Relative Abundance and Trends of Waterbirds from Aerial Breeding Pair Surveys, 1988 to 2002, on the coastal zone of the Yukon Kuskokwim Delta, Alaska

photo by Paul Anderson

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Abstract: Fifteen years (1988-2002) of annual aerial surveys for breeding waterfowl have been flown on the coastal zone of the Yukon Kuskokwim delta. This report summarizes data collected by the observer in the back seat of the aircraft. Northern pintails (*Anas acuta*), greater scaup (*Aythya marila*), and northern shovelers (*Anas clypeata*) were the most numerous waterfowl species averaging 155,557, 69,328, and 36,431 birds (with visibility correction), respectively, for the history of the survey. However, the 2002 population estimates for pintails, mallards (*Anas platyrhynchos*), and American wigeon (*Anas americana*) were the lowest in the history of the survey. The average number for four species of special concern, the threatened spectacled eider (*Somateria fisheri*), long-tailed duck (*Clangula hyamelis*), black scoter (*Melanitta nigra*) and red-throated loon (*Gavia stellata*), was 8,485, 11,759, 11,470, and 2,327, respectively. After pintails, scaup, and shovelers, other waterfowl species in decreasing order of abundance were American green-winged teal (*Anas crecca*), American wigeon, mallard, long-tailed duck, black scoter, spectacled eider, common eider (*Somateria mollissima*), and canvasback (*Aythya valisineria*). Very small numbers of goldeneyes (*Bucephala* spp), mergansers (*Mergus* spp), common loons (*Gavia immer*), and red-necked grebes (*Podiceps grisegena*) were seen on the surveys. The average population size for glaucous gull (*Larus hyperboreus*), mew gull (*Larus canus*), and Sabine's gull (*Xema sabini*) was 41,863, 11,432, and 14,215, respectively, with all three gull species showing an increasing population trend. Population trends based on log-linear regression and power analysis were significantly declining for mallards and American wigeon at the 0.10 level. Significantly increasing populations occurred for spectacled eiders, common eiders, greater scaup, and red-breasted mergansers (*Mergus serrator*). Over 74,000 geographic locations of 33 species of waterbirds have been collected and incorporated into a geographic information system for research and management purposes.

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Annual aerial surveys of breeding waterbirds on the coastal zone of the Yukon-Kuskokwim Delta, Alaska provide population indices, trends, and distributions for use by biologists and land managers. Since 1985, intensive systematic aerial surveys have been conducted to monitor populations of several goose species that had declined. The initial surveys consisted of a pilot/observer in the left front seat and an additional observer in the right front seat of the aircraft, each counting geese, swans, and cranes.

In 1988, an observer in the right rear seat was added to record other species and begin monitoring their populations. This was done because it was too difficult for the front seat observers to record the large numbers of birds of all species on the Yukon Delta. The objective for the back seat observer was to document the relative abundance, trend, and distribution of ducks, gulls, terns (*Sterna* spp.), grebes, jaegers (*Stercorarius* spp.), and loons. These surveys have been primarily used to monitor the threatened spectacled eider population and other species of concern such as the red-throated loon, black scoter, and long-tailed duck. Our objective in this report is to summarize the population indices and trends for all species recorded by the rear seat observers from 1988 to 2002.

METHODS

Survey Design

The survey area included the coastal tundra from Norton Sound in the north to Kuskokwim Bay in the south and extended from the west coast to about 50 km inland. This area was divided into 18 strata by identifying areas of generally homogeneous physiographic features from unclassified LANDSAT images at 1:250,000 scale. The survey area encompassed 12,832 km^2. The survey was originally designed to optimize monitoring of declining goose populations. We used a True BASIC program and ARC/INFO geographic information system (GIS) software to generate systematically-spaced transects from a random coordinate within the survey area. Transects were oriented east west along great circle routes and totaled about 2,500 kms (Fig. 1) for a sample of about 1,000 km^2. Strata known to have higher numbers of waterfowl were allocated more transects. Prior to 1998, we used a 1.61-kilometer transect spacing in the higher density areas. Transects in other strata with fewer waterfowl were spaced at 3.22, 6.44, or 12.88 kilometers. The survey design changed slightly in number and placement of transects over the years. Since 1998, the transects have been spaced at 1.60, 3.20, 6.40, or 12.80 km within the various strata. A different set of transects was flown in each year, 1998-2001, such that we obtained complete coverage in the 1.60 km interval strata when combining data from those four years. The 2002 transects were the same as the ones flown in 1998.

Data Collection

Survey methods followed the conventions established for breeding ground surveys in North America (USFWS and CWS 1987). The surveys were generally flown during the first 2 weeks of June to coincide with egg-laying or early incubation stages of breeding waterfowl (Fig. 2). The Cessna 206 amphibious 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, 1992-2002) and survey maps to maintain a precise course while flying transects.

Data collection prior to 1998 used cassette recorders running continuously while on the transects (Butler et al. 1995). Since 1998, the observer used a computerized data collection program called GPS Voice Survey written by John Hodges (USFWS, Migratory Bird Management, Juneau, Alaska). This system consisted of a notebook computer connected with a GPS receiver and a remote microphone and mouse. The observer recorded transect numbers, start and stop points, cardinal direction of the transect start, and bird observations out to 200 meters into the computer to a .WAV sound file using the remote microphone and mouse. Birds observed were identified to species and counted as a single, pair, or number in flock. Simultaneously, latitude/longitude coordinates for each observation were automatically downloaded from the GPS to a text file. A computer transcription program was used to replay the sound files, enter header information (e.g. year, month, day, observer initials, etc), species codes, group sizes and combine these with the coordinate information to produce a final data file. Karen Bollinger was the observer in 1988 and 1989, Leslie Slater observed in 1990, and Bob Platte has collected the data since 1991.

We collected fifteen years (1988 to 2002) of aerial counts of duck species but data on other waterbird species were not collected in all years. Jaegers were recorded in 1989, then 1993 to 2002. Loons were recorded from 1989 to 2002. Gulls and terns were recorded from 1992 to 2002. The back seat observer was unable to collect data on thirteen transects north of the Askinuk Mountains in 1997. Data from the 1996 survey for those transects were added to the 1997 data set to make up for the missing transects. Twenty three transects were not flown in 1999. Thus, the 1999 population indices may be biased for some strata with missing transects. However, the survey was generally flown by skipping some transects early in the survey, then doing them later to spread the effort out over time. Thus while some transects were missed in some strata in 1999, the transects flown were relatively systematically spaced. The back seat observer was unable to fly thirteen transects in the central coastal zone and the 23 transects north of the Askinuk Mountains in 2001. No data were collected for the 13 mid-coast transects, however, William Eldridge, in the right front seat, recorded observations for all species on the 23 transects north of the Askinuk Mountains. This was accomplished because of the relatively lower number of geese, swans, and cranes north of the Askinuk Mountains. All transects were flown for the 2002 survey. Because of the threatened status of spectacled eiders, the two front seat observers began to record observations of this species in 1995.

Data Analysis

We calculated densities, population indices, and variability for each species using a ratio estimate described by Cochran (1977). Duck population indices were based on indicated total birds: 2*(S+P)+F where S = number of single birds observed, P = number of bird pairs observed, and F = number of birds in flocks. For ducks, a single male was assumed to represent a breeding pair with the nesting hen not easily observable. Single male ducks were doubled for all observed species except scaup. Single observations of other waterbird species (grebes, loons, terns, and gulls) were not doubled. Population indices were calculated for each year for 18 strata and summed for the entire survey area. This stratified analysis was done to try to reduce the variance of the indices. Population index variance was based on the variation among sampling units (entire transects). Population indices in this report were not corrected for visibility bias unless noted.

The population index was plotted for each year by species and included the singles, pairs, and flock components. The 95% confidence interval, indicated by a vertical line, around each annual index was calculated as the ratio estimator variance among the transects (sampling error) within each of the 18 physiographic strata. This sampling standard error divided by the mean index estimated the annual coefficient of variation (CV) of the population index. The average of the estimated annual CVs provided a measure of average survey precision, the sampling error CV. The trend was the average rate of log-linear population change (Stehn 1993). Trend lines were presented for indicated total birds (ducks) or observed total birds (species other than ducks).

The residuals around the regression line provided another estimate of survey precision, a residual CV that included both sampling error and lack-of-fit error. A standardized measure of the relative precision of the aerial survey for each species can be calculated from the approximate formula of Gerrodette (1987) that relates sample size, slope, CV, and probabilities for Type 1 and Type 2 errors. With alpha and beta at 0.10, if the population grew with a slope of 0.0693 (50% change in numbers over 10 years) and the estimated sampling error CV was accurate, the minimum years needed to detect a slope significantly different from 0.0 was calculated.

The number of Spectacled Eider observations recorded on the early June Yukon-Kuskokwim aerial survey depends on both population size and timing of the survey relative to chronology of nesting. We assumed a constant detection rate of male eiders over time (both within and between years), and also assumed the proportion of males remaining to be seen progressively declines after clutch completion. We used multiple regression to examine the effect of survey timing on the population trend of spectacled eiders. We also used the relationship between survey timing and population size to adjust the growth rate after removing the timing effect.

RESULTS

Relative abundance

Relative abundance indices by group category for species with sufficient data are shown in Figs. 3 - 22, with long term averages listed in Table 1. None of the population indices in these figures was corrected for visibility bias (detection rate). For the following results, we used the correction factors determined by helicopter-fixed wing aircraft comparisons (Conant et al. 2000). Based on the fifteen-year average population indices for each species corrected for detection rate, the most abundant species was northern pintail (155,557), followed by greater scaup (69,328), then northern shoveler (36,431). The average number for four species of special concern, the threatened spectacled eider, long-tailed duck, black scoter, and red-throated loon, was 8,485, 11,759, 11,470, and 2,327, respectively. Spectacled eider numbers in the previous summary report (Platte and Stehn 2002) are slightly different for some years compared to the numbers in this report (Fig. 3). This is because a few single spectacled eider hens were previously included in the population estimate calculations. The new numbers do not include single spectacled eider hens. Very small numbers of canvasbacks, goldeneyes, mergansers, common loons, and red-necked grebes were seen on the surveys.

Corrected for visibility, the number of pintails and scaup for 2002 was 87,684 and 66,548, respectively. The 2002 estimates for pintails, mallards, and wigeon were the lowest in the history of the survey. Remaining waterfowl species in decreasing order of abundance for 2002 were northern shoveler, American green-winged teal, spectacled eider, long-tailed duck, mallard, black scoter, common eider, American wigeon, canvasback, and red-breasted merganser.

Population trend/power analysis

Mallards and American wigeon showed a relatively strong decreasing trend (Figs. 7 and 8 and Table 1). Significantly increasing trends occurred for common eiders, spectacled eiders, scaup, and Pacific loons. Other species showed relatively stable trends over the survey period.

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Spectacled eider population, trend, and survey timing

The number of indicated total spectacled eiders from the aerial survey in 2002 was 4,049 birds or 2,025 pairs (uncorrected for visibility bias). The spectacled eider nest estimate for the entire coastal zone from the ground study in 2002 was 2,831 (Bowman et al. 2002). Corrected with a nest detection rate of 78% (T. Bowman, unpub. data), the nest population estimate was 3,629. Thus the proportion of aerial pairs to nests was 0.56. If the ground nest estimate is assumed to represent the true population, then the aerial visibility correction factor would be 1.79. Spectacled eider nesting chronology was about 1 week earlier in 2002 than the long-term ground plot average with less fox predation and higher nest success than in 2001 (Bowman et al. 2002). The population growth rate for aerial indicated total birds from 1988 to 2002 was 1.076 (Fig. 23). The growth rate for the nest population from ground studies during this same period was 0.98.

Plotting the aerial index data against year showed an average increasing trend of 170 more birds each year (Fig. 24), or a 0.0728 slope for the log of population size, 7.6% annual growth rate (Fig. 25). Plotting the aerial index of population size against the average date of the survey period before average spectacled eider hatch (earlier survey timing) showed an increasing trend of 121 more birds for each day earlier or 0.050 slope (5.1% growth rate) per day. The question arises as to which factor is more important in explaining the observed data, or what would the growth rate be if the timing of the survey were constant.

Multiple regression with both variables in a linear model indicated the regression coefficients were 149 per year + 45 per day. Using the log of the population index, the best fit indicated 0.065 per year + 0.017 per day. The survey timing effect coefficient was not significant when year was in the model. Because more unexplained variation remains after regression with timing days compared to year, the multiple regression model favors the year effect. This analysis indicated that the population growth rate is still 6.7% (slope = 0.06507 ± 0.01615 SE) per year with the timing coefficient as part of the model compared to 7.5% growth (slope = 0.07307 ± 0.00126 SE) without a timing effect.

Perhaps the timing effect is real, and the poorer fit is simply caused by measurement error rather than any lack of strength in a biologically valid relationship. The best linear and quadratic models (upper right graphs) for relating the population index (Fig. 24) and the log of the population index (Fig. 25) were therefore used to calculate the predicted population index for each survey date. The residuals of the observed population minus the predicted population were then plotted against year for a linear (lower left) and a quadratic relationship (lower right) to remove the influence of survey timing. The average population residuals still grew at an average of 113 or 93 birds per year, or on a log scale, the slope averaged 0.0497 and 0.0413 per year. Thus, the minimum observed population growth rate would be 4.2% per year even after adjustment for survey timing.

Distribution

The geographic locations of over 74,000 observations of 33 species of waterbirds have been collected over the 15 years of this survey. These spatial data have been incorporated into a GIS database for research and management purposes. Average location accuracy of the observations when the surveys were flown using LORAN for navigation was within 367 meters along transect compared to 214 meters when using the GPS (Butler et al. 1995). Locations of the various species observed during the 2002 survey are given in Figs. 26-33.

DISCUSSION

Three different observers have collected data for this survey, although the same observer has collected the last 12 years data. All observers were experienced at identifying and counting birds from aircraft, however, there was the possibility of a "learning curve" for some species and that an observer became more skilled over time resulting in more accurate information in later years. Thus, both relative abundance indices and population trends could be affected by this. Trends can be statistically significant but still not reflect actual population change. As the observer gained experience on the area, species identification and counting of groups probably improved. However, the long-term trends were influenced by the low counts in the early years. It is difficult to determine whether the trends reflect actual population growth or are attributable to this or other potential errors in the survey. Strip width may vary both within a survey and between years although an effort was made to be consistent. Some proportion of each species was missed each year due to various factors such as weather. It was assumed that the proportion was constant year to year for the trend calculations. The trends could be biased if this assumption was not true.

Timing of surveys was also a factor potentially affecting trend. The survey was supposed to be timed according to annual phenology to coincide with the first half of incubation for geese nesting in the area. However, we were not always able to time our surveys optimally. In some years, surveys were early relative to breeding chronology and phenology, whereas other years surveys were late relative to these factors. To get the best trend information, the surveys should be timed consistently relative to nesting chronology every year. Spectacled eider males begin to depart the breeding grounds shortly after the hens begin incubating so the survey misses an unknown portion of these males. If the survey timing was late relative to phenology, a greater proportion of spectacled eiders had departed resulting in a lower population index for that year (Platte and Stehn 1999 and Fig. 25). Thus, the true growth rate may be lower than reported here.

The discrepancy between the trend in nests (Bowman et al. 2002) and the trend in aerial estimates is due partly to a decline in nests from 1988-1993. The growth rate of number of nests from 1993-2002 has been slightly increasing. Since 1993, the nests estimates and aerial birds estimates track very closely, except for 2001, a poor production year. The number of spectacled eider pairs detected during the aerial survey in 2001 was the highest in the history of the survey. This may have been due to increased visibility of the birds because of high fox predation and/or late nesting chronology

The large number of geographic locations of birds has been useful for a number of purposes. Distribution information has been used to evaluate coastal zone areas for potential inclusion as designated critical habitat for spectacled eiders. Density distribution maps have been used to evaluate potential land exchange impacts on waterbirds. Survey information has been incorporated into Birds of North America species accounts for Sabine's gulls. Loon information has been contributed to the Loon Working Group for baseline monitoring and red-throated loon ground work. Seaduck trends were useful for comparison with other information in evaluating population status.

The survey was originally designed to monitor geese. Because the distribution of Cackling Canada geese coincided with that of the spectacled eider, the survey was stratified appropriately for spectacled eiders. However, the sampling intensity was low for other sea duck species because they occurred farther inland, which was sampled only every 12.80 km.

RECOMMENDATIONS

Currently there are two survey efforts to monitor the spectacled eider population on the Yukon Delta: the coastal zone aerial survey and the nest plot survey. Because the nest plot survey does not sample the entire coast, it is necessary to continue the aerial survey to expand the nest estimate. Conversely, since not all eiders are seen from the air, the nest plot study provides a visibility correction factor for the aerial data. We believe these two surveys are highly complementary and provide more detailed information when analyzed together than either one alone for monitoring the spectacled eider population.

The aerial survey provided information on other species of interest. However, the information is limited because these species range beyond the coastal zone. Long-tailed ducks, scoters, and scaup are abundant in more inland strata that were not sampled as intensively. If more detailed information is desired for these species, we need to allocate more effort in this area. We should examine the effect of decreasing the number of transects in high intensity sample strata to determine effect on precision of cackling Canada goose population estimates by subsampling existing data. If these strata could be sampled at a lower rate, then we could increase sampling in inland strata to obtain better information on seaducks such as long-tailed ducks, black scoters, and greater scaup.

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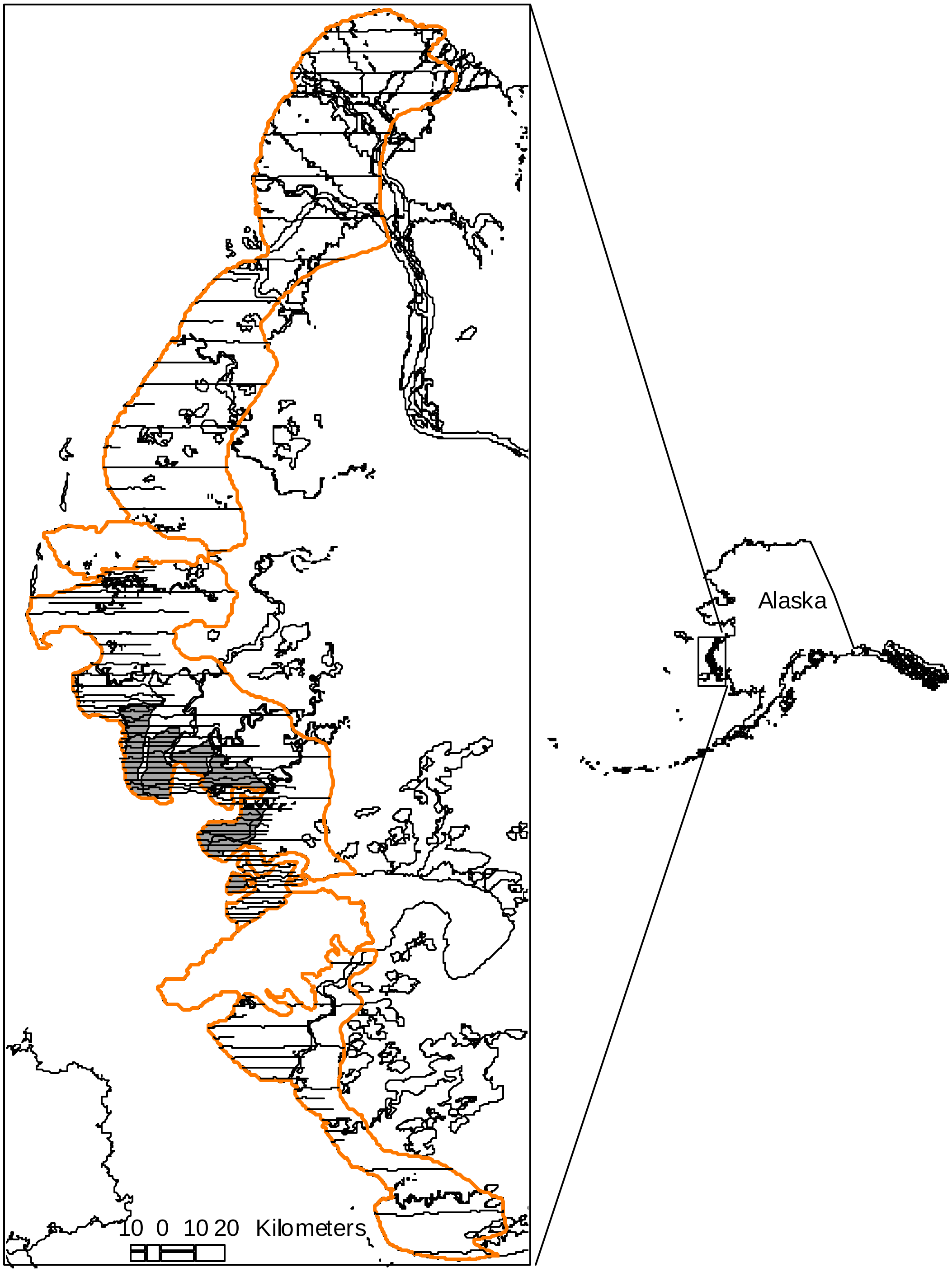


Fig. 1. 2002 aerial strip transects of 200 meter width (horizontal lines) and nest survey area (shaded) on the coastal zone of Yukon Delta NWR, Alaska.

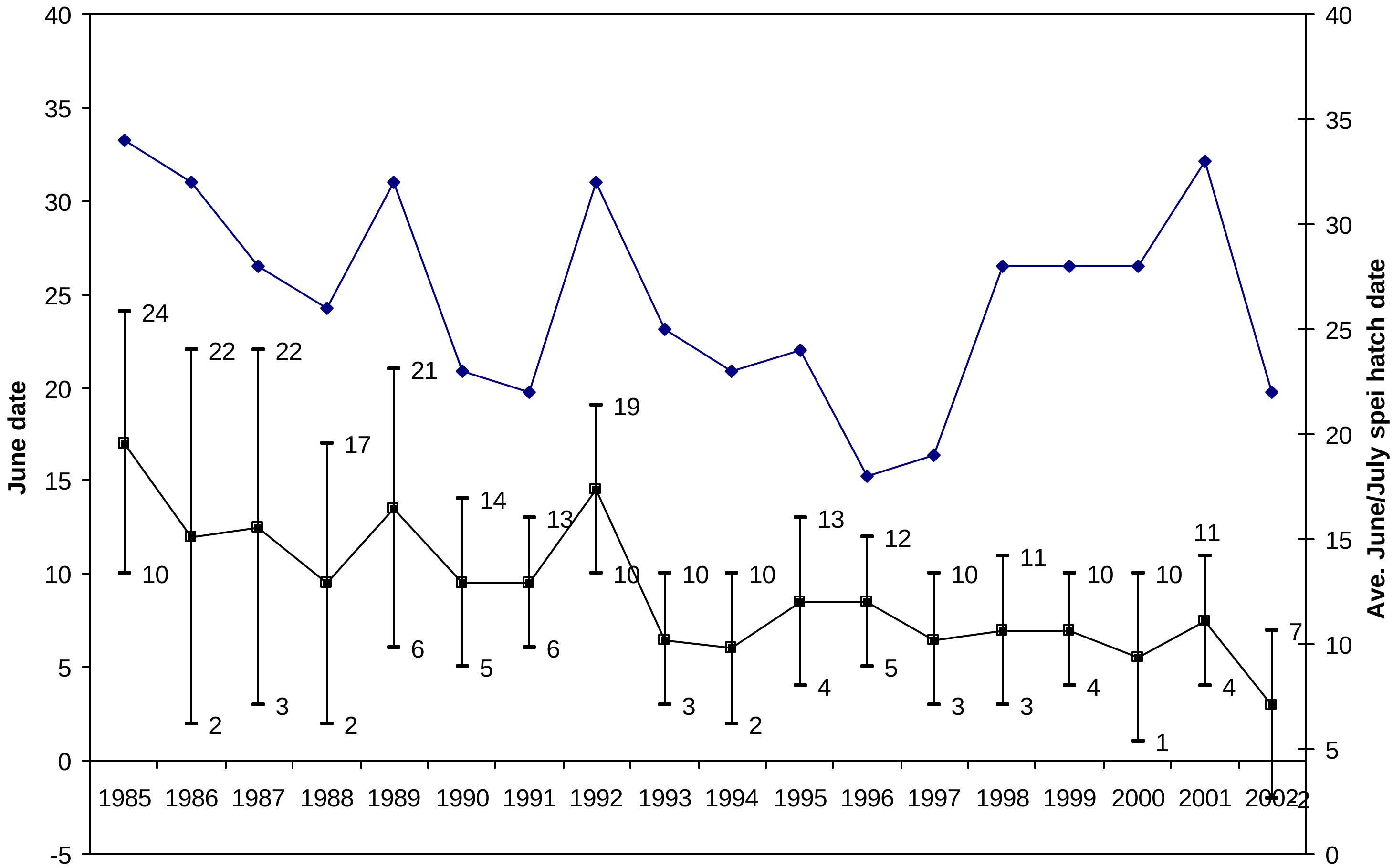
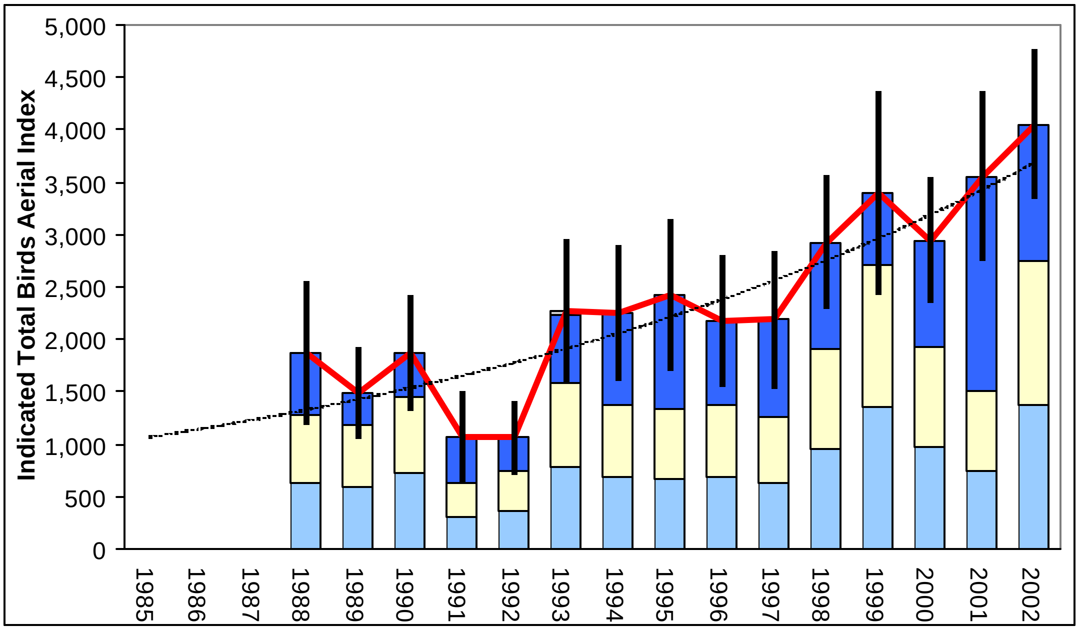


Fig. 2. Timing and duration of the coastal zone aerial survey in relation to average spectacled eider hatch date from ground surveys (Bowman et al. 2002), Yukon-Kuskokwim Delta, Alaska, 1985-2002.

Spectacled Eider



Aerial index: Indicated total birds — SPEI

year	2*sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	1272	602	0	**1874**	349
1989	1188	302	0	**1490**	222
1990	1450	422	0	**1872**	284
1991	630	446	0	**1075**	222
1992	748	318	0	**1066**	180
1993	1588	640	42	**2271**	347
1994	1386	866	0	**2252**	331
1995	1334	1092	0	**2426**	366
1996	1374	802	0	**2176**	324
1997	1262	930	0	**2192**	334
1998	1906	1014	0	**2920**	326
1999	2702	690	0	**3393**	493
2000	1938	1008	0	**2945**	305
2001	1500	2048	0	**3549**	413
2002	2740	1310	0	**4049**	362

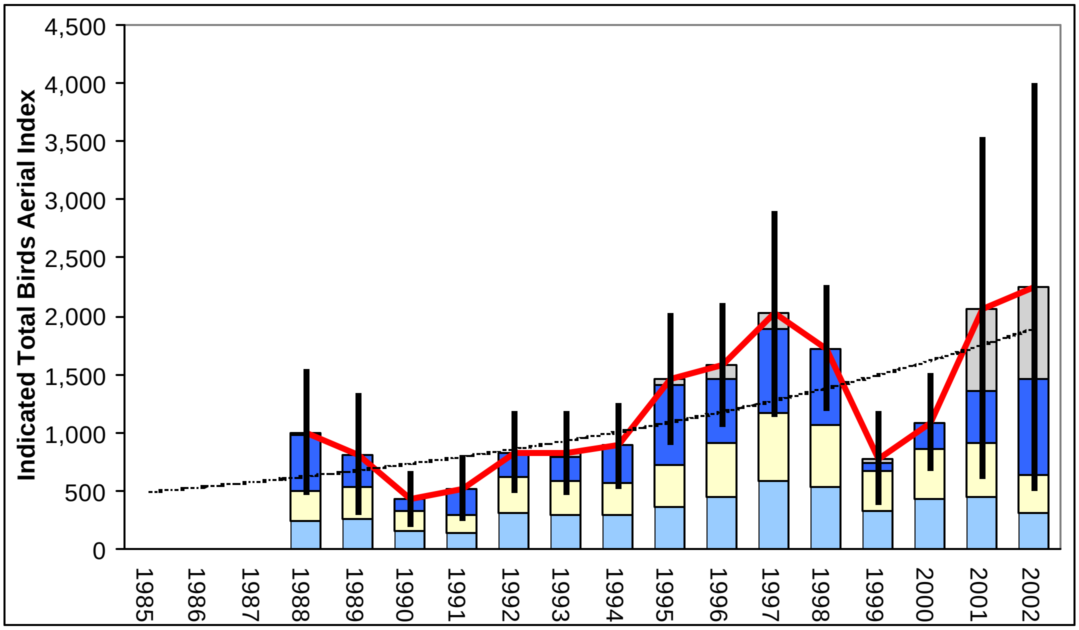
n =	15
mean =	2370
slope =	0.0728
SE slope =	0.0141
Growth Rate =	**1.0755**
low 90%ci GR =	1.0509
high 90%ci GR =	1.1007
regression residual CV =	0.2358
avg sampling error CV =	0.1454

min yrs to detect 50%/10yr change:

w/ regression resid CV =	10.6
w/ sampling error CV =	7.7

Figure 3. Population trend for Spectacled Eiders (*Somateria fischeri*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Common Eider



Aerial index: Indicated total birds

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	496	476	33	**1005**	275
1989	530	280	0	**810**	267
1990	324	102	0	**427**	122
1991	292	232	0	**525**	143
1992	620	210	0	**829**	180
1993	588	198	42	**829**	184
1994	578	312	0	**888**	190
1995	724	680	58	**1463**	291
1996	910	556	115	**1580**	272
1997	1172	722	126	**2019**	447
1998	1064	662	0	**1727**	278
1999	670	70	43	**783**	207
2000	870	222	0	**1091**	213
2001	904	460	706	**2070**	751
2002	636	818	801	**2255**	893

COEI

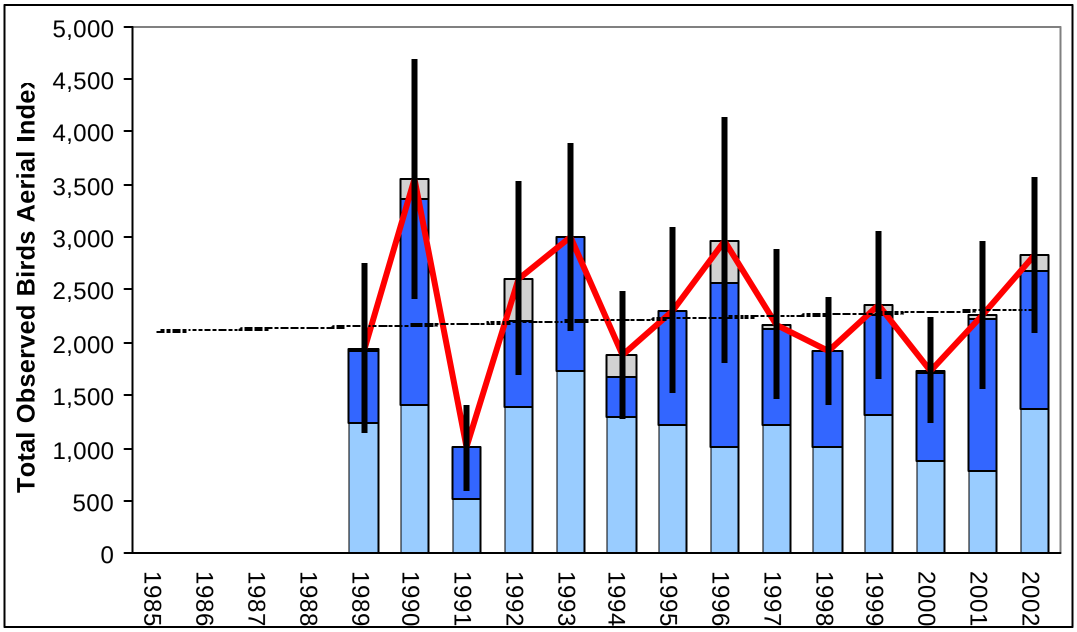
n =	15
mean =	1220
slope =	0.0791
SE slope =	0.0223
Growth Rate =	**1.0823**
low 90%ci GR =	1.0432
high 90%ci GR =	1.1227
regression residual CV =	0.3737
avg sampling error CV =	0.2524

min yrs to detect 50%/10yr change:

w/ regression resid CV =	14.4
w/ sampling error CV =	11.1

Figure 4. Population trend for Common Eiders (*Somateria mollissima*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Red-throated Loon



Aerial index: Total birds observed

RTLO

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

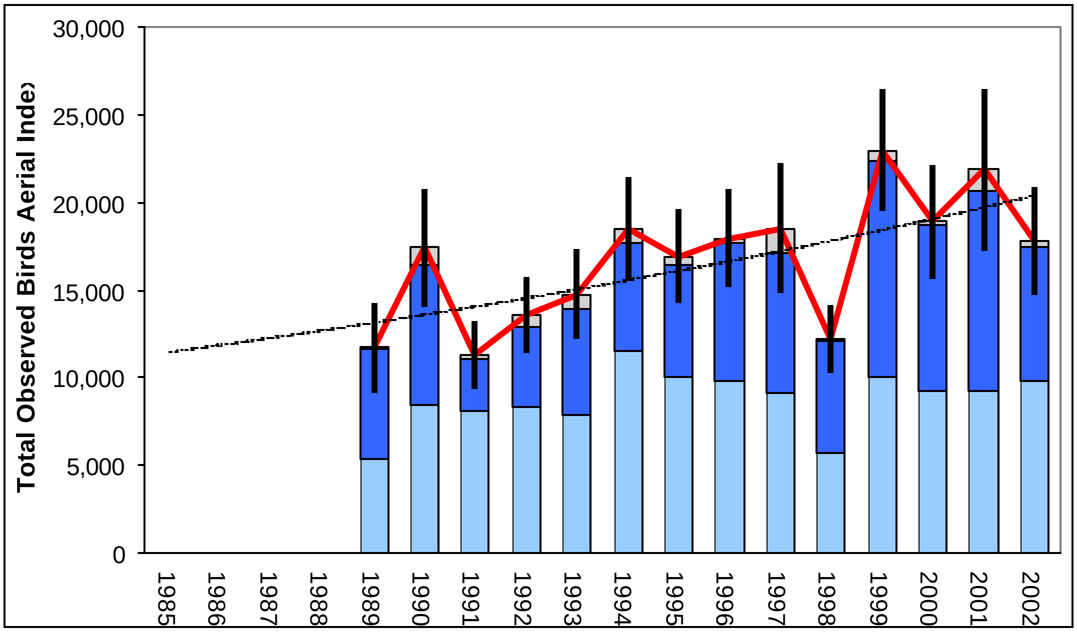
n =	14
mean =	2327
slope =	0.0056
SE slope =	0.0212
Growth Rate =	**1.0056**
low 90%ci GR =	0.9711
high 90%ci GR =	1.0414
regression residual CV =	0.3204
avg sampling error CV =	0.1678

min yrs to detect 50%/10yr change:

w/ regression resid CV =	13.0
w/ sampling error CV =	8.4

Figure 5. Population trend for Red-throated Loons (*Gavia stellata*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Pacific Loon



Aerial index: Total birds observed

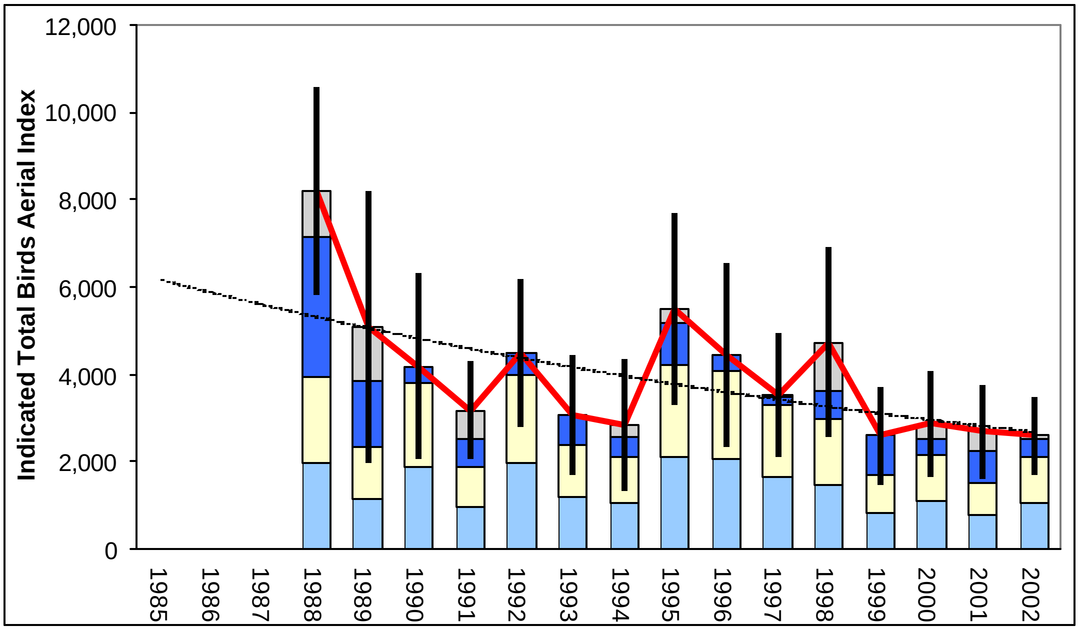
PALO

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989	5408	6216	90	**11712**	1317
1990	8469	7994	943	**17407**	1703
1991	8096	2928	257	**11281**	969
1992	8317	4592	671	**13581**	1121
1993	7849	6036	874	**14759**	1298
1994	11526	6104	855	**18485**	1517
1995	10087	6402	440	**16929**	1389
1996	9808	7820	317	**17945**	1427
1997	9148	7986	1389	**18523**	1871
1998	5728	6402	81	**12212**	1004
1999	10004	12304	661	**22970**	1770
2000	9295	9446	151	**18891**	1673
2001	9248	11366	1229	**21842**	2346
2002	9826	7628	337	**17792**	1553

n =	14
mean =	16738
slope =	0.0338
SE slope =	0.0120
Growth Rate =	**1.0344**
low 90%ci GR =	1.0142
high 90%ci GR =	1.0549
regression residual CV =	0.1806
avg sampling error CV =	0.0896
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	8.9
w/ sampling error CV =	5.5

Figure 6. Population trend for Pacific Loons (*Gavia pacifica*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Mallard



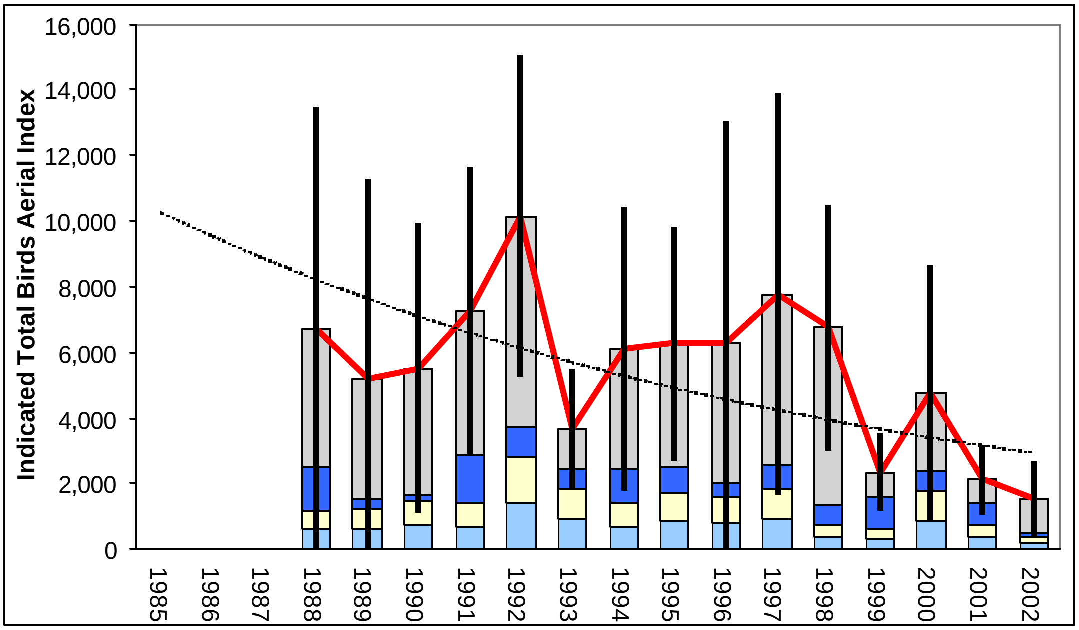
Aerial index: Indicated total birds — MALL

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

n =	15
mean =	3998
slope =	-0.0488
SE slope =	0.0158
Growth Rate =	**0.9524**
low 90%ci GR =	0.9279
high 90%ci GR =	0.9775
regression residual CV =	0.2651
avg sampling error CV =	0.2194
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	11.4
w/ sampling error CV =	10.1

Figure 7. Population trend for Mallards (*Anas platyrhynchos*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

American Wigeon



Aerial index: Indicated total birds

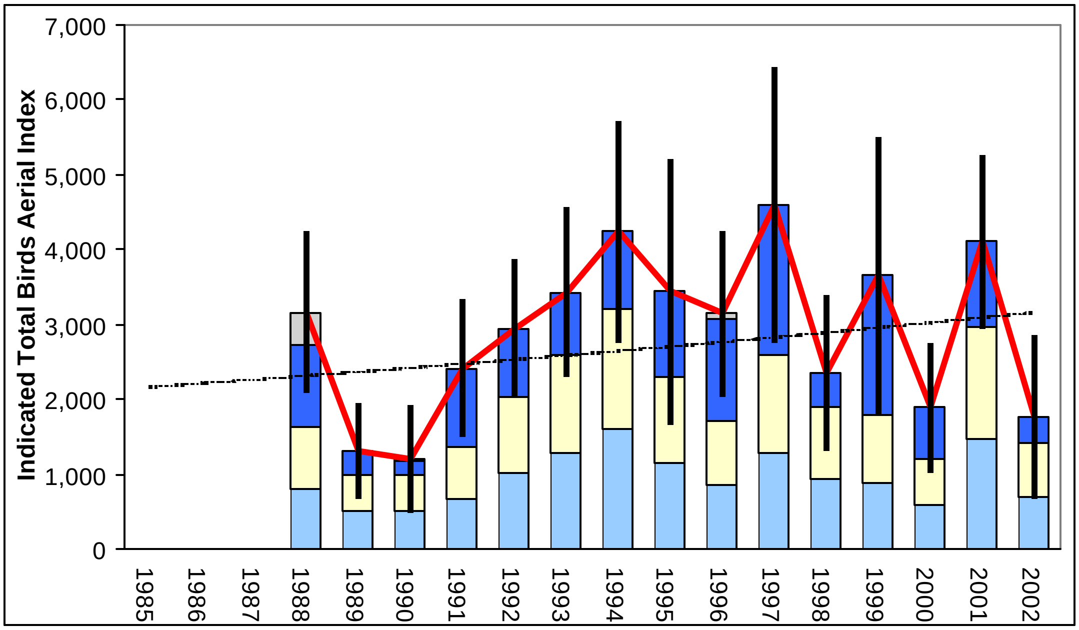
AMWI

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	1202	1312	4196	**6708**	3445
1989	1228	318	3646	**5192**	3102
1990	1492	142	3890	**5524**	2261
1991	1404	1494	4374	**7270**	2235
1992	2842	864	6435	**10141**	2503
1993	1830	624	1205	**3658**	932
1994	1430	994	3670	**6096**	2211
1995	1702	804	3769	**6275**	1825
1996	1618	384	4267	**6271**	3470
1997	1854	742	5193	**7790**	3121
1998	732	644	5385	**6761**	1916
1999	640	970	744	**2354**	606
2000	1798	592	2373	**4763**	1992
2001	732	666	733	**2133**	548
2002	402	124	1014	**1540**	581

n =	15
mean =	5498
slope =	-0.0734
SE slope =	0.0259
Growth Rate =	**0.9292**
low 90%ci GR =	0.8905
high 90%ci GR =	0.9696
regression residual CV =	0.4328
avg sampling error CV =	0.3687
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	15.8
w/ sampling error CV =	14.2

Figure 8. Population trend for American Wigeon (*Anas americana*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Green-winged Teal



Aerial index: Indicated total birds

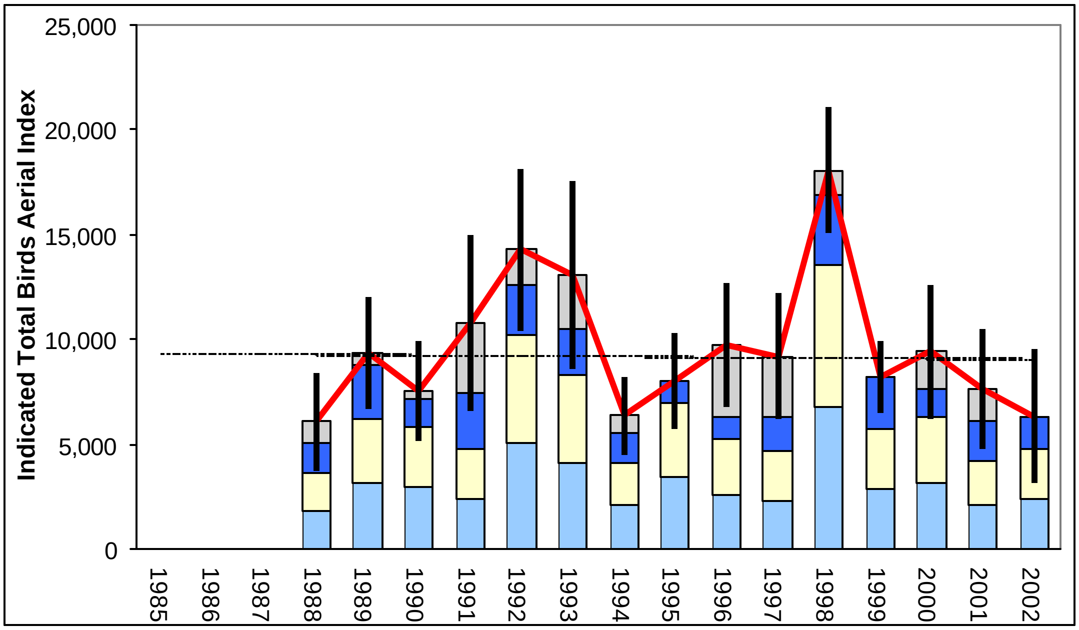
year	2*sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	1624	1104	435	**3163**	554
1989	1002	312	0	**1313**	328
1990	1006	164	41	**1212**	367
1991	1370	1042	0	**2412**	470
1992	2038	908	0	**2945**	472
1993	2596	836	0	**3431**	579
1994	3216	1024	0	**4240**	754
1995	2308	1128	0	**3436**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

AGWT

n =	15
mean =	2910
slope =	0.0222
SE slope =	0.0251
Growth Rate =	**1.0225**
low 90%ci GR =	0.9812
high 90%ci GR =	1.0655
regression residual CV =	0.4197
avg sampling error CV =	0.2169
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	15.5
w/ sampling error CV =	10.0

Figure 9. Population trend for American Green-winged Teal (*Anas crecca*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Northern Shoveler



Aerial index: Indicated total birds

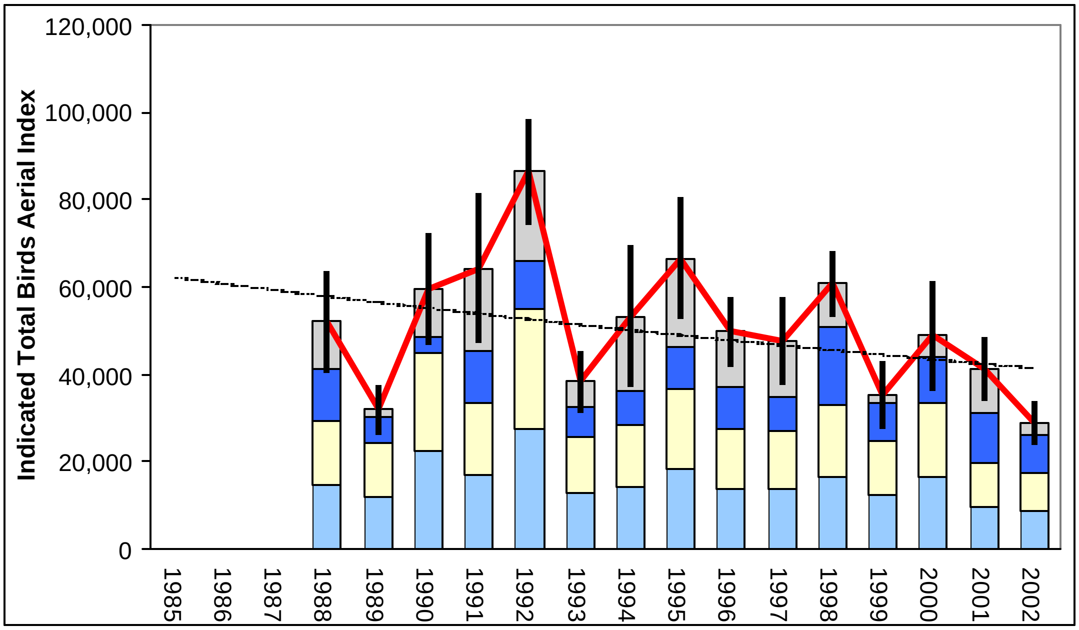
NSHO

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	3620	1442	1024	**6085**	1180
1989	6250	2484	639	**9373**	1363
1990	5882	1260	431	**7574**	1210
1991	4754	2738	3298	**10791**	2135
1992	10234	2388	1640	**14263**	1951
1993	8326	2164	2621	**13112**	2286
1994	4162	1356	839	**6358**	927
1995	6952	1066	0	**8018**	1174
1996	5250	1078	3389	**9716**	1504
1997	4694	1654	2866	**9214**	1525
1998	13586	3270	1204	**18060**	1551
1999	5756	2418	48	**8220**	853
2000	6274	1396	1740	**9409**	1645
2001	4252	1888	1510	**7650**	1465
2002	4754	1540	48	**6342**	1614

n =	15
mean =	9612
slope =	-0.0018
SE slope =	0.0193
Growth Rate =	**0.9982**
low 90%ci GR =	0.9671
high 90%ci GR =	1.0303
regression residual CV =	0.3223
avg sampling error CV =	0.1621
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	13.0
w/ sampling error CV =	8.2

Figure 10. Population trend for Northern Shoveler (*Anas clypeata*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Northern Pintail



Aerial index: Indicated total birds

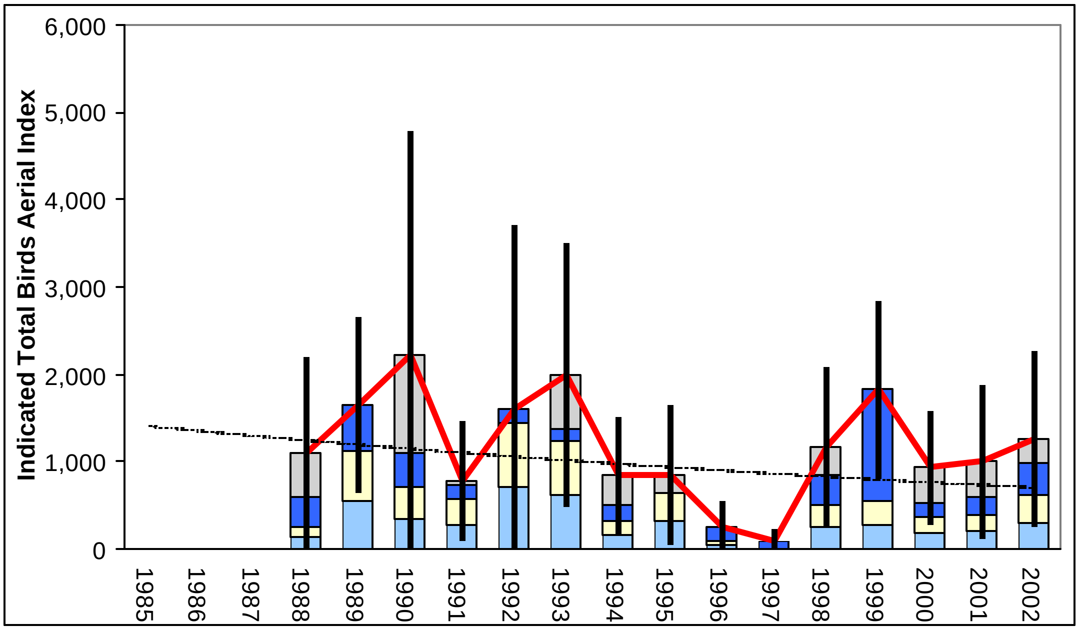
NOPI

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	29350	12110	10593	**52052**	5916
1989	24168	6324	1470	**31962**	2842
1990	44940	3638	11085	**59663**	6490
1991	33658	11812	18780	**64250**	8719
1992	55086	11048	20139	**86273**	6082
1993	25554	7122	5703	**38379**	3644
1994	28292	7988	17055	**53336**	8254
1995	36894	9570	20095	**66559**	7133
1996	27708	9590	12549	**49847**	4055
1997	27284	7670	12521	**47476**	5128
1998	33010	17790	10064	**60863**	3861
1999	24752	8776	1855	**35381**	4025
2000	33328	10490	4973	**48791**	6474
2001	19950	11492	10010	**41452**	3727
2002	17702	8322	2725	**28749**	2547

n =	15
mean =	51002
slope =	-0.0238
SE slope =	0.0173
Growth Rate =	**0.9764**
low 90%ci GR =	0.9491
high 90%ci GR =	1.0046
regression residual CV =	0.2891
avg sampling error CV =	0.1035
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	12.1
w/ sampling error CV =	6.1

Figure 11. Population trend for Northern Pintail (*Anas acuta*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Canvasback



Aerial index: Indicated total birds

CANV

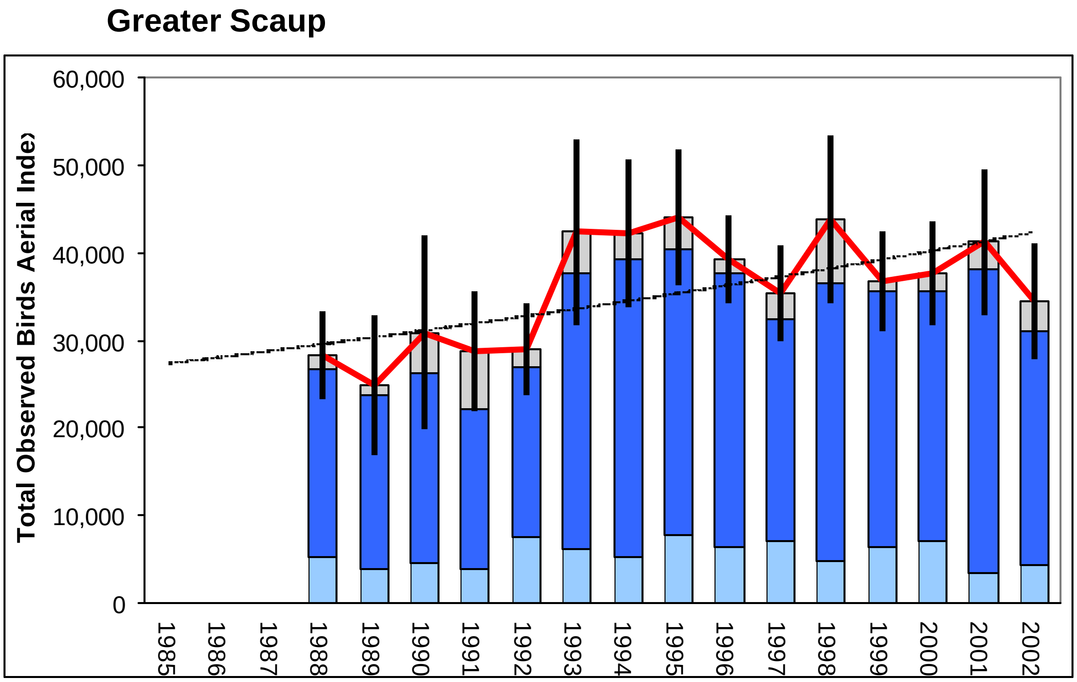
year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	268	334	502	**1103**	561
1989	1124	516	0	**1641**	512
1990	718	386	1111	**2215**	1314
1991	566	168	46	**781**	352
1992	1438	172	0	**1609**	1066
1993	1238	136	614	**1988**	768
1994	332	178	331	**840**	340
1995	648	0	194	**843**	408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

n =	15
mean =	1170
slope =	-0.0405
SE slope =	0.0509
Growth Rate =	**0.9604**
low 90%ci GR =	0.8833
high 90%ci GR =	1.0442
regression residual CV =	0.8523
avg sampling error CV =	0.4755

min yrs to detect 50%/10yr change:

w/ regression resid CV =	24.9
w/ sampling error CV =	16.9

Figure 12. Population trend for Canvasback (*Aythya valisineria*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.



Aerial index: Total birds observed

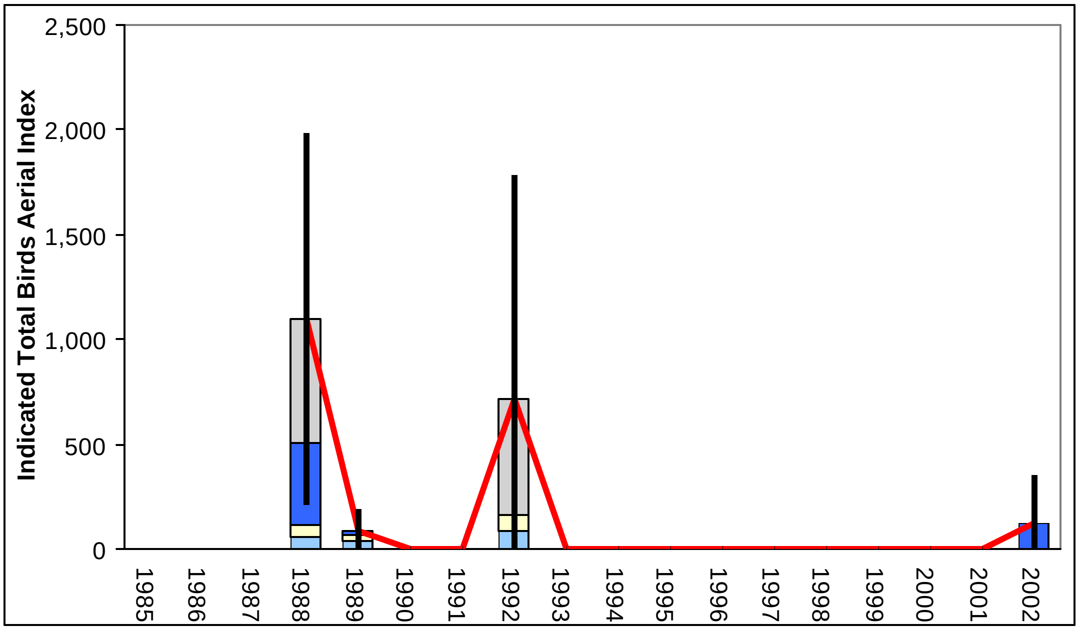
SCAU

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	5191	21434	1722	**28347**	2573
1989	3999	19674	1107	**24780**	4076
1990	4500	21698	4696	**30895**	5652
1991	3900	18230	6623	**28753**	3541
1992	7536	19474	1962	**28973**	2673
1993	6074	31656	4668	**42398**	5421
1994	5330	33778	3196	**42304**	4289
1995	7782	32556	3745	**44083**	3965
1996	6500	31166	1590	**39256**	2581
1997	7180	25312	2788	**35280**	2791
1998	4746	31766	7204	**43715**	4863
1999	6400	29076	1237	**36712**	2934
2000	7059	28474	2099	**37631**	3018
2001	3526	34638	3047	**41211**	4203
2002	4333	26744	3403	**34481**	3371

n =	15
mean =	35921
slope =	0.0256
SE slope =	0.0089
Growth Rate =	**1.0260**
low 90%ci GR =	1.0110
high 90%ci GR =	1.0412
regression residual CV =	0.1496
avg sampling error CV =	0.1059
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	7.8
w/ sampling error CV =	6.2

Figure 13. Population trend for Greater Scaup (*Aythya marila*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Barrow's Goldeneye



Aerial index: Indicated total birds

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	120	384	595	**1099**	451
1989	72	16	0	**89**	54
1990	0	0	0	**0**	0
1991	0	0	0	**0**	0
1992	168	0	548	**717**	544
1993	0	0	0	**0**	0
1994	0	0	0	**0**	0
1995	0	0	0	**0**	0
1996	0	0	0	**0**	0
1997	0	0	0	**0**	0
1998	0	0	0	**0**	0
1999	0	0	0	**0**	0
2000	0	0	0	**0**	0
2001	0	0	0	**0**	0
2002	0	124	0	**123**	118

GOLD

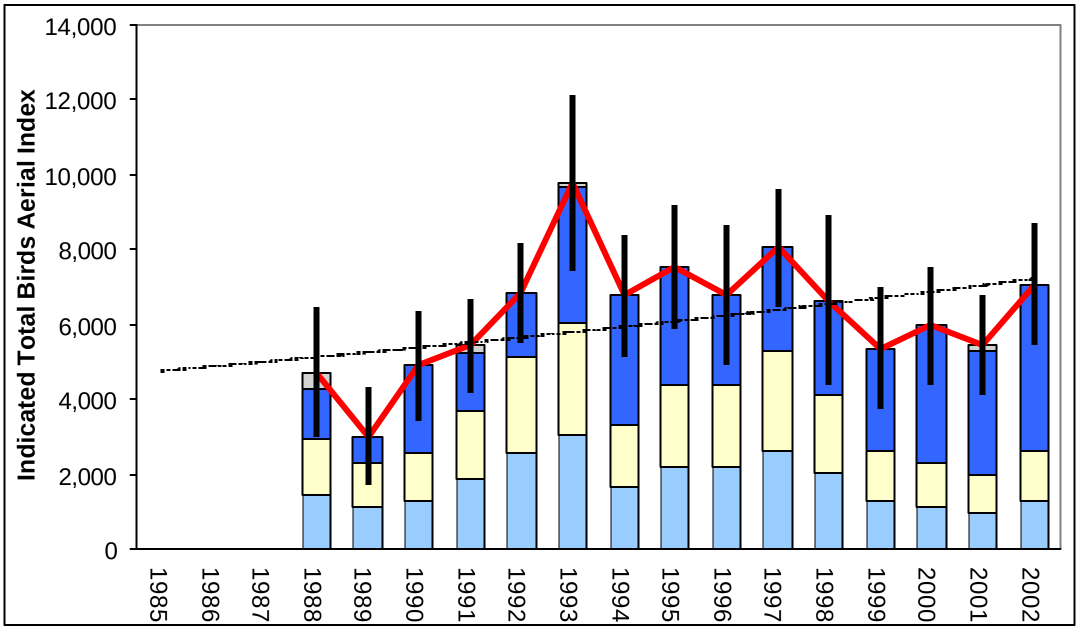
n =	15
mean =	135
slope =	-0.1474
SE slope =	0.0950
Growth Rate =	**0.8630**
low 90%ci GR =	0.7381
high 90%ci GR =	1.0090
regression residual CV =	1.5971
avg sampling error CV =	0.1823

min yrs to detect 50%/10yr change:

w/ regression resid CV =	37.8
w/ sampling error CV =	8.9

Figure 14. Population trend for Barrow's Goldeneye (*Bucephala islandica*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Long-tailed Duck



Aerial index: Indicated total birds

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	2942	1330	451	**4723**	882
1989	2316	704	0	**3020**	661
1990	2592	2304	0	**4897**	757
1991	3720	1512	211	**5443**	643
1992	5120	1714	0	**6834**	690
1993	6062	3598	100	**9759**	1199
1994	3342	3434	0	**6776**	833
1995	4364	3162	0	**7525**	838
1996	4388	2400	0	**6789**	939
1997	5306	2746	0	**8053**	801
1998	4100	2550	0	**6649**	1148
1999	2608	2762	0	**5370**	827
2000	2310	3672	0	**5982**	801
2001	2002	3268	169	**5439**	675
2002	2622	4446	0	**7068**	825

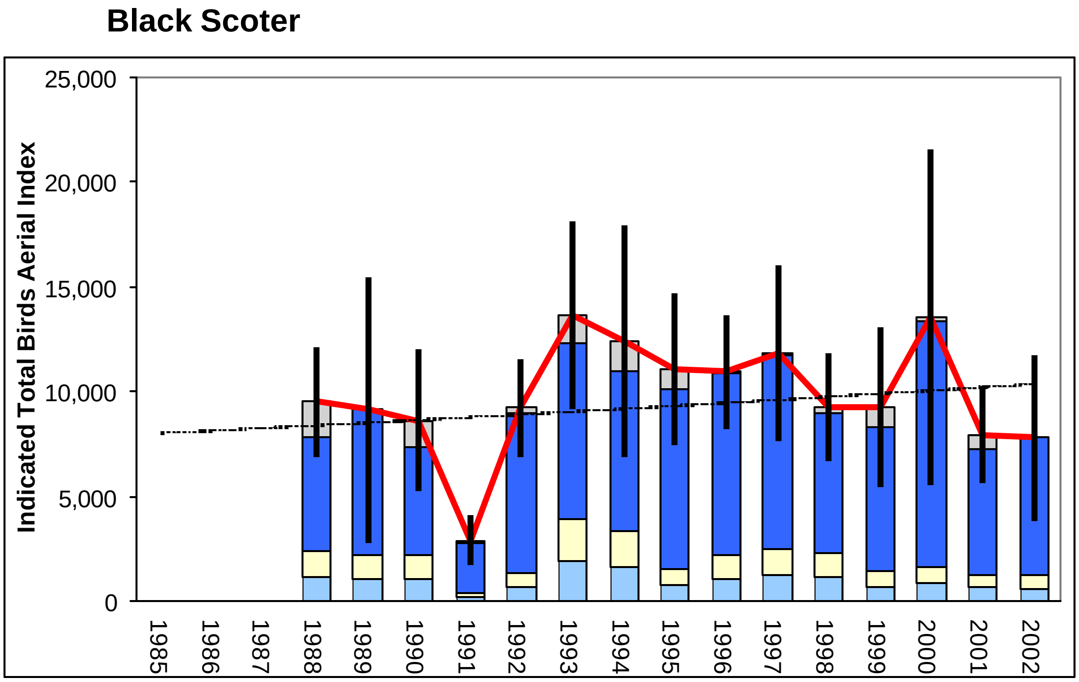
OLDS

n =	15
mean =	6288
slope =	0.0244
SE slope =	0.0156
Growth Rate =	**1.0247**
low 90%ci GR =	0.9987
high 90%ci GR =	1.0514
regression residual CV =	0.2617
avg sampling error CV =	0.1384

min yrs to detect 50%/10yr change:

w/ regression resid CV =	11.3
w/ sampling error CV =	7.4

Figure 15. Population trend for Long-tailed Duck (*Clangula hyamelis*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.



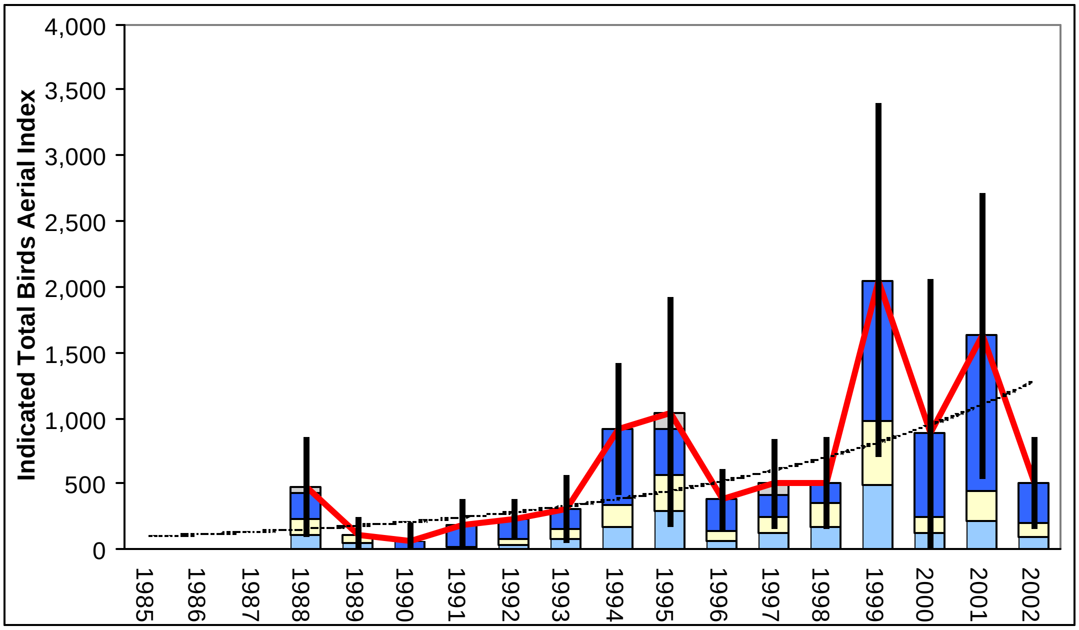
Aerial index: Indicated total birds — BLSC

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	2364	5492	1675	**9531**	1329
1989	2188	6938	0	**9124**	3225
1990	2172	5194	1267	**8631**	1729
1991	432	2318	165	**2915**	599
1992	1380	7574	286	**9240**	1179
1993	3904	8440	1269	**13613**	2285
1994	3318	7628	1482	**12427**	2810
1995	1516	8608	934	**11057**	1855
1996	2236	8638	59	**10934**	1374
1997	2506	9240	81	**11826**	2150
1998	2332	6598	291	**9220**	1308
1999	1414	6850	999	**9264**	1928
2000	1668	11732	142	**13542**	4062
2001	1296	5946	676	**7917**	1155
2002	1256	6548	0	**7804**	2025

n =	15
mean =	9803
slope =	0.0150
SE slope =	0.0224
Growth Rate =	**1.0152**
low 90%ci GR =	0.9784
high 90%ci GR =	1.0533
regression residual CV =	0.3753
avg sampling error CV =	0.1967
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	14.4
w/ sampling error CV =	9.4

Figure 16. Population trend for Black Scoter (*Melanitta nigra*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Red-breasted Merganser



Aerial index: Indicated total birds — RBME

year	2*sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988	236	196	41	**473**	195
1989	104	0	0	**104**	73
1990	0	66	0	**66**	68
1991	18	164	0	**182**	100
1992	74	152	0	**226**	78
1993	164	146	0	**310**	131
1994	344	572	0	**917**	257
1995	576	344	127	**1047**	450
1996	140	240	0	**380**	120
1997	252	166	83	**500**	175
1998	358	146	0	**503**	180
1999	980	1072	0	**2052**	690
2000	248	636	0	**885**	600
2001	446	1184	0	**1630**	555
2002	206	298	0	**504**	180

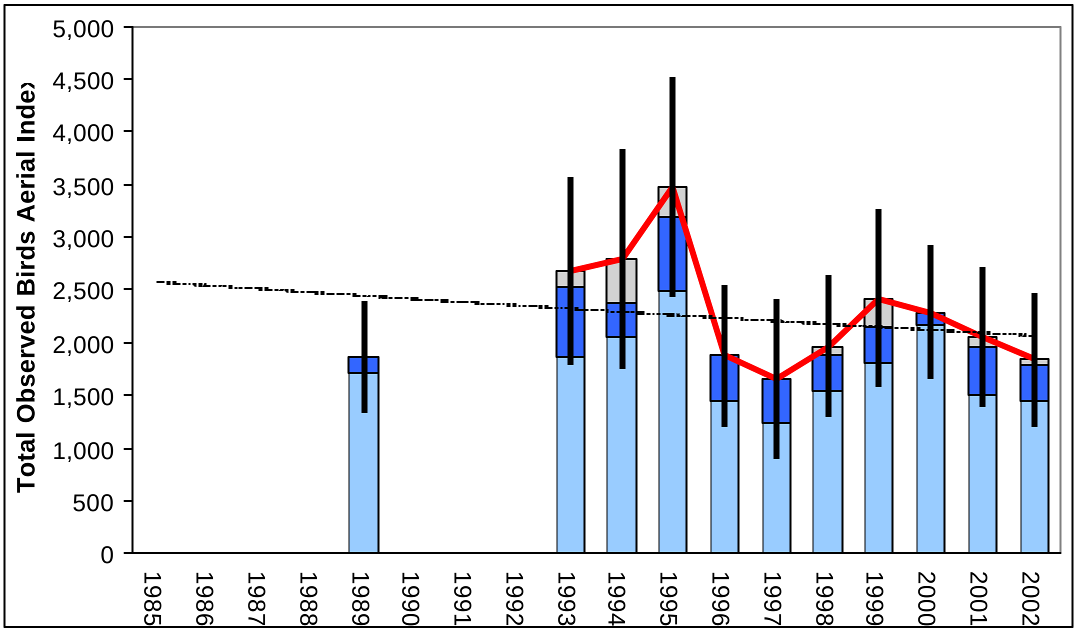
n =	15
mean =	652
slope =	0.1504
SE slope =	0.0427
Growth Rate =	**1.1623**
low 90%ci GR =	1.0834
high 90%ci GR =	1.2468
regression residual CV =	0.7151
avg sampling error CV =	0.4605

min yrs to detect 50%/10yr change:

w/ regression resid CV =	22.1
w/ sampling error CV =	16.5

Figure 17. Population trend for Red-breasted Merganser (*Mergus serrator*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The indicated total birds population index is the sum of birds observed as singles, an equal number of unseen but indicated single birds, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Jaeger spp



Aerial index: Total birds observed

JAEG

year	sq	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989	1708	160	0	**1869**	271
1990					
1991					
1992					
1993	1857	664	159	**2679**	455
1994	2055	316	426	**2797**	530
1995	2498	690	289	**3477**	536
1996	1438	440	0	**1878**	342
1997	1231	428	0	**1660**	388
1998	1539	342	87	**1968**	348
1999	1812	338	269	**2419**	430
2000	2169	120	0	**2289**	324
2001	1505	454	97	**2055**	341
2002	1443	354	42	**1838**	325

n = 11
mean = 2266

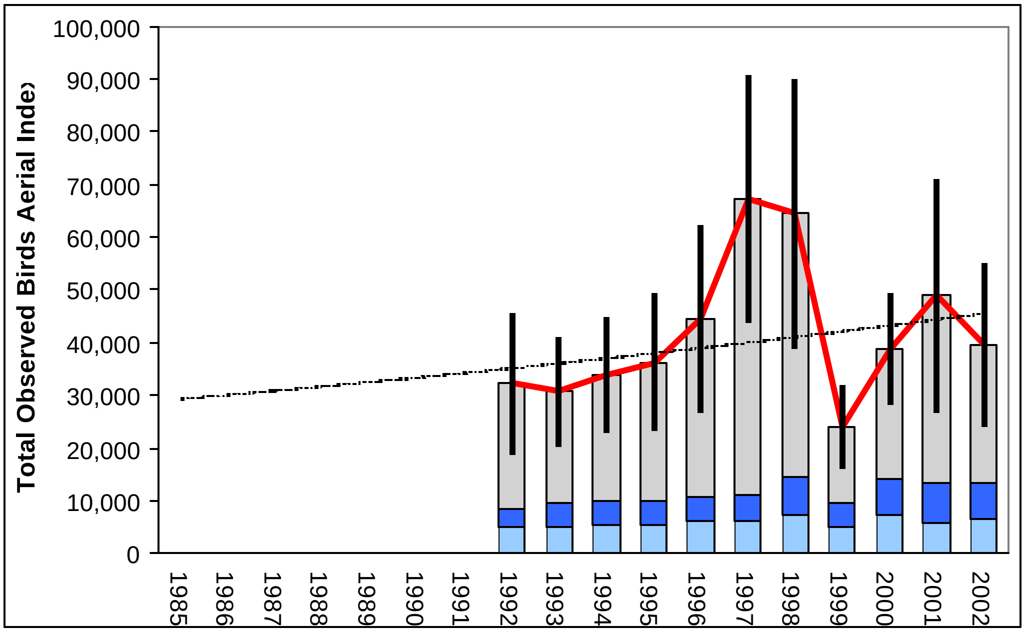
slope = -0.0129
SE slope = 0.0188
Growth Rate = **0.9871**
low 90%ci GR = 0.9571
high 90%ci GR = 1.0182

regression residual CV = 0.2289
avg sampling error CV = 0.1739

min yrs to detect 50%/10yr change:
w/ regression resid CV = 10.4
w/ sampling error CV = 8.6

Figure 18. Population trend for Parasitic Jaegers (*Stercorarius parasiticus*) and Long-tailed Jaegers (*Stercorarius longicaudus*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Glaucous Gull



Aerial index: Total birds observed

GLGU

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992	4881	3480	23861	**32221**	6858
1993	4938	4726	21023	**30688**	5275
1994	5243	4790	23914	**33946**	5663
1995	5336	4634	26213	**36183**	6691
1996	6283	4384	33718	**44384**	9110
1997	6170	4960	56059	**67188**	12002
1998	7180	7178	50135	**64492**	13138
1999	5101	4442	14448	**23992**	4083
2000	7082	7042	24810	**38934**	5455
2001	5797	7728	35424	**48950**	11358
2002	6697	6648	26178	**39524**	7978

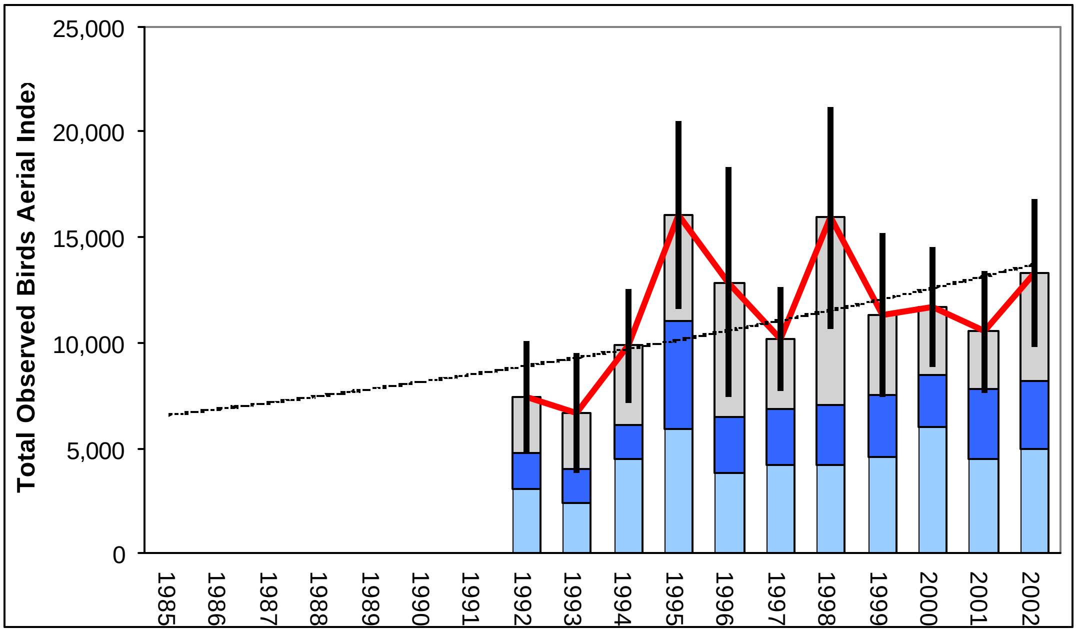
n =	11
mean =	41864
slope =	0.0259
SE slope =	0.0300
Growth Rate =	**1.0263**
low 90%ci GR =	0.9769
high 90%ci GR =	1.0782
regression residual CV =	0.3147
avg sampling error CV =	0.1880

min yrs to detect 50%/10yr change:

w/ regression resid CV =	12.8
w/ sampling error CV =	9.1

Figure 19. Population trend for Glaucous Gulls (*Larus hyperboreus*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Mew Gull

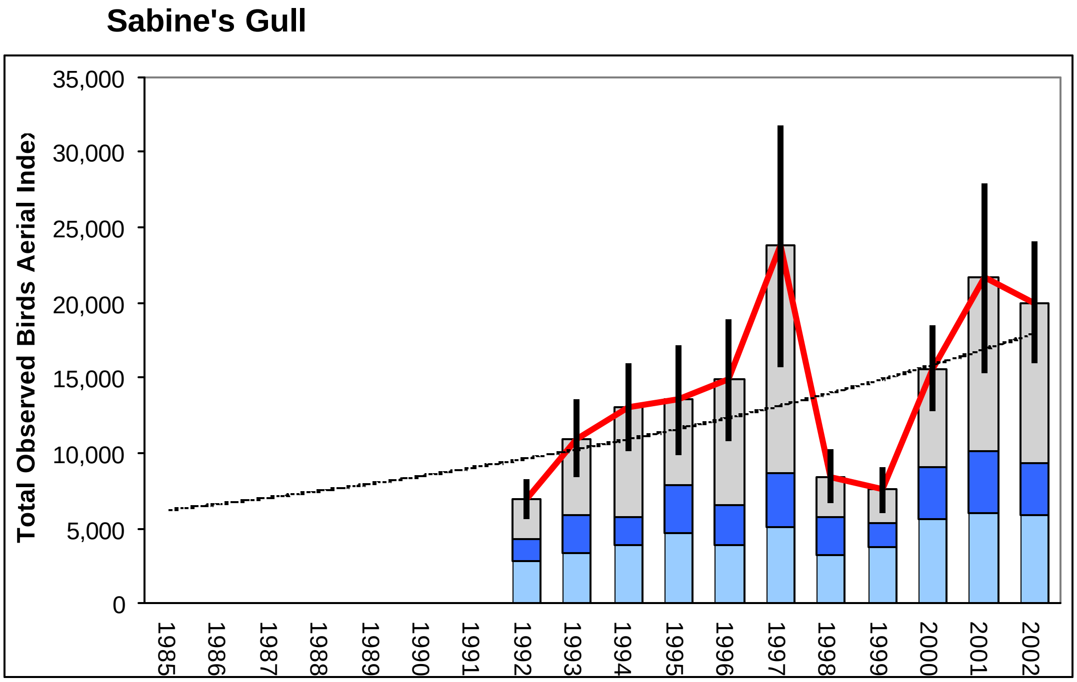


Aerial index: Total birds observed — MEGU

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992	3025	1792	2594	**7411**	1359
1993	2349	1634	2679	**6663**	1459
1994	4494	1626	3746	**9866**	1368
1995	5915	5146	4990	**16051**	2279
1996	3806	2652	6392	**12849**	2785
1997	4232	2656	3326	**10213**	1266
1998	4157	2914	8853	**15925**	2691
1999	4588	2928	3767	**11284**	1997
2000	6041	2390	3272	**11704**	1449
2001	4500	3252	2760	**10512**	1487
2002	4997	3194	5093	**13283**	1795

n =	11
mean =	11433
slope =	0.0433
SE slope =	0.0239
Growth Rate =	**1.0443**
low 90%ci GR =	1.0041
high 90%ci GR =	1.0861
regression residual CV =	0.2504
avg sampling error CV =	0.1609
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	11.0
w/ sampling error CV =	8.2

Figure 20. Population trend for Mew Gulls (*Larus canus*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.



Aerial index: Total birds observed

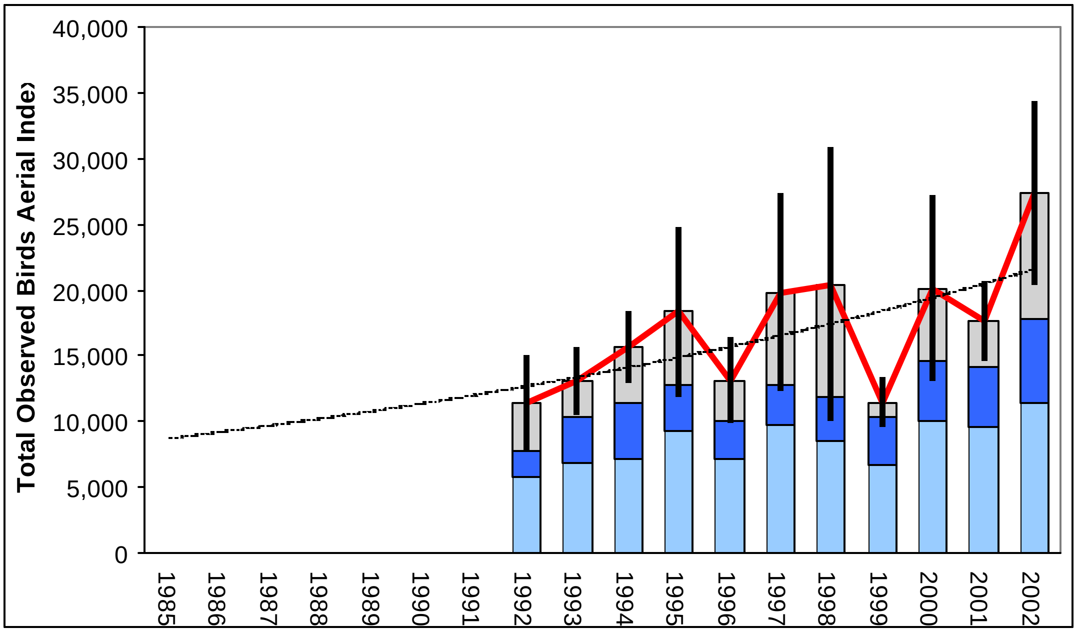
SAGU

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992	2846	1404	2642	**6893**	688
1993	3327	2560	5099	**10986**	1318
1994	3847	1860	7330	**13036**	1511
1995	4650	3212	5682	**13543**	1887
1996	3863	2622	8388	**14874**	2060
1997	5108	3532	15113	**23754**	4125
1998	3226	2502	2706	**8435**	909
1999	3741	1594	2235	**7570**	778
2000	5642	3404	6592	**15638**	1484
2001	5975	4100	11560	**21635**	3204
2002	5901	3416	10688	**20004**	2064

n =	11
mean =	14215
slope =	0.0623
SE slope =	0.0369
Growth Rate =	**1.0643**
low 90%ci GR =	1.0017
high 90%ci GR =	1.1308
regression residual CV =	0.3866
avg sampling error CV =	0.1222
min yrs to detect 50%/10yr change:	
w/ regression resid CV =	14.7
w/ sampling error CV =	6.8

Figure 21. Population trend for Sabine's Gulls (*Xema sabini*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

Arctic Tern



Aerial index: Total birds observed

ARTE

year	sg	2*pr	flocks	Index	Std Err
1985					
1986					
1987					
1988					
1989					
1990					
1991					
1992	5816	1936	3662	**11414**	1865
1993	6820	3518	2693	**13031**	1319
1994	7226	4240	4181	**15648**	1391
1995	9347	3424	5601	**18372**	3301
1996	7133	2922	3106	**13161**	1696
1997	9802	2934	7112	**19848**	3866
1998	8585	3348	8480	**20413**	5317
1999	6757	3548	1193	**11497**	952
2000	10000	4680	5440	**20120**	3584
2001	9592	4580	3486	**17659**	1577
2002	11437	6372	9563	**27372**	3536

n =	11
mean =	17140
slope =	0.0531
SE slope =	0.0215
Growth Rate =	**1.0546**
low 90%ci GR =	1.0180
high 90%ci GR =	1.0925
regression residual CV =	0.2252
avg sampling error CV =	0.1452

min yrs to detect 50%/10yr change:

w/ regression resid CV =	10.3
w/ sampling error CV =	7.7

Figure 22. Population trend for Arctic Terns (*Sterna paradisaea*) observed by the right-rear-seat observer on aerial survey transects sampling 12,832 km^2 of the coastal Yukon-Kuskokwim Delta in western Alaska. The total birds observed population index is the sum of birds observed as singles, birds in pairs, and all birds in flocks, indicated by column divisions from bottom to top. Vertical lines indicate 95% confidence intervals based on sampling error calculated among transects. Stratification included 18 physiographic regions. Average annual growth rate is calculated by log-linear regression. Power calculations use alpha and beta set at p=0.10 and a coefficient of variation based on either regression residuals or sampling errors. The power of the survey to detect trends can be compared for each species using an estimate of the minimum number of years necessary to detect a given slope of –0.0693, a 50% decline in 10 years.

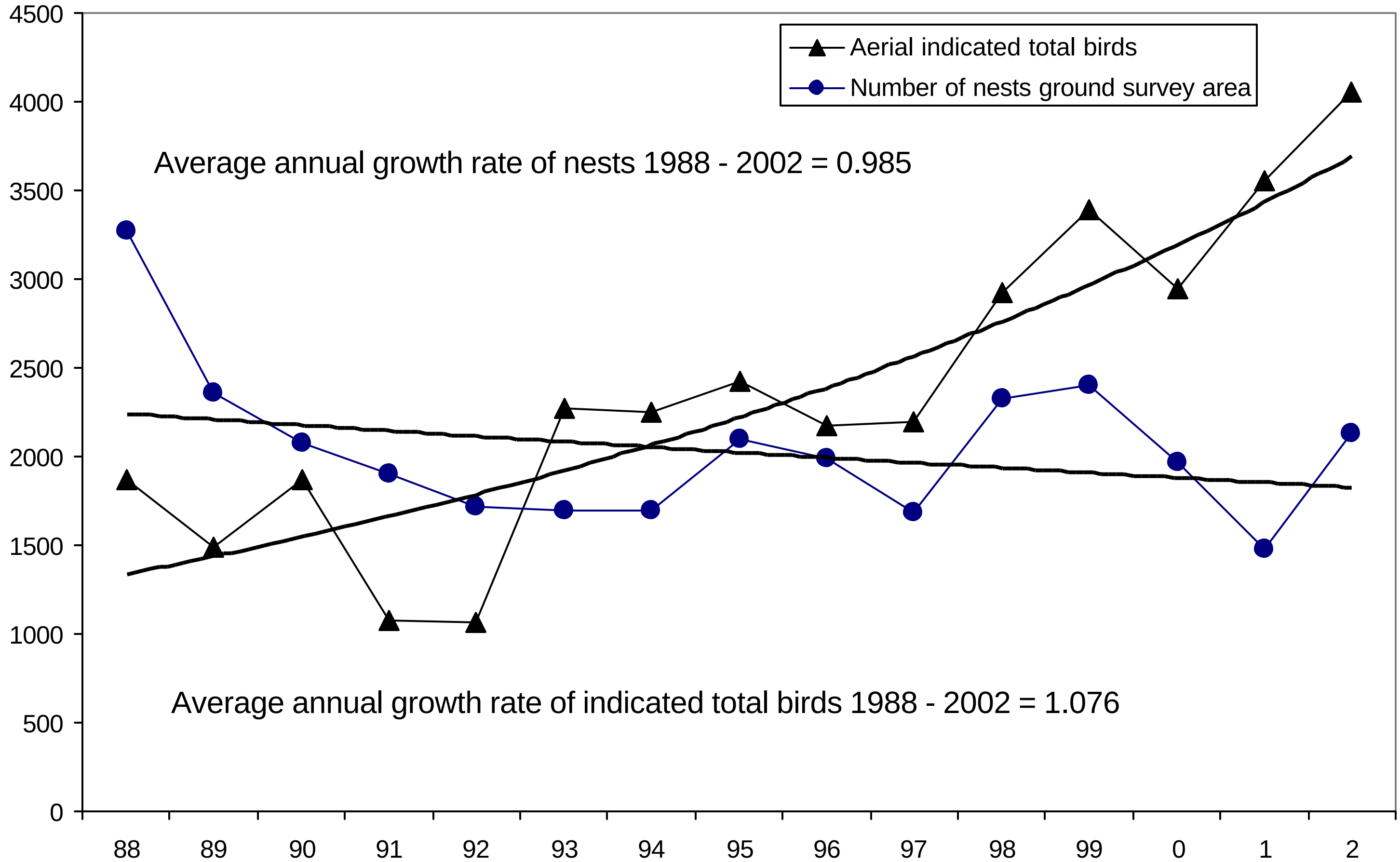


Fig. 23. Population estimates and trends for spectacled eider nests from the ground-sampled area (Bowman et al. 2002) and indicated total birds from aerial surveys of the Yukon Delta coastal zone, 1988 - 2002.

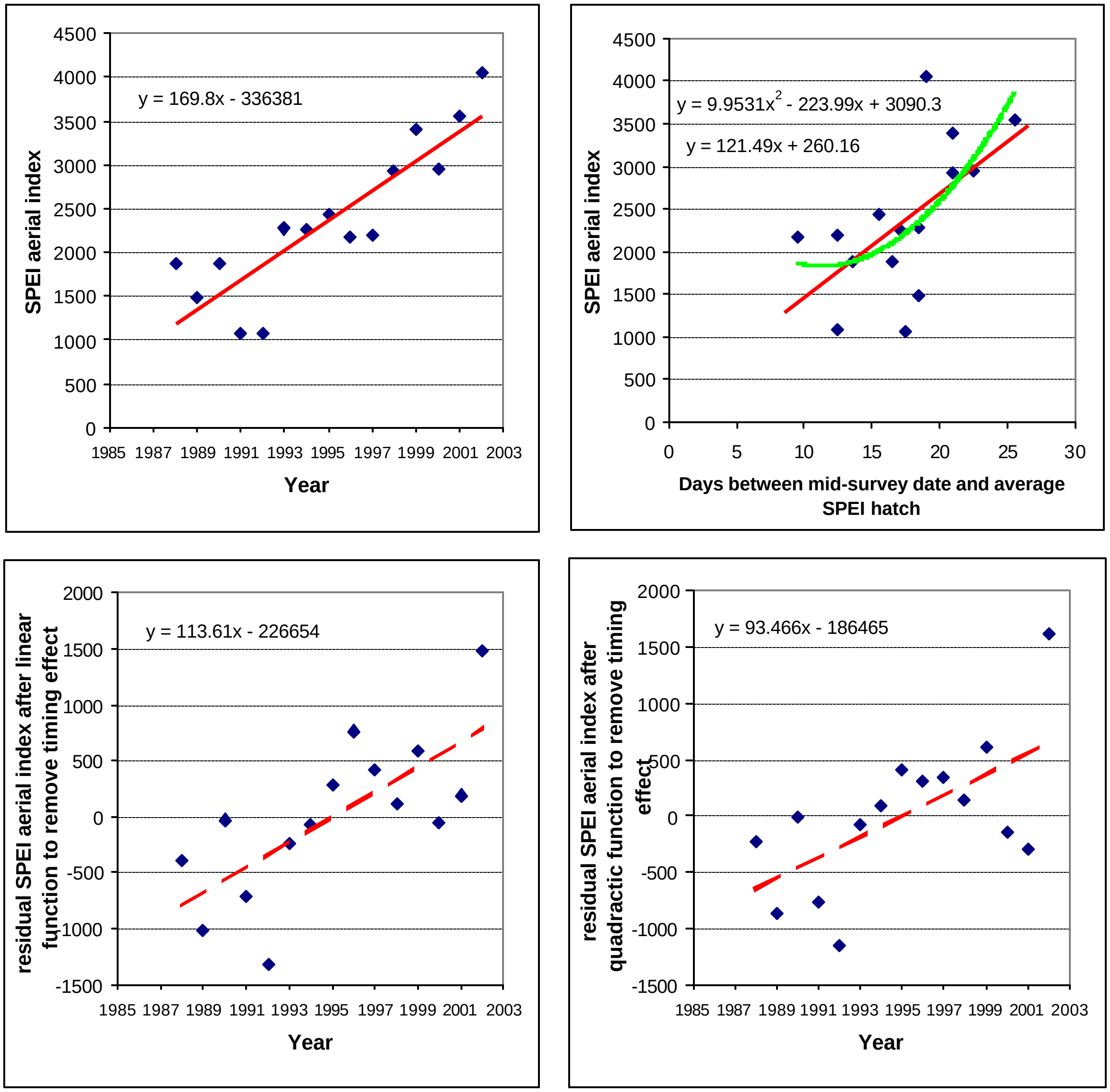


Fig. 24. Aerial survey index of population size of Spectacled Eiders on the Yukon-Kuskokwim Delta plotted against year (upper left) and days between survey timing and average hatch (upper right). The lower panels indicate the population growth after removal of the survey timing effect by linear (lower left) or quadratic relationship (lower right).

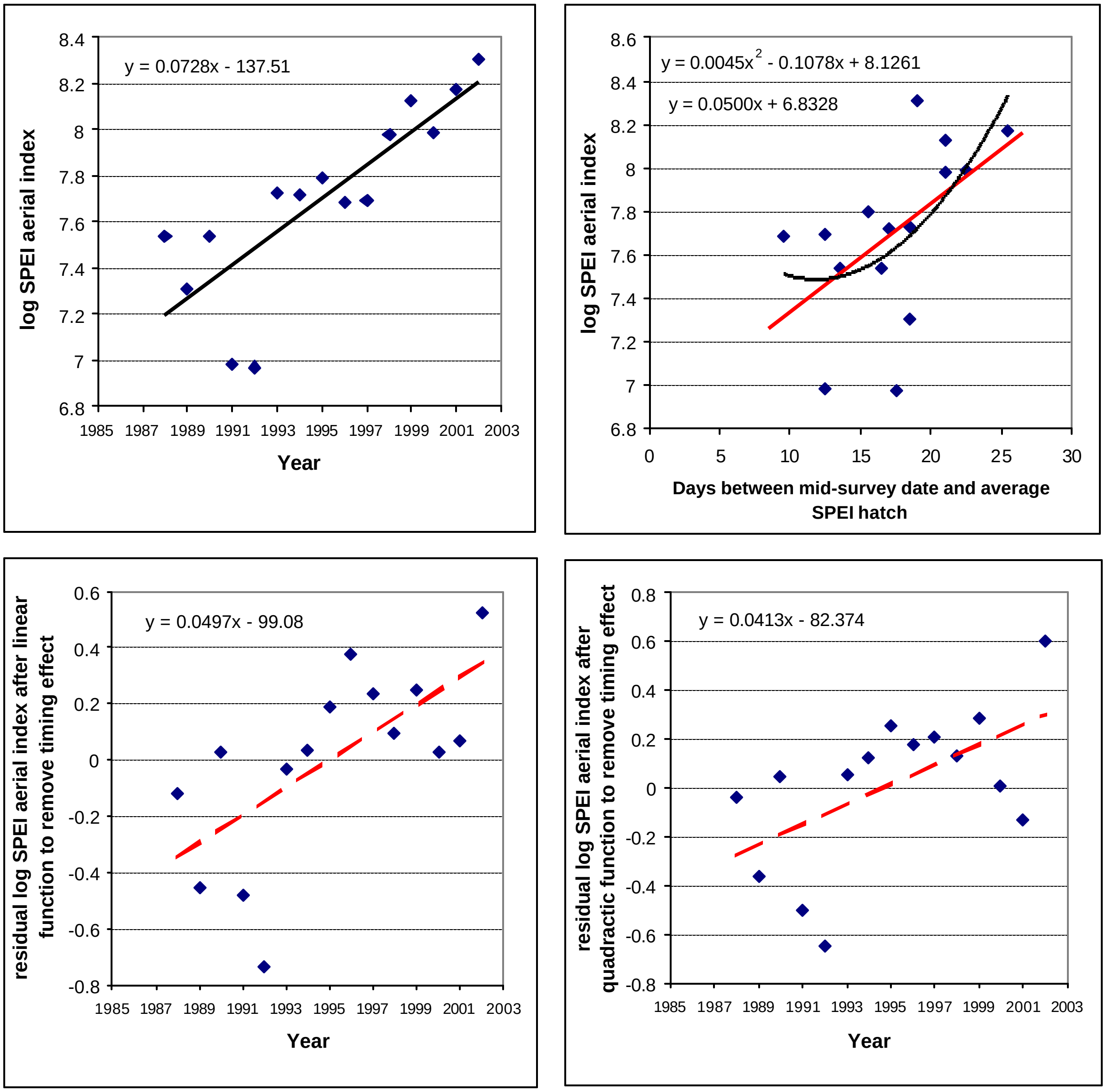


Fig. 25. Aerial survey index of population size of Spectacled Eiders on the Yukon-Kuskokwim Delta after conversion to a log scale plotted against year (upper left) and days between survey timing and average hatch (upper right). The lower panels indicate the population growth after removal of the survey timing effect by linear (lower left) or quadratic relationship (lower right).