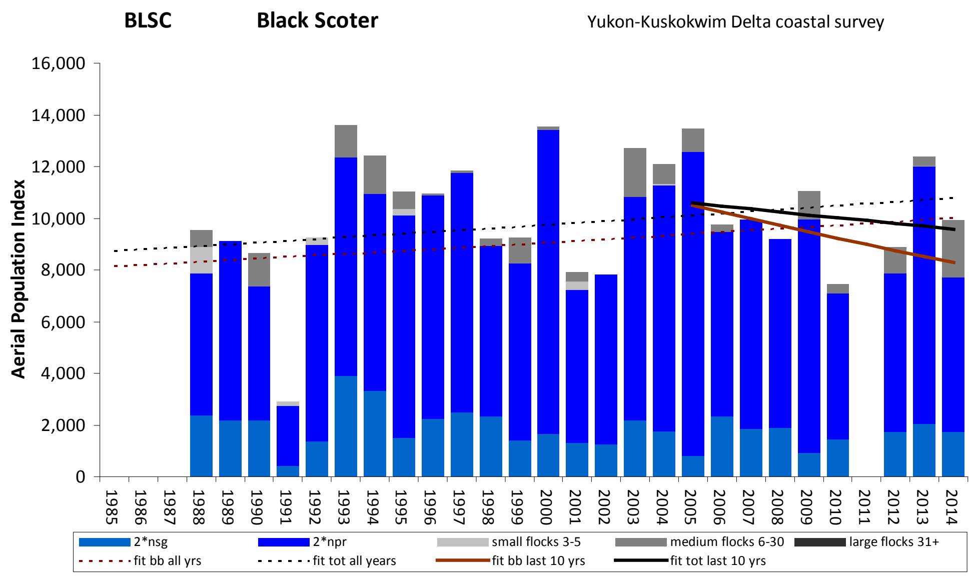


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**2941**	**1331**	**0**	**451**	**0**	**4272**	*812*	**4723**	*882*
1989	**2316**	**704**	**0**	**0**	**0**	**3019**	*660*	**3019**	*660*
1990	**2592**	**2305**	**0**	**0**	**0**	**4897**	*757*	**4897**	*757*
1991	**3720**	**1513**	**211**	**0**	**0**	**5232**	*544*	**5443**	*643*
1992	**5121**	**1713**	**0**	**0**	**0**	**6834**	*690*	**6834**	*690*
1993	**6062**	**3598**	**42**	**58**	**0**	**9659**	*1193*	**9759**	*1199*
1994	**3343**	**3433**	**0**	**0**	**0**	**6776**	*833*	**6776**	*833*
1995	**4364**	**3161**	**0**	**0**	**0**	**7525**	*838*	**7525**	*838*
1996	**4388**	**2401**	**0**	**0**	**0**	**6789**	*939*	**6789**	*939*
1997	**5306**	**2747**	**0**	**0**	**0**	**8053**	*801*	**8053**	*801*
1998	**4099**	**2550**	**0**	**0**	**0**	**6650**	*1148*	**6650**	*1148*
1999	**2607**	**2762**	**0**	**0**	**0**	**5370**	*827*	**5370**	*827*
2000	**2311**	**3671**	**0**	**0**	**0**	**5982**	*801*	**5982**	*801*
2001	**2003**	**3267**	**0**	**169**	**0**	**5270**	*702*	**5439**	*675*
2002	**2622**	**4445**	**0**	**0**	**0**	**7068**	*825*	**7068**	*825*
2003	**4927**	**3483**	**0**	**0**	**0**	**8409**	*2181*	**8409**	*2181*
2004	**3450**	**2474**	**0**	**0**	**0**	**5924**	*779*	**5924**	*779*
2005	**4502**	**1979**	**0**	**0**	**0**	**6482**	*869*	**6482**	*869*
2006	**4604**	**3441**	**0**	**0**	**0**	**8044**	*917*	**8044**	*917*
2007	**2774**	**2567**	**0**	**0**	**0**	**5340**	*773*	**5340**	*773*
2008	**1626**	**2112**	**0**	**0**	**0**	**3736**	*708*	**3736**	*708*
2009	**2601**	**1750**	**0**	**0**	**0**	**4351**	*824*	**4351**	*824*
2010	**2163**	**1849**	**0**	**0**	**0**	**4012**	*567*	**4012**	*567*
2011									
2012	**2783**	**2010**	**0**	**0**	**0**	**4793**	*823*	**4793**	*823*
2013	**2891**	**2032**	**26**	**0**	**0**	**4923**	*544*	**4948**	*545*
2014	**2041**	**1951**	**0**	**338**	**0**	**3993**	*549*	**4331**	*666*

	LTDU bb	total
over all years :		
n yrs =	26	26
average index =	**5900**	**5950**
std dev =	1635	1608
std err mean =	321	315
lo 90% ci mean=	5373	5431
hi 90% ci mean=	6428	6469
loglinear slope =	-0.007	-0.008
SE ln slope =	0.007	0.007
Growth Rate =	**0.993**	**0.992**
lo 90% ci GR =	0.981	0.981
hi 90% ci GR =	1.005	1.004
regr resid CV =	0.284	0.276
sampl err CV =	0.146	0.147
nyrs to detect -.034 =	11.1	11.1
last 10 years:		
n yrs =	9	9
average index =	**5075**	**5115**
std dev =	1396	1367
std err mean =	465	456
lo 90% ci mean=	4310	4366
hi 90% ci mean=	5840	5865
loglinear slope =	-0.047	-0.042
SE ln slope =	0.024	0.024
Growth Rate =	**0.954**	**0.958**
lo 90% ci GR =	0.917	0.921
hi 90% ci GR =	0.992	0.997
regr resid CV =	0.214	0.217
sampl err CV =	0.148	0.150
nyrs to detect -.034 =	11.2	11.3

Figure 18. Population trend for Long-tailed Duck (*Clangula hyemalis*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

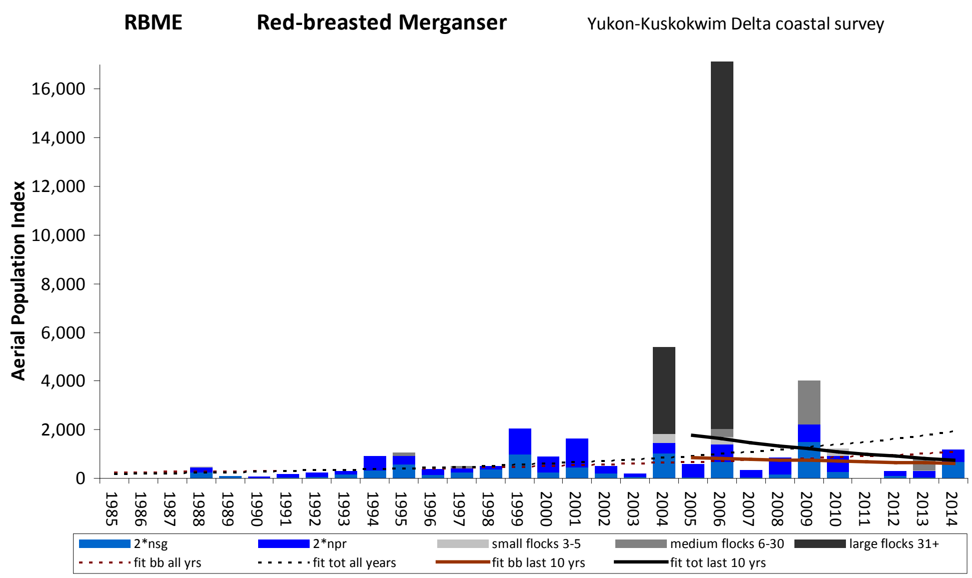


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	2*nsg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988	**2364**	**5493**	**1052**	**623**	**0**	**7856**	*966*	**9531**	*1329*
1989	**2187**	**6937**	**0**	**0**	**0**	**9124**	*3225*	**9124**	*3225*
1990	**2171**	**5193**	**0**	**1267**	**0**	**7364**	*1141*	**8631**	*1729*
1991	**432**	**2319**	**165**	**0**	**0**	**2751**	*557*	**2915**	*599*
1992	**1379**	**7575**	**286**	**0**	**0**	**8954**	*1159*	**9240**	*1179*
1993	**3903**	**8441**	**0**	**1270**	**0**	**12344**	*1855*	**13614**	*2285*
1994	**3317**	**7629**	**0**	**1482**	**0**	**10946**	*2349*	**12427**	*2810*
1995	**1516**	**8607**	**231**	**702**	**0**	**10124**	*1672*	**11057**	*1855*
1996	**2236**	**8639**	**0**	**59**	**0**	**10875**	*1374*	**10934**	*1374*
1997	**2505**	**9240**	**0**	**81**	**0**	**11745**	*2147*	**11826**	*2150*
1998	**2332**	**6599**	**0**	**291**	**0**	**8930**	*1303*	**9221**	*1308*
1999	**1414**	**6850**	**0**	**999**	**0**	**8265**	*1383*	**9264**	*1928*
2000	**1667**	**11732**	**0**	**142**	**0**	**13400**	*4061*	**13542**	*4062*
2001	**1297**	**5945**	**321**	**355**	**0**	**7242**	*1071*	**7917**	*1155*
2002	**1257**	**6547**	**0**	**0**	**0**	**7804**	*2025*	**7804**	*2025*
2003	**2179**	**8645**	**0**	**1868**	**0**	**10825**	*2500*	**12692**	*3468*
2004	**1751**	**9500**	**84**	**756**	**0**	**11250**	*1677*	**12090**	*1913*
2005	**797**	**11790**	**0**	**888**	**0**	**12587**	*1913*	**13475**	*1922*
2006	**2325**	**7159**	**0**	**290**	**0**	**9484**	*1251*	**9775**	*1281*
2007	**1855**	**8089**	**0**	**0**	**0**	**9943**	*2564*	**9943**	*2564*
2008	**1893**	**7300**	**0**	**0**	**0**	**9194**	*2144*	**9194**	*2144*
2009	**915**	**9037**	**0**	**1086**	**0**	**9952**	*2471*	**11038**	*2370*
2010	**1449**	**5656**	**0**	**346**	**0**	**7104**	*1098*	**7450**	*1140*
2011									
2012	**1732**	**6148**	**0**	**1017**	**0**	**7879**	*1651*	**8896**	*1740*
2013	**2043**	**9942**	**55**	**355**	**0**	**11985**	*1753*	**12394**	*1776*
2014	**1730**	**5996**	**0**	**2191**	**0**	**7725**	*1077*	**9916**	*1382*

	BLSC bb	total
<u>over all years :</u>		
n yrs =	26	26
average index =	**9448**	**10150**
std dev =	2265	2359
std err mean =	444	463
lo 90% ci mean=	8717	9389
hi 90% ci mean=	10179	10911
loglinear slope =	0.007	0.007
SE ln slope =	0.008	0.008
Growth Rate =	**1.007**	**1.007**
lo 90% ci GR =	0.994	0.994
hi 90% ci GR =	1.020	1.020
regr resid CV =	0.308	0.304
sampl err CV =	0.188	0.192
nyrs to detect -.034 =	13.1	13.3
<u>last 10 years:</u>		
n yrs =	9	9
average index =	**9539**	**10231**
std dev =	1861	1831
std err mean =	620	610
lo 90% ci mean=	8519	9227
hi 90% ci mean=	10560	11235
loglinear slope =	-0.026	-0.011
SE ln slope =	0.021	0.021
Growth Rate =	**0.974**	**0.989**
lo 90% ci GR =	0.941	0.956
hi 90% ci GR =	1.008	1.023
regr resid CV =	0.187	0.186
sampl err CV =	0.186	0.179
nyrs to detect -.034 =	13.0	12.7

Figure 19. Population trend for Black Scoter (*Melanitta nigra*) observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

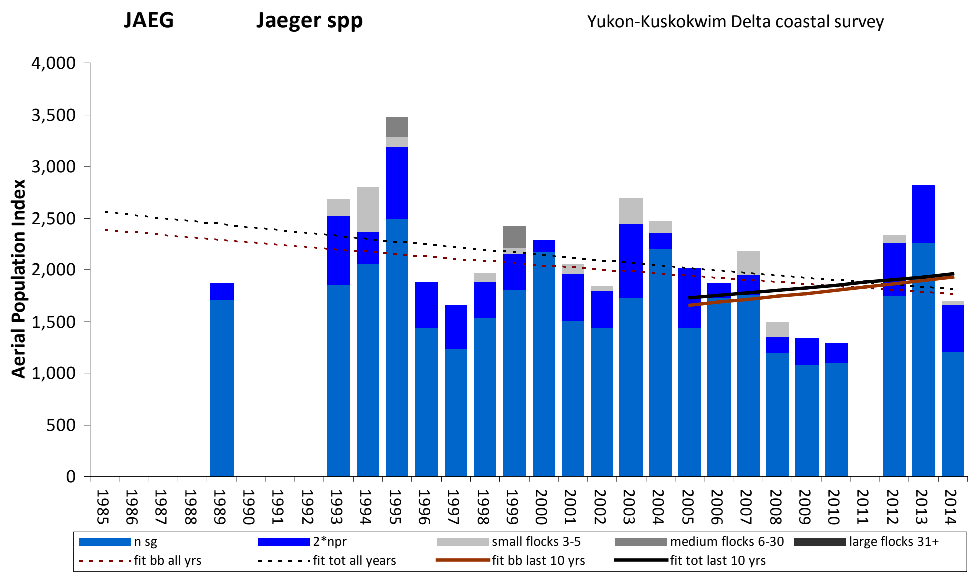


18 strata = 12,832 km² — **Aerial Index with singles doubled**

0	**2*nsg**	**2*npr**	**s flks**	**m flks**	**l flks**	**bb**	*SE bb*	**total**	*SE tot*
1985									
1986									
1987									
1988	**236**	**197**	**41**	**0**	**0**	**433**	*191*	**473**	*195*
1989	**104**	**0**	**0**	**0**	**0**	**104**	*73*	**104**	*73*
1990	**0**	**66**	**0**	**0**	**0**	**67**	*68*	**67**	*68*
1991	**18**	**164**	**0**	**0**	**0**	**182**	*100*	**182**	*100*
1992	**74**	**152**	**0**	**0**	**0**	**226**	*78*	**226**	*78*
1993	**164**	**146**	**0**	**0**	**0**	**310**	*131*	**310**	*131*
1994	**344**	**572**	**0**	**0**	**0**	**917**	*257*	**917**	*257*
1995	**576**	**344**	**0**	**127**	**0**	**920**	*429*	**1047**	*450*
1996	**140**	**239**	**0**	**0**	**0**	**380**	*120*	**380**	*120*
1997	**251**	**166**	**0**	**83**	**0**	**417**	*156*	**500**	*175*
1998	**358**	**145**	**0**	**0**	**0**	**503**	*180*	**503**	*180*
1999	**981**	**1072**	**0**	**0**	**0**	**2052**	*690*	**2052**	*690*
2000	**249**	**636**	**0**	**0**	**0**	**885**	*600*	**885**	*600*
2001	**447**	**1184**	**0**	**0**	**0**	**1630**	*555*	**1630**	*555*
2002	**206**	**297**	**0**	**0**	**0**	**504**	*180*	**504**	*180*
2003	**79**	**130**	**0**	**0**	**0**	**209**	*143*	**209**	*143*
2004	**1018**	**454**	**361**	**0**	**3581**	**1472**	*758*	**5414**	*3466*
2005	**34**	**540**	**0**	**0**	**0**	**574**	*188*	**574**	*188*
2006	**667**	**715**	**304**	**365**	**15178**	**1381**	*350*	**17227**	*12937*
2007	**35**	**310**	**0**	**0**	**0**	**344**	*155*	**344**	*155*
2008	**155**	**684**	**0**	**0**	**0**	**838**	*228*	**838**	*228*
2009	**1500**	**719**	**0**	**1784**	**0**	**2219**	*1051*	**4003**	*1982*
2010	**282**	**643**	**306**	**0**	**0**	**925**	*243*	**1231**	*385*
2011									
2012	**86**	**222**	**0**	**0**	**0**	**308**	*117*	**308**	*117*
2013	**34**	**277**	**43**	**476**	**0**	**311**	*176*	**830**	*463*
2014	**676**	**524**	**0**	**0**	**0**	**1200**	*511*	**1200**	*511*

RBME	bb	total
over all years :		
n yrs =	26	26
average index =	**743**	**1614**
std dev =	596	3407
std err mean =	117	668
lo 90% ci mean=	550	515
hi 90% ci mean=	935	2713
loglinear slope =	0.053	0.081
SE ln slope =	0.021	0.029
Growth Rate =	**1.055**	**1.084**
lo 90% ci GR =	1.019	1.034
hi 90% ci GR =	1.091	1.137
regr resid CV =	0.811	1.125
sampl err CV =	0.446	0.469
nyrs to detect -.034 =	23.3	24.1
last 10 years:		
n yrs =	9	9
average index =	**900**	**2951**
std dev =	630	5470
std err mean =	210	1823
lo 90% ci mean=	554	-49
hi 90% ci mean=	1246	5950
loglinear slope =	-0.035	-0.096
SE ln slope =	0.084	0.147
Growth Rate =	**0.965**	**0.909**
lo 90% ci GR =	0.840	0.714
hi 90% ci GR =	1.108	1.157
regr resid CV =	0.753	1.315
sampl err CV =	0.379	0.441
nyrs to detect -.034 =	20.9	23.1

Figure 20. Population trend for Red-breasted Merganser (*Mergus serrator*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The indicated total aerial index is the sum of birds observed as singles, an equal number of unseen single birds, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

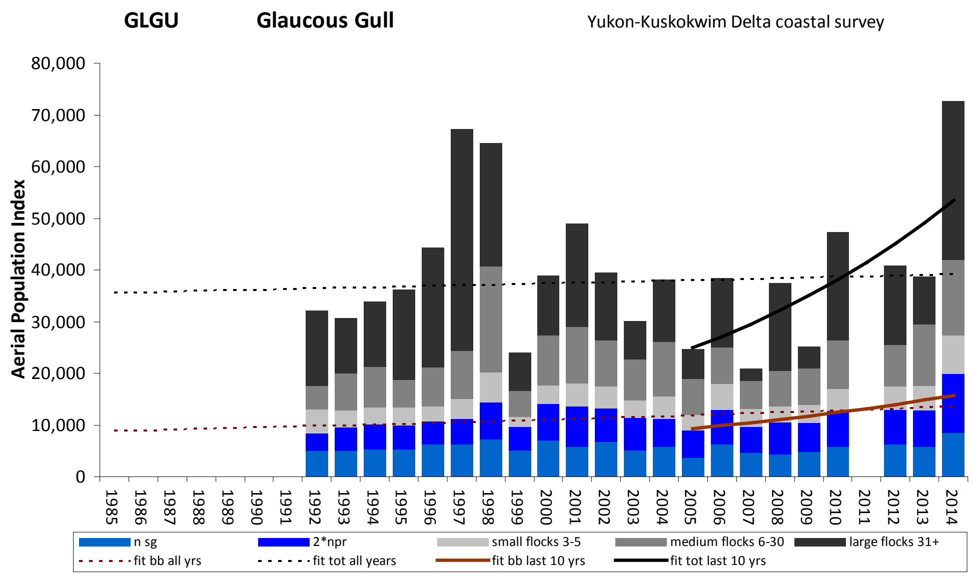


18 strata = 12,832 km² **Aerial Index with singles =1**

0	n sg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988									
1989	**1708**	**161**	**0**	**0**	**0**	**1869**	*271*	**1869**	*271*
1990									
1991									
1992									
1993	**1857**	**663**	**159**	**0**	**0**	**2521**	*458*	**2679**	*455*
1994	**2055**	**316**	**426**	**0**	**0**	**2371**	*342*	**2797**	*530*
1995	**2498**	**690**	**97**	**192**	**0**	**3188**	*483*	**3477**	*536*
1996	**1438**	**440**	**0**	**0**	**0**	**1878**	*342*	**1878**	*342*
1997	**1231**	**429**	**0**	**0**	**0**	**1660**	*388*	**1660**	*388*
1998	**1539**	**342**	**87**	**0**	**0**	**1881**	*345*	**1968**	*348*
1999	**1812**	**338**	**58**	**211**	**0**	**2150**	*372*	**2419**	*430*
2000	**2170**	**120**	**0**	**0**	**0**	**2290**	*324*	**2290**	*324*
2001	**1505**	**453**	**97**	**0**	**0**	**1958**	*311*	**2055**	*341*
2002	**1443**	**353**	**42**	**0**	**0**	**1796**	*324*	**1838**	*325*
2003	**1732**	**718**	**246**	**0**	**0**	**2450**	*471*	**2696**	*547*
2004	**2198**	**162**	**109**	**0**	**0**	**2359**	*364*	**2468**	*378*
2005	**1434**	**585**	**0**	**0**	**0**	**2018**	*428*	**2018**	*428*
2006	**1726**	**146**	**0**	**0**	**0**	**1872**	*289*	**1872**	*289*
2007	**1754**	**190**	**231**	**0**	**0**	**1944**	*370*	**2176**	*396*
2008	**1193**	**160**	**141**	**0**	**0**	**1353**	*198*	**1494**	*207*
2009	**1079**	**256**	**0**	**0**	**0**	**1335**	*262*	**1335**	*262*
2010	**1093**	**194**	**0**	**0**	**0**	**1287**	*215*	**1287**	*215*
2011									
2012	**1747**	**511**	**79**	**0**	**0**	**2258**	*343*	**2337**	*352*
2013	**2262**	**553**	**0**	**0**	**0**	**2815**	*526*	**2815**	*526*
2014	**1205**	**463**	**25**	**0**	**0**	**1668**	*350*	**1693**	*351*

	JAEG	
	bb	total
over all years :		
n yrs =	22	22
average index =	**2042**	**2142**
std dev =	471	539
std err mean =	100	115
lo 90% ci mean=	1877	1953
hi 90% ci mean=	2207	2331
loglinear slope =	-0.010	-0.012
SE ln slope =	0.007	0.008
Growth Rate =	**0.990**	**0.988**
lo 90% ci GR =	0.978	0.976
hi 90% ci GR =	1.001	1.001
regr resid CV =	0.226	0.244
sampl err CV =	0.174	0.176
nyrs to detect -.034 =	12.5	12.5
last 10 years:		
n yrs =	9	9
average index =	**1839**	**1892**
std dev =	500	503
std err mean =	167	168
lo 90% ci mean=	1565	1616
hi 90% ci mean=	2113	2168
loglinear slope =	0.017	0.014
SE ln slope =	0.031	0.031
Growth Rate =	**1.017**	**1.014**
lo 90% ci GR =	0.966	0.963
hi 90% ci GR =	1.070	1.067
regr resid CV =	0.277	0.278
sampl err CV =	0.179	0.177
nyrs to detect -.034 =	12.7	12.6

Figure 21. Population trend for Jaeger spp (*Stercorarius parasiticus*, *S. longicauda*, *S. pomarinus*) observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

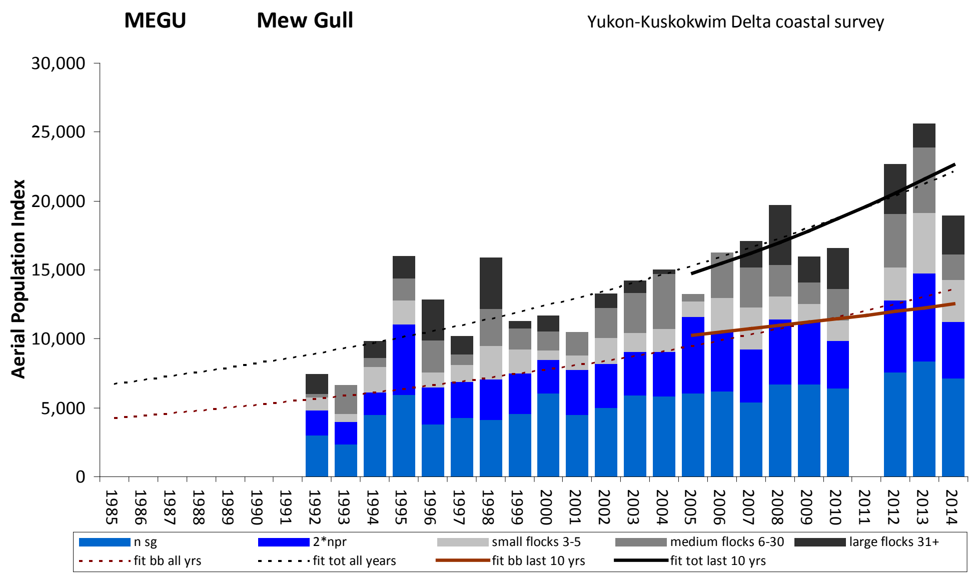


18 strata = 12,832 km² **Aerial Index with singles =1**

0	**n sg**	**2*npr**	**s flks**	**m flks**	**l flks**	**bb**	*SE bb*	**total**	*SE tot*
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	**4881**	**3480**	**4619**	**4636**	**14606**	**8361**	*1132*	**32221**	*6858*
1993	**4938**	**4726**	**3215**	**7136**	**10672**	**9664**	*797*	**30688**	*5275*
1994	**5243**	**4790**	**3438**	**7730**	**12746**	**10032**	*896*	**33947**	*5663*
1995	**5336**	**4633**	**3529**	**5284**	**17400**	**9969**	*832*	**36183**	*6691*
1996	**6283**	**4384**	**2918**	**7501**	**23299**	**10667**	*735*	**44384**	*9110*
1997	**6170**	**4960**	**3858**	**9273**	**42928**	**11129**	*876*	**67188**	*12002*
1998	**7180**	**7177**	**5775**	**20544**	**23815**	**14358**	*1877*	**64493**	*13138*
1999	**5101**	**4442**	**2005**	**5080**	**7363**	**9544**	*985*	**23992**	*4084*
2000	**7082**	**7043**	**3433**	**9804**	**11572**	**14125**	*1090*	**38934**	*5455*
2001	**5798**	**7728**	**4629**	**10835**	**19960**	**13525**	*1318*	**48950**	*11358*
2002	**6697**	**6648**	**4028**	**9070**	**13080**	**13346**	*1931*	**39524**	*7978*
2003	**5148**	**6158**	**3400**	**7936**	**7452**	**11306**	*1142*	**30094**	*4064*
2004	**5734**	**5503**	**4332**	**10518**	**12072**	**11237**	*1042*	**38158**	*5892*
2005	**3733**	**5161**	**3032**	**6950**	**5819**	**8894**	*826*	**24694**	*3800*
2006	**6194**	**6732**	**5056**	**6918**	**13421**	**12926**	*1973*	**38321**	*7207*
2007	**4641**	**4923**	**3627**	**5372**	**2420**	**9565**	*762*	**20984**	*2226*
2008	**4329**	**6194**	**3043**	**6974**	**16923**	**10523**	*724*	**37463**	*6024*
2009	**4782**	**5600**	**3470**	**7096**	**4164**	**10382**	*1059*	**25111**	*4390*
2010	**5727**	**7102**	**4080**	**9484**	**20939**	**12830**	*1866*	**47334**	*9182*
2011									
2012	**6267**	**6691**	**4476**	**8008**	**15303**	**12958**	*1072*	**40744**	*5462*
2013	**5714**	**7066**	**4810**	**11870**	**9229**	**12781**	*1434*	**38689**	*5917*
2014	**8417**	**11501**	**7497**	**14533**	**30623**	**19917**	*3707*	**72570**	*15748*

GLGU	bb	total
over all years :		
n yrs =	22	22
average index =	**11729**	**39758**
std dev =	2536	13695
std err mean =	541	2920
lo 90% ci mean=	10840	34955
hi 90% ci mean=	12618	44560
loglinear slope =	0.015	0.003
SE ln slope =	0.006	0.011
Growth Rate =	**1.015**	**1.003**
lo 90% ci GR =	1.005	0.986
hi 90% ci GR =	1.024	1.021
regr resid CV =	0.176	0.333
sampl err CV =	0.105	0.175
nyrs to detect -.034 =	8.9	12.5
last 10 years:		
n yrs =	9	9
average index =	**12308**	**38434**
std dev =	3265	15498
std err mean =	1088	5166
lo 90% ci mean=	10518	29936
hi 90% ci mean=	14099	46933
loglinear slope =	0.058	0.085
SE ln slope =	0.018	0.032
Growth Rate =	**1.060**	**1.089**
lo 90% ci GR =	1.029	1.033
hi 90% ci GR =	1.092	1.148
regr resid CV =	0.163	0.287
sampl err CV =	0.114	0.165
nyrs to detect -.034 =	9.4	12.0

Figure 22. Population trend for Glaucous Gull (*Larus hyperboreus)* observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at *p*=0.10, beta set at *p*=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

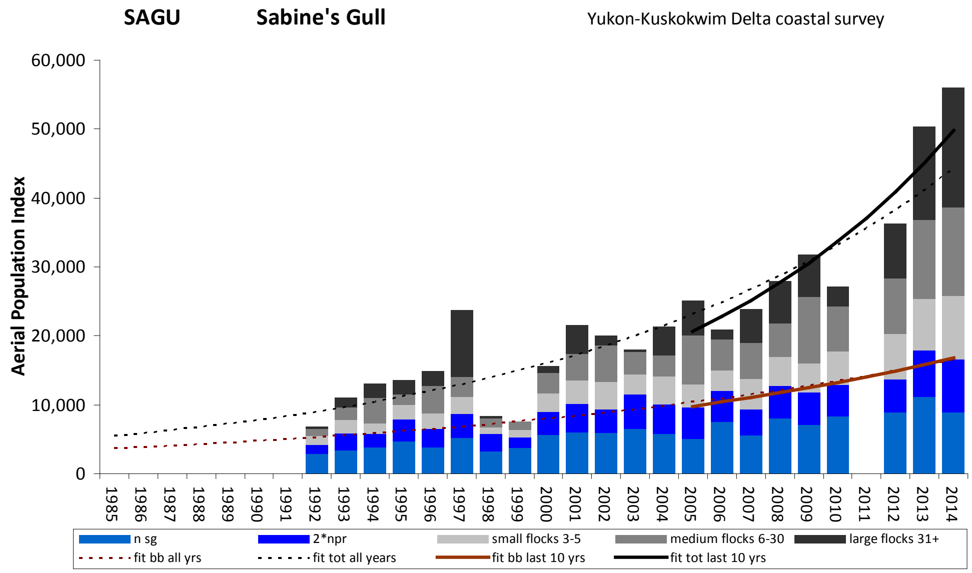


18 strata = 12,832 km² — **Aerial Index with singles =1**

0	n sg	2*npr	s flks	m flks	l flks	bb	*SE bb*	total	*SE tot*
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	3025	1792	934	238	1422	4817	*591*	7411	*1359*
1993	2349	1634	591	2088	0	3984	*469*	6663	*1459*
1994	4494	1626	1870	669	1207	6120	*609*	9866	*1368*
1995	5915	5145	1695	1653	1642	11061	*1213*	16051	*2279*
1996	3806	2651	1093	2333	2966	6457	*714*	12849	*2785*
1997	4232	2655	1188	815	1324	6887	*615*	10213	*1266*
1998	4157	2915	2403	2698	3752	7073	*589*	15926	*2691*
1999	4588	2928	1720	1488	560	7517	*1105*	11284	*1997*
2000	6041	2391	724	1385	1164	8431	*776*	11704	*1449*
2001	4499	3251	1074	1687	0	7751	*613*	10512	*1487*
2002	4997	3193	1869	2156	1068	8190	*767*	13283	*1795*
2003	5857	3208	1392	2851	937	9064	*832*	14244	*2323*
2004	5819	3267	1650	3963	285	9086	*904*	14984	*2030*
2005	6082	5497	1130	554	0	11579	*2019*	13262	*2122*
2006	6180	4321	2487	3244	0	10501	*1065*	16232	*2121*
2007	5404	3864	3038	2888	1888	9268	*806*	17082	*2487*
2008	6723	4703	1626	2337	4318	11426	*940*	19708	*3416*
2009	6735	4496	1304	1562	1861	11231	*1230*	15959	*2014*
2010	6424	3425	1496	2305	2894	9849	*1050*	16544	*3601*
2011									
2012	7561	5214	2415	3888	3622	12775	*752*	22700	*3063*
2013	8338	6418	4399	4700	1746	14756	*1490*	25601	*3340*
2014	7125	4099	3083	1823	2839	11223	*1139*	18968	*3289*

MEGU	bb	total
over all years :		
n yrs =	22	22
average index =	**9048**	**14593**
std dev =	2650	4626
std err mean =	565	986
lo 90% ci mean=	8118	12971
hi 90% ci mean=	9977	16215
loglinear slope =	0.040	0.041
SE ln slope =	0.006	0.006
Growth Rate =	**1.041**	**1.042**
lo 90% ci GR =	1.031	1.032
hi 90% ci GR =	1.051	1.053
regr resid CV =	0.177	0.188
sampl err CV =	0.103	0.157
nyrs to detect -.034 =	8.7	11.6
last 10 years:		
n yrs =	9	9
average index =	**11401**	**18451**
std dev =	1620	3785
std err mean =	540	1262
lo 90% ci mean=	10512	16375
hi 90% ci mean=	12289	20526
loglinear slope =	0.022	0.048
SE ln slope =	0.014	0.016
Growth Rate =	**1.022**	**1.049**
lo 90% ci GR =	0.999	1.022
hi 90% ci GR =	1.046	1.076
regr resid CV =	0.126	0.139
sampl err CV =	0.102	0.155
nyrs to detect -.034 =	8.7	11.5

Figure 23. Population trend for Mew Gull (*Larus canus)* observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at *p*=0.10, beta set at *p*=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

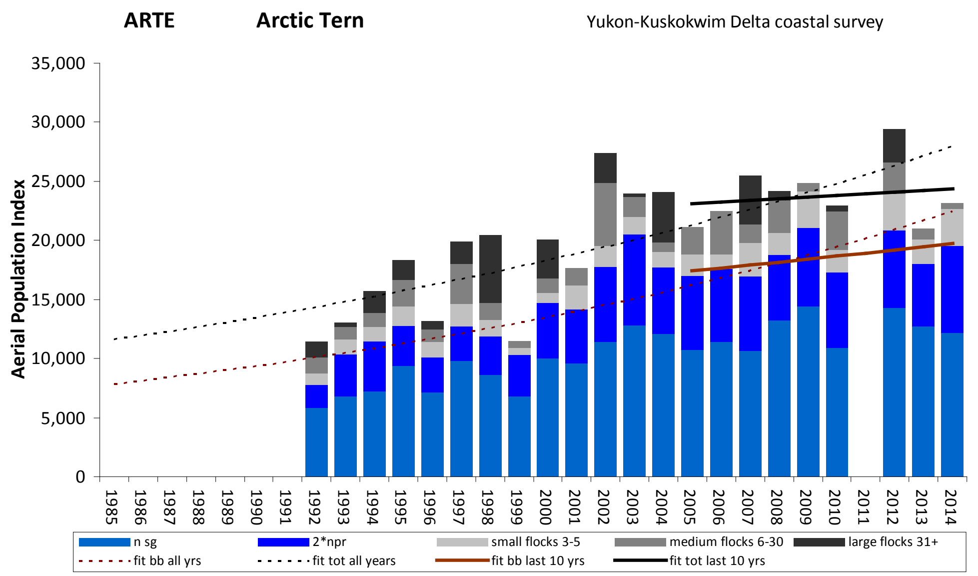


18 strata = 12,832 km² **Aerial Index with singles =1**

0	**n sg**	**2*npr**	**s flks**	**m flks**	**l flks**	**bb**	*SE bb*	**total**	*SE tot*
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	**2847**	**1404**	**1288**	**914**	**440**	**4250**	*439*	**6893**	*688*
1993	**3327**	**2560**	**1872**	**1888**	**1340**	**5887**	*564*	**10986**	*1318*
1994	**3847**	**1859**	**1626**	**3652**	**2052**	**5707**	*380*	**13036**	*1511*
1995	**4651**	**3212**	**2071**	**1600**	**2011**	**7862**	*630*	**13544**	*1887*
1996	**3863**	**2622**	**2317**	**3899**	**2172**	**6486**	*569*	**14874**	*2060*
1997	**5108**	**3532**	**2482**	**2933**	**9699**	**8640**	*698*	**23754**	*4125*
1998	**3218**	**2503**	**1009**	**1329**	**369**	**5720**	*690*	**8426**	*909*
1999	**3741**	**1594**	**1073**	**1162**	**0**	**5336**	*453*	**7570**	*778*
2000	**5642**	**3404**	**2635**	**2926**	**1032**	**9046**	*689*	**15638**	*1484*
2001	**5975**	**4100**	**3467**	**3887**	**4206**	**10075**	*975*	**21635**	*3204*
2002	**5901**	**3416**	**3982**	**5318**	**1388**	**9317**	*780*	**20005**	*2064*
2003	**6514**	**5051**	**2837**	**3250**	**406**	**11565**	*1258*	**18058**	*1681*
2004	**5753**	**4326**	**4122**	**2972**	**4144**	**10079**	*656*	**21317**	*1952*
2005	**4984**	**4653**	**3320**	**7107**	**4998**	**9636**	*658*	**25061**	*4213*
2006	**7524**	**4500**	**2997**	**4419**	**1413**	**12024**	*911*	**20853**	*1902*
2007	**5534**	**3867**	**4343**	**5163**	**5030**	**9400**	*633*	**23936**	*2497*
2008	**8053**	**4707**	**4107**	**4968**	**6184**	**12760**	*719*	**28019**	*2594*
2009	**7025**	**4688**	**4227**	**9753**	**6067**	**11713**	*685*	**31760**	*5004*
2010	**8299**	**4579**	**4839**	**6576**	**2812**	**12878**	*899*	**27104**	*2335*
2011									
2012	**8912**	**4718**	**6650**	**8004**	**7939**	**13630**	*801*	**36224**	*3722*
2013	**11106**	**6746**	**7504**	**11458**	**13539**	**17852**	*1116*	**50352**	*8748*
2014	**8851**	**7744**	**9251**	**12741**	**17464**	**16595**	*1204*	**56050**	*9007*

	SAGU bb	total
over all years :		
n yrs =	22	22
average index =	**9839**	**22504**
std dev =	3601	12612
std err mean =	768	2689
lo 90% ci mean=	8576	18081
hi 90% ci mean=	11102	26928
loglinear slope =	0.052	0.072
SE ln slope =	0.005	0.009
Growth Rate =	**1.053**	**1.075**
lo 90% ci GR =	1.044	1.059
hi 90% ci GR =	1.062	1.091
regr resid CV =	0.163	0.279
sampl err CV =	0.079	0.121
nyrs to detect -.034 =	7.4	9.8
last 10 years:		
n yrs =	9	9
average index =	**12943**	**33262**
std dev =	2824	12227
std err mean =	941	4076
lo 90% ci mean=	11395	26558
hi 90% ci mean=	14492	39967
loglinear slope =	0.060	0.098
SE ln slope =	0.012	0.016
Growth Rate =	**1.062**	**1.103**
lo 90% ci GR =	1.041	1.075
hi 90% ci GR =	1.083	1.132
regr resid CV =	0.108	0.140
sampl err CV =	0.066	0.126
nyrs to detect -.034 =	6.5	10.0

Figure 24. Population trend for Sabine's Gull (*Xema sabini)* observed on aerial transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.



18 strata = 12,832 km² — **Aerial Index with singles =1**

0	**n sg**	**2*npr**	**s flks**	**m flks**	**l flks**	**bb**	*SE bb*	**total**	*SE tot*
1985									
1986									
1987									
1988									
1989									
1990									
1991									
1992	**5816**	**1937**	**1022**	**1311**	**1329**	**7752**	*614*	**11414**	*1865*
1993	**6820**	**3517**	**1302**	**1022**	**370**	**10337**	*868*	**13031**	*1319*
1994	**7226**	**4241**	**1220**	**1208**	**1754**	**11467**	*746*	**15648**	*1391*
1995	**9347**	**3424**	**1644**	**2246**	**1711**	**12771**	*1115*	**18372**	*3301*
1996	**7133**	**2922**	**1361**	**1037**	**708**	**10055**	*1022*	**13161**	*1696*
1997	**9802**	**2935**	**1924**	**3346**	**1841**	**12737**	*944*	**19848**	*3866*
1998	**8585**	**3347**	**1347**	**1418**	**5716**	**11933**	*1239*	**20413**	*5317*
1999	**6757**	**3547**	**645**	**547**	**0**	**10304**	*798*	**11497**	*952*
2000	**10000**	**4680**	**845**	**1277**	**3318**	**14680**	*1018*	**20120**	*3584*
2001	**9592**	**4581**	**1994**	**1493**	**0**	**14173**	*1153*	**17659**	*1577*
2002	**11437**	**6372**	**1711**	**5324**	**2528**	**17809**	*1456*	**27372**	*3536*
2003	**12840**	**7694**	**1441**	**1677**	**285**	**20534**	*1659*	**23937**	*2027*
2004	**12085**	**5611**	**1371**	**718**	**4271**	**17696**	*1270*	**24055**	*3418*
2005	**10723**	**6276**	**1862**	**2259**	**0**	**17000**	*1516*	**21121**	*2505*
2006	**11392**	**6144**	**1290**	**3645**	**0**	**17536**	*1825*	**22471**	*3248*
2007	**10635**	**6286**	**2903**	**1545**	**4098**	**16921**	*936*	**25467**	*2895*
2008	**13239**	**5519**	**1921**	**2716**	**749**	**18758**	*1240*	**24144**	*2443*
2009	**14446**	**6595**	**3108**	**681**	**0**	**21041**	*1432*	**24829**	*1798*
2010	**10926**	**6350**	**1877**	**3307**	**499**	**17275**	*1468*	**22958**	*2624*
2011									
2012	**14274**	**6562**	**3116**	**2627**	**2849**	**20835**	*1303*	**29427**	*2964*
2013	**12735**	**5285**	**2055**	**917**	**0**	**18020**	*927*	**20993**	*1722*
2014	**12194**	**7355**	**3166**	**433**	**0**	**19549**	*1480*	**23147**	*2197*

ARTE	bb	total
over all years :		
n yrs =	22	22
average index =	**15417**	**20504**
std dev =	3960	5050
std err mean =	844	1077
lo 90% ci mean=	14029	18733
hi 90% ci mean=	16806	22275
loglinear slope =	0.036	0.030
SE ln slope =	0.005	0.006
Growth Rate =	**1.037**	**1.031**
lo 90% ci GR =	1.029	1.020
hi 90% ci GR =	1.045	1.041
regr resid CV =	0.145	0.188
sampl err CV =	0.078	0.126
nyrs to detect -.034 =	7.3	10.0
last 10 years:		
n yrs =	9	9
average index =	**18548**	**23840**
std dev =	1599	2588
std err mean =	533	863
lo 90% ci mean=	17671	22421
hi 90% ci mean=	19425	25259
loglinear slope =	0.014	0.006
SE ln slope =	0.009	0.012
Growth Rate =	**1.014**	**1.006**
lo 90% ci GR =	1.000	0.986
hi 90% ci GR =	1.029	1.026
regr resid CV =	0.077	0.110
sampl err CV =	0.073	0.105
nyrs to detect -.034 =	7.0	8.9

Figure 25. Population trend for Arctic Tern (*Sterna paradisaea)* observed on aerial transects sampling 12,832 km² of the coastal Yukon-Kuskokwim Delta. The total aerial index is the sum of birds observed as singles, birds in pairs, and all birds in flocks of 3-5, 6-30, and 31 or more. Average annual growth rate was calculated by log-linear regression. The power to detect a significant growth rate of -0.034, a 50% decline in 20 years, if it were to occur, used alpha set at p=0.10, beta set at p=0.20, and a coefficient of variation based on regression residuals or average annual sampling error.

Table 1. Number of birds sighted by category and expanded numbers for waterbirds counted by the right-rear-seat observer on the June 2014 Yukon Delta Coastal Zone aerial survey, Alaska. Species sorted in order of decreasing population estimates for ducks, then for other species. Survey area = 12,831.5 km^2 and sampled area = 469.7 km^2. Number of transects (n) = 235. 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	550	190	432	1,912	2.65	33,981	4,016	3.05	**103,642**
Greater scaup	89	360	170	979	2.21	28,368	2,820	1.93	**54,750**
Spectacled eider	212	116	5	661	0.46	5,879	541	3.58	**21,047**
Northern shoveler	33	13	15	107	0.25	3,158	848	3.79	**11,969**
Black scoter	25	86	95	317	0.77	9,916	1,382	1.17	**11,602**
Mallard	43	8	0	102	0.17	2,207	425	4.01	**8,850**
Long-tailed duck	40	48	12	188	0.34	4,331	666	1.87	**8,099**
Common eider	66	39	5	215	0.16	2,022	499	3.58	**7,239**
American green-winged teal	7	3	0	20	0.06	814	339	8.36	**6,805**
American wigeon	6	7	17	43	0.06	780	314	3.84	**2,995**
Red-breasted merganser	9	13	11	55	0.09	1,200	511	1.27	**1,524**
Canvasback	0	0	0	0	0.00	0	0	2	**0**
Glaucous gull	511	330	2,798	3,969	5.66	**72,570**	15,748	unknown	n/a
Sabine's gull	835	344	2,704	4,227	4.37	**56,050**	9,007	unknown	n/a
Arctic tern	704	185	152	1,226	1.80	**23,147**	2,197	unknown	n/a
Mew gull	457	127	615	1,326	1.48	**18,968**	3,289	unknown	n/a
Pacific loon	337	150	33	670	1.07	**13,720**	1,268	unknown	n/a
Red-throated loon	70	42	17	171	0.21	**2,644**	428	unknown	n/a
Jaeger species	44	8	3	63	0.13	**1,693**	351	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 2013 and from the long-term average (1988-2013), sorted in decreasing order of percent change from long-term average, first for waterfowl and then for other species.

Species	Population estimate 2013	Population estimate 2014	Change between 2013 and 2014	Long term (1988-2013) average population estimate	Change between 2014 and long term average
Spectacled eider	24,373	21,047	-14%	12,358	70%
Common eider	7,343	7,239	-1%	4,761	52%
Black scoter	14,501	11,602	-20%	11,887	-2%
Greater scaup	46,750	54,750	17%	70,377	-22%
Red-breasted merganser	1,054	1,524	45%	2,070	-26%
Long-tailed duck	9,253	8,099	-12%	11,248	-28%
Northern pintail	115,479	103,642	-10%	150,313	-31%
Mallard	11,753	8,850	-25%	16,236	-45%
Northern shoveler	12,465	11,969	-4%	34,720	-66%
Green-winged teal	12,582	6,805	-46%	22,639	-70%
American wigeon	7,549	2,995	-60%	17,560	-83%
Canvasback	165	0	-100%	2,384	-100%
Sabine's gull	50,352	56,050	-58%	20,907	168%
Glaucous gull	38,689	72,570	-1%	38,195	90%
Mew gull	25,601	18,968	-44%	14,385	32%
Arctic tern	20,993	23,147	-3%	20,378	14%
Red-throated loon	2,352	2,644	1%	2,386	11%
Pacific loon	19,043	13,720	-13%	16,513	-17%
Jaeger spp.	2,815	1,693	-23%	2,163	-22%

Table 3. Summary of trends for waterbird species counted by the right-back-seat observer on the Yukon-Kuskokwim Delta coastal zone aerial survey Alaska. Ducks have been counted from 1988 to 2014 (except no survey in 2011). 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.

species name	Sppn	Meas	N yrs	Mean	Std dev	Log-linear slope	SE slope	**Growth Rate**	Low 90% CI GR	High 90% CI GR	Regress. resid CV	Sampling error CV	N yrs w/ resid CV	N yrs w/ sampling err CV	**GR last 10 yrs**	Low 90% CI 10 yr	High 90% CI 10 yr
1985-2014																	
Spectacled Eider	SPEI	ind.total	26	**3545**	1742	0.0634	0.0052	**1.065**	1.056	1.075	0.204	0.126	13.8	10.0	**1.040**	1.020	1.060
Common Eider	COEI	ind.total	26	**1357**	548	0.0355	0.0095	**1.036**	1.020	1.052	0.372	0.232	20.6	15.1	**1.010**	0.969	1.053
Red-throated Loon	RTLO	total	25	**2397**	719	-0.0019	0.0096	**0.998**	0.983	1.014	0.355	0.166	20.0	12.1	**0.930**	0.862	1.003
Pacific Loon	PALO	total	25	**16401**	3135	0.0040	0.0053	**1.004**	0.995	1.013	0.196	0.089	13.5	8.0	**0.981**	0.952	1.011
Mallard	MALL	ind.total	26	**3978**	1452	-0.0128	0.0084	**0.987**	0.974	1.001	0.329	0.217	19.0	14.4	**0.917**	0.875	0.961
American Wigeon	AMWI	ind.total	26	**4427**	2282	-0.0517	0.0113	**0.950**	0.932	0.967	0.442	0.366	23.1	20.4	**0.942**	0.855	1.038
Green-winged Teal	AGWT	ind.total	26	**2635**	1005	-0.0154	0.0112	**0.985**	0.967	1.003	0.439	0.236	23.0	15.2	**0.908**	0.837	0.986
Northern Shoveler	NSHO	ind.total	26	**8930**	3623	-0.0301	0.0114	**0.970**	0.952	0.989	0.446	0.183	23.3	12.9	**0.836**	0.781	0.894
Northern Pintail	NOPI	ind.total	26	**48695**	13291	-0.0110	0.0067	**0.989**	0.978	1.000	0.261	0.113	16.3	9.3	**0.983**	0.937	1.032
Canvasback	CANV	ind.total	26	**942**	1037	-0.1438	0.0346	**0.866**	0.818	0.917	1.361	0.594	48.9	28.2	**0.785**	0.627	0.983
Scaup spp.	SCAU	total	26	**35842**	6181	0.0009	0.0047	**1.001**	0.993	1.009	0.186	0.104	13.0	8.8	**0.958**	0.933	0.983
Long-tailed Duck	LTDU	ind.total	26	**5950**	1608	-0.0076	0.0070	**0.992**	0.981	1.004	0.276	0.147	16.9	11.1	**0.958**	0.921	0.997
Black Scoter	BLSC	ind.total	26	**10150**	2359	0.0073	0.0078	**1.007**	0.994	1.020	0.304	0.192	18.0	13.3	**0.989**	0.956	1.023
Red-breasted Merganser	RBME	ind.total	26	**1614**	3407	0.0809	0.0287	**1.084**	1.034	1.137	1.125	0.469	43.1	24.1	**0.909**	0.714	1.157
Jaeger spp	JAEG	total	22	**2142**	539	-0.0119	0.0076	**0.988**	0.976	1.001	0.244	0.176	15.6	12.5	**1.014**	0.963	1.067
Glaucous Gull	GLGU	total	22	**39758**	13695	0.0032	0.0108	**1.003**	0.986	1.021	0.333	0.175	19.2	12.5	**1.089**	1.033	1.148
Mew Gull	MEGU	total	22	**14593**	4626	0.0411	0.0061	**1.042**	1.032	1.053	0.188	0.157	13.1	11.6	**1.049**	1.022	1.076
Sabine's Gull	SAGU	total	22	**22504**	12612	0.0721	0.0091	**1.075**	1.059	1.091	0.279	0.121	17.0	9.8	**1.103**	1.075	1.132
Arctic Tern	ARTE	total	22	**20504**	5050	0.0303	0.0061	**1.031**	1.020	1.041	0.188	0.126	13.1	10.0	**1.006**	0.986	1.026