Relative Abundance, Distribution, and Trends of Waterbirds from Aerial Breeding Pair Surveys, 1988 to 2004, on the coastal zone of the Yukon-Kuskokwim Delta, Alaska

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Abstract: Seventeen years (1988-2004) of annual aerial surveys for all species of breeding waterfowl have been flown on the coastal zone of the Yukon-Kuskokwim delta. This report summarizes data collected by the rear-seat observer whose objective is to determine relative abundance, trend, and distribution of ducks, gulls, terns, jaegers, loons, and grebes, all the large waterbird species except the geese, swans, and cranes that are recorded by front-seat observers. A main objective of the survey is to document the trend of threatened spectacled eider (*Somateria fisheri*). Northern pintails (*Anas acuta*) were the most numerous waterfowl species observed with an average estimated indicated total population size, with visibility correction, of 155,550 birds. Greater scaup (*Aythya marila*) with 69,328 birds and northern shovelers (*Anas clypeata*) with 36,429 birds were next most abundant. Other waterfowl species in decreasing order of abundance were American green-winged teal (*Anas crecca*), American wigeon (*Anas americana*), mallard (*Anas platyrhynchos*), long-tailed duck (*Clangula hyamelis*), black scoter (*Melanitta nigra*), 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 estimated indicated total birds for four species of special concern were 8,485 threatened spectacled eiders, 11,759 long-tailed ducks, 11,470 black scoters, and 3,495 red-throated loons (*Gavia stellata*). Population sizes averaged 41,864 glaucous gulls (*Larus hyperboreus*), 11,433 mew gulls (*Larus canus*), and 14,215 Sabine's gulls (*Xema sabini*).

Population trends based on log-linear regression declined significantly for mallards and American wigeon at the $p<0.10$ level. Significant increasing population trends occurred for spectacled eiders, common eiders, greater scaup, long-tailed ducks, red-breasted mergansers (*Mergus serrator*), and Pacific loons (*Gavia pacifica*). Mew gulls, Sabine's gulls, and arctic terns (*Sterna paradisaea*) showed increasing population trends whereas glaucous gulls were stable. Modeling the spectacled eider population trend to include changes in survey timing indicated a revised trend of 1.01 (± 0.02), much lower than the uncorrected trend of 1.064. This preliminary result shows that change in survey timing, or correlation with other variables that may influence the index ratio, can seriously bias indicated population trend. Over 90,000 sightings with geographic locations on 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 data on population sizes, trends, and distributions for use by biologists and land managers. Intensive aerial surveys have been conducted since 1985 to monitor populations of geese. The initial surveys were conducted by 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 (Eldridge 2003). In 1988, an observer in the right rear seat was added to monitor populations of other species. This was necessary because it was too difficult for front seat observers to detect and record birds of all species in the high nesting density areas of the coastal Yukon-Kuskokwim Delta. The objective for the rear-seat observer was to document the relative abundance, trend, and distribution of ducks, gulls, terns, jaegers (*Stercorarius* spp.), loons, and grebes. This survey is a primary method used to monitor the threatened spectacled eider population along with 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 2004. Also included are maps that show the distributions of birds observed in 2004.

METHODS

Survey Design

The survey area includes the coastal tundra from Norton Sound to Kuskokwim Bay and extends from the west coast to about 50 km inland. This area is divided into 18 strata based on appearance of generally homogeneous physiographic features from unclassified LANDSAT images at 1:250,000 scale. The total survey area encompasses 12,832 km^2. The survey was originally designed to optimize monitoring of declining goose populations. We use 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 approximately east-west along great circle routes. The annual average totals were 2,222 linear transect kilometers (Fig. 1) in 206 transect sections for a sample of about 444 km^2 (range = 383-478 km^2 among years). Strata with higher density of waterfowl were allocated a greater sampling intensity. The survey design has changed slightly in number and placement of transects over the years. Prior to 1998, we used a 1.61 kilometer interval in higher density areas and 3.22, 6.44, or 12.88 km in other strata. In 1998, we generated four distinct sets of transects. Since 1998, transects have been spaced at 1.60, 3.20, 6.40, or 12.80 km within the various strata. A different set of transects is flown in each year so that in four years we obtain complete coverage (4 x 400m transect width for front-seat observers) in each 1.60 km interval when combining data from 4 years, 1998-2001. In 2002, we began repeating this set of transects again by flying the same lines as in 1998, and in 2004 we flew the same transects as in 2000.

Data Collection

Survey methods followed the conventions established for waterfowl 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). A 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, 1992-2004) with reference to 1:250,000 scale topographic maps with printed flightlines to maintain a precise course while flying transects.

For data collection prior to 1998, we used cassette recorders running continuously while observing on transect (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 consists of a notebook computer connected with a GPS receiver and a remote microphone and mouse. The observer records 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, and 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 seventeen years (1988 to 2004) 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 2004. Loons were recorded from 1989 to 2004. Gulls and terns were recorded from 1992 to 2004. 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. Eleven transects north of the Askinuk Mountains had no data for the 2003 survey due to a malfunctioning microphone. In 2004, 2 short transects in the Scammon Coast Stratum and 1 transect in the South Yukon/North Yukon strata were skipped due to wind.

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 over 10 years) and the estimated sampling error CV was accurate, the minimum years 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 there was no trend in the observer's detection rates 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.

RESULTS

Relative abundance

Relative abundance indices for species with sufficient data are shown in Figs. 3 - 22. 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 seventeen-year average population indices for each species corrected for detection rate, the most abundant species was northern pintail (155,550), followed by greater scaup (69,328), then northern shoveler (36,429). 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 3,495, respectively. 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 2004 was 145,265 and 78,954, respectively. Remaining waterfowl species in decreasing order of abundance for 2004 were northern shoveler, mallard, American green-winged teal, black scoter, canvasback, long-tailed duck, American wigeon, spectacled eider, common eider, and red-breasted merganser.

Population trend/power analysis

Mallards and American wigeon showed a relatively strong decreasing trend (Figs. 7 and 8). Significantly increasing trends occurred for common eiders, spectacled eiders, scaup, long-tailed ducks, Pacific loons, mew gulls, Sabine’s gulls, and arctic terns. Other species showed relatively stable trends over the survey period. We calculated the most recent 7-year trends for all species as well. Only red-throated loons, Sabine’s gulls, and arctic terns showed significantly increasing trends whereas the other species were relatively stable.

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Spectacled eider population and trend

The number of indicated total spectacled eiders from the aerial survey in 2004 was 2,727 birds or 1,744 pairs (uncorrected for visibility bias). The spectacled eider nest estimate for the entire coastal zone from the ground study in 2004 was 3,529 (Fischer et al. 2004). Corrected with a nest detection rate of 78% (T. Bowman, unpub. data), the nest population estimate was

4,524. Thus, the proportion of aerial pairs to nests was 0.30. Spectacled eider nesting phenology in 2004 was about 12 days earlier than the long-term ground plot average (Fischer et al. 2004). The population growth rate for aerial indicated total birds from 1988 to 2004 was 1.064 (Fig. 23). The growth rate for the nest population from ground studies during this same period was 0.987.

Distribution

The geographic locations of over 90,000 observations of 33 species of waterbirds have been collected over the 17 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 2004 survey are given in Figs. 24-31.

DISCUSSION

Three different observers have collected data for this survey, although the same observer has collected the last 14 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 there was no trend in detection rates 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 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 phenology, whereas other year's surveys were late relative to this factor. To get the best trend information, the surveys should be timed consistently relative to nesting phenology every year. Spectacled eider males begin to depart the breeding grounds shortly after the hens begin incubating so the survey misses an unknown proportion 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 et al. 1999). The discrepancy between the trend in nests (Fischer et al. 2004) and the trend in aerial estimates was analyzed more fully in 2004 and was found to be largely due to earlier survey timing beginning in 1998. When survey timing was taken into account there was no difference in the trends (Stehn unpublished data).

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 high fox predation on nests and/or late nesting chronology causing increased visibility of the birds. Predation was also high in 2003 but nest initiation was relatively early. This may have accounted for relatively higher numbers of pairs of spectacled eiders being observed in 2003 as well. Spring was very early in 2004; however the survey was flown June 1 – 7, relatively closer to average spectacled eider hatch date which may have caused the index to be lower.

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. 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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Table 1. Relative abundance of large waterbirds as shown by average population indices from aerial transect surveys over all surveyed years 1985-2004 sampling across 12832 sq km of coastal YKD tundra wetlands. Visibility correction factors (VCF) are based on the ratio of helicopter to fixed-wing observations on Alaska tundra habitat flown in 1989-91.

Species	Sppn	Nyrs	Meas [a]	Pop index	SE pop	CV	VCF [c]	SE vcf	CV	Pop Estim	SE est	CV
White-fronted Goose	WFGO	20	13	61322	3942	0.064						
Northern Pintail	NOPI	17	13	50582	5751	0.114	3.045	0.229	0.075	154023	20997	0.136
Cackling Canada Goose	CCGO	20	13	48379	2476	0.051						
Glaucous Gull	GLGU	13	12	40673	7505	0.185						
Greater Scaup	SCAU	17	12	36548	3776	0.103	1.933	0.206	0.107	70647	10487	0.148
Tundra Swan	TUSW	20	12	24865	3081	0.124						
Black Brant	BRAN	19	13	22272	3222	0.145						
Emperor Goose	EMGO	20	13	18335	1196	0.065						
Arctic Tern	ARTE	13	12	18194	2604	0.143						
Sandhill Crane	SACR	18	13	16995	1548	0.091						
Pacific Loon	PALO	16	12	16689	1479	0.089						
Sabine's Gull	SAGU	13	12	15057	1820	0.121						
Mew Gull	MEGU	13	12	11922	1868	0.157						
Black Scoter	BLSC	17	13	10107	2023	0.200	1.167	0.105	0.090	11795	2589	0.219
Northern Shoveler	NSHO	17	13	9867	1780	0.180	3.790	0.479	0.126	37395	8236	0.220
Taverner's Canada Goose	TCGO	20	13	7754	1777	0.229						
Long-tailed Duck	LTDU	17	13	6392	911	0.142	1.867	0.272	0.146	11933	2432	0.204
American Wigeon	AMWI	17	13	5276	2041	0.387	3.835	0.467	0.122	20233	8206	0.406
Mallard	MALL	17	13	3922	885	0.226	4.008	0.557	0.139	15719	4165	0.265
Swan nests	SWNE	20	8	3517	287	0.082						
Green-winged Teal	AGWT	17	13	2816	596	0.212	8.358	1.353	0.162	23533	6268	0.266
Spectacled Eider	SPEI	17	13	2457	329	0.134	3.580	0.716 [b]	0.200	8795	2117	0.241
Red-throated Loon	RTLO	16	12	2363	386	0.164						
Jaeger spp	JAEG	13	12	2315	401	0.173						
Canvasback	CANV	17	13	1325	671	0.507	2.433	0.457	0.188	3223	1741	0.540
Common Eider	COEI	17	13	1180	300	0.254	3.580	0.716	0.200	4225	1365	0.323
Red-breasted Merganser	RBME	17	13	906	439	0.484	1.278	0.344	0.269	1158	642	0.554
Barrow's Goldeneye	GOLD	17	13	119	69	0.575						

[a] measure 13 = Indicated total = 2*nsg + 2*npr + birds in flocks (nsg =number of singles, npr =number of pairs)

[a] measure 12 = Total birds observedl = nsg + 2*npr + flocks

[a] measure 8 = Number of sightings = number of sg + pr + flocks

[b] assigned SE value at 20% of the VCF

[c] VCF from G.W. Smith 1995, Table 8, except canvasback and merganser Table 7 Alaska boreal habitat 1986-88, and eider unpublished FWS report, Lensink 1968

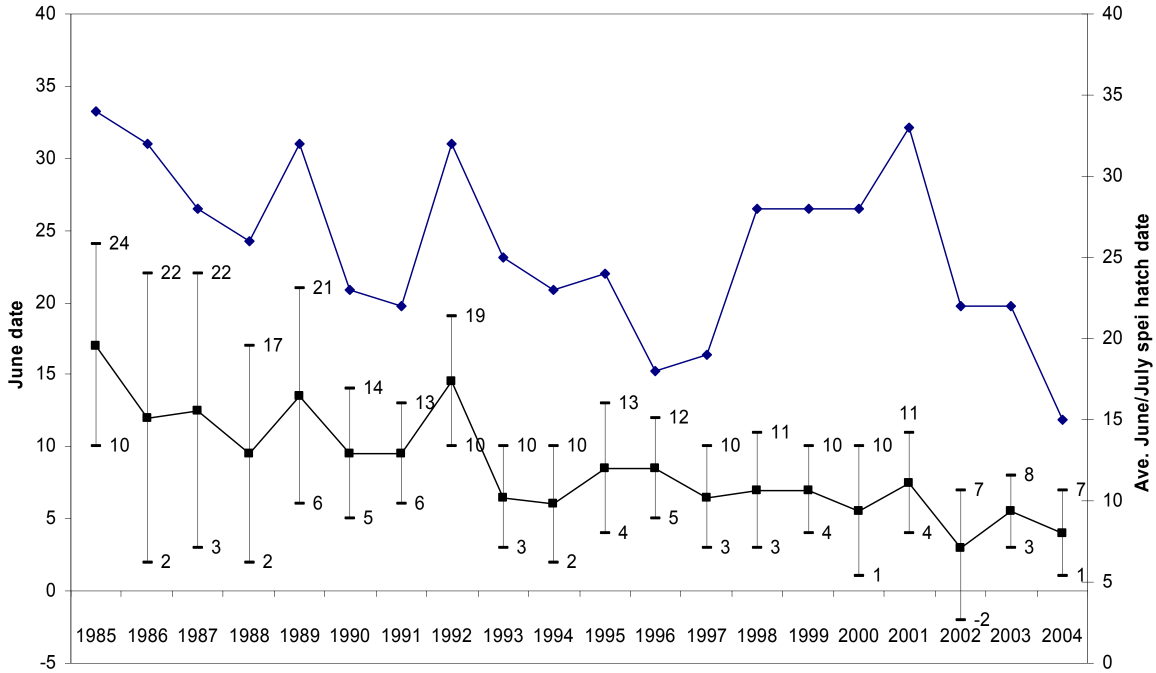

Fig. 2. Timing and duration of the coastal zone aerial survey in relation to average spectacled eider hatch date from ground surveys (Fischer et al. 2004), Yukon-Kuskokwim Delta, Alaska, 1985-2004.

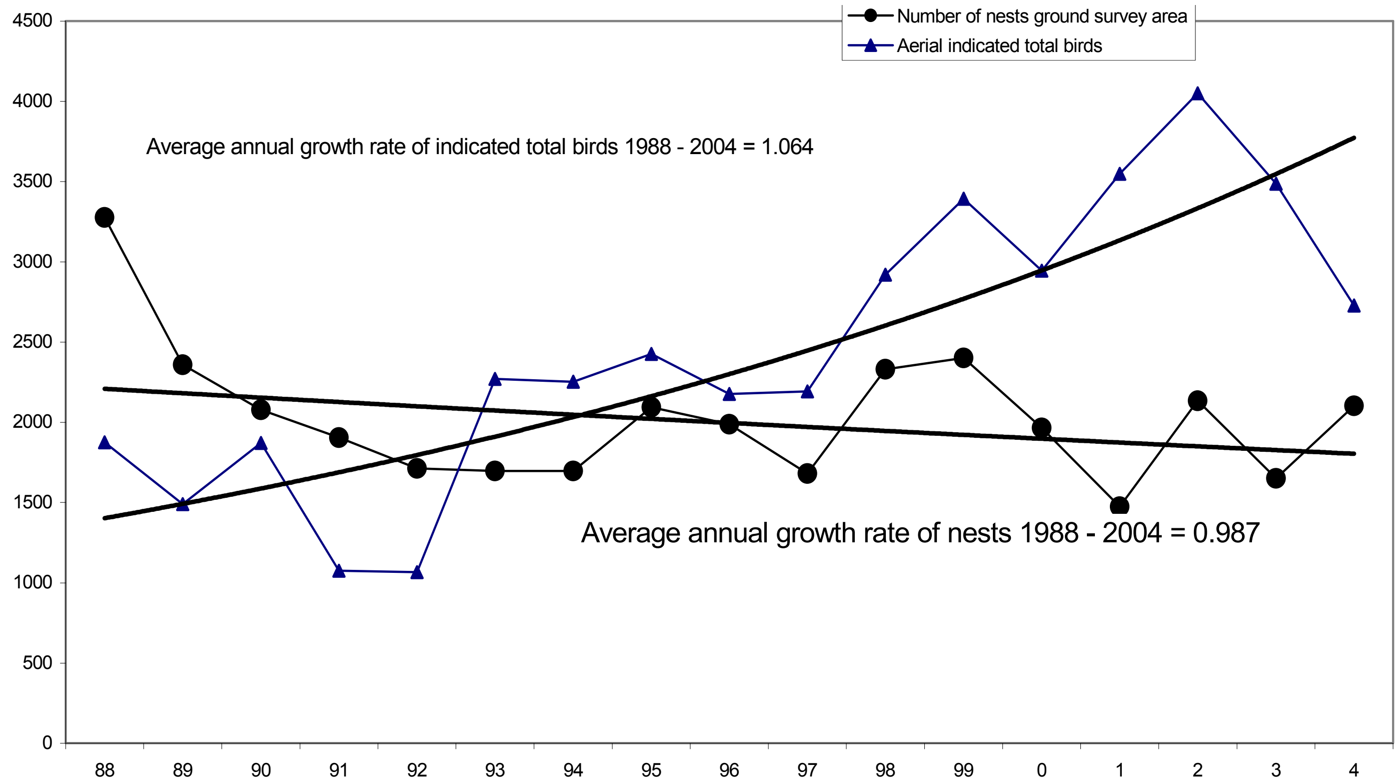

Fig. 23. Population estimates and trends for spectacled eider nests from the ground-sampled area (Fischer et al. 2004) and indicated total birds from aerial surveys of the Yukon Delta coastal zone, 1988 - 2004.