Steller's eider distribution, abundance, and trend on the Arctic Coastal Plain, Alaska, 1989-2008.

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Abstract

- Three aerial surveys provide data that can be used to assess population status and trend of the Steller's Eider (STEI) population nesting on tundra wetlands of northern Alaska. These are the Arctic Coastal Plain survey (ACP), the North Slope Eider survey (NSE), and the Barrow Triangle survey (ABR).

- The data reported from these three surveys provide different estimates of average population size and trend. The 1989-2006 ACP survey data (Mallek et al. 2007) estimated a total average population of 866 birds with a declining growth rate of 0.778. The NSE area from 1992-2008 (Larned et al. 2008) averaged 162 birds with increasing growth rate of 1.059. The ABR survey from 1999-2007 (Obrischkewitsch et al. 2008) averaged 100 birds with a growth rate of 0.934.

- Average population size and trend can be biased if counts of birds are influenced by change in observers, detection rate, or survey timing. Timing is especially important for species with male departure early in incubation or with other marked shifts in habitat use, movements, or flocking behavior. Based on ground study observations near Barrow, the best timing for aerial surveys of breeding Steller's eiders is about 12 – 20 June, after the arrival of most breeding birds and before the departure of many males.

- Using a subset of data that was least confounded by changes in survey timing and observers, the appropriately-timed NSE survey observations from 1993-2008 averaged 173 indicated total STEI (88-258, 90% confidence interval) with a growth rate of 1.011 (0.857-1.193, 90% c.i.). Assuming a detection probability of 30%, the total average population of Steller's eiders breeding on the Arctic Coastal Plain is about 576 birds.

Introduction

The Alaskan breeding population of Steller's Eiders (*Polysticta stelleri*) is classified as threatened under the Endangered Species Act, and its population status is monitored by ground studies and several aerial surveys. Three aerial survey data sets provide information that can be used to assess population status and trend of the species on its Alaskan arctic coastal plain breeding grounds. These surveys differ in spatial

extent, seasonal timing, sampling intensity, and duration. Steller's Eider (STEI) population size and trend estimates differed from each. In 2007, the Eider Recovery Team identified the need to evaluate and reconcile these differences. The purpose of this report is to meet that stated need by presenting the results of the three survey efforts, examining potential biases associated with each, and recommending which data are least subject to confounding factors.

Methods

Migratory Bird Management (MBM USFWS) pilots have flown aerial surveys on the arctic coastal plain of Alaska each year since 1986. Surveys follow standard protocol of the North American Waterfowl Breeding Pair and Habitat Survey (USFWS and CWS 1987). MBM Fairbanks flew the **Arctic Coastal Plain** (ACP) survey (Mallek et al. 2007) from 1986-2006 that sampled about 2% of 61,645 km^2 of wetlands. Survey timing initially was in early July but more recently shifted to late June (Table 2). MBM Anchorage flew the **North Slope Eider** (NSE) survey from 1992-2006 (Larned et al. 2008). The NSE annually sampled about 4% of 30,465 km^2 in the northern portion of the ACP. Although designed specifically for monitoring spectacled eiders, observations of all large waterbird species were recorded. In 2007, we redesigned these two surveys as a single survey flown in mid-June suitable for eiders and comparable to the NSE survey. The 2007-2008 new survey continued observations from the ACP survey area with a slight reduction to 57,336 km^2 caused by exclusion of some marginal habitat (Fig. 15). Two strata in the northern portion and two in the southern were sampled at 4.0%, 2.1%, 1.3%, or 0.7% sampling intensity. We refer to the 2007-08 data as the ACP survey, however, to clarify interpretation, the observations from the northern portion are comparable to previous NSE survey data, and data from southern portion are comparable, except for timing, to the earlier ACP survey. The **Barrow Triangle survey** (ABR) was flown from 1999-2007 by ABR, Inc. Environmental Research and Services, Fairbanks in mid-June, averaging a few days later than the NSE survey. The ABR survey sampled a 2,757 km^2 area with two observers recording eiders, swans, Snowy Owls, and Yellow-billed Loons on transects flown 0.5 km apart resulting in a 50% sampling fraction (Obrischkewitsch et al. 2008).

The timing of the NSE survey was adjusted to begin each year based on weather, snow-melt, observations of field biologists at Barrow and Prudhoe Bay, and reconnaissance flights to verify presence of spectacled eiders as single males or pairs on available nesting habitat (Larned et al. 2008). Surveys were started between 7-12 June and completed by 14-20 June (Table 2).

Comparisons among years in the relative seasonal chronology were made using daily mean temperature recorded at automated weather stations (METAR) at Wainwright, Barrow, Nuiqsut, Kuparuk, Deadhorse, and Barter Island. Timing of spring warm-up was indexed as the day when thaw-degree-days first reached 33. This measure was among the top several that used local weather station temperatures to predict nest initiation date for Cackling Geese on the Yukon Delta (R. Stehn, unpubl. data). Thaw-degree-days (TDD) is calculated as the accumulated daily mean temperature degrees above 32 F. Day-of-year (DOY) notation was used to adjust for the extra day in leap years (DOY = Julian date, e.g. 152 = 1 June, in non-leap years). The TDD>33 index day

was re-expressed as the deviation from the 1984-2008 average TDD>33 DOY for each station, and then the six station deviates were averaged to produce a regional annual index to the timing of spring warm-up.

Sightings and population indices

In the first 3 years of the ACP survey, eiders were recorded only as King, Common, or unidentified eiders. Relatively few eiders were seen. Although no STEI were recorded (Table 1), we could not be sure this was a valid estimate of zero population size because STEI could have been recorded as unidentified eider. We did not include 1986-1988 data in the population analysis presented here. Since 1989, nearly all eiders have been recorded as either Steller's (STEI), Spectacled (SPEI), King (KIEI), or Common eider (COEI) (Table 1).

Sightings of lone or flocked eider hens were also recorded (Table 1) and included on the sighting location maps (Figs. 1-10). Hens unaccompanied by males were not included in the calculated population indices, in accord with the protocol for standard waterfowl aerial surveys (USFWS and CWS 1987). Males observed as singles were assumed paired and their count was doubled to compensate for mostly unseen, or the few observed, hens. For most waterfowl species, the indicated total bird index, calculated as 2*single males + birds in pairs + birds in flocks, is assumed to best correlate with the total size of the population and is the parameter of most interest. The breeding bird index is 2*single males + birds in pairs and excludes birds in flocks that may be non-breeding birds.

The reported population index numbers from the ACP survey (Mallek et al. 2007) and the NSE survey (Larned et al. 2008) were calculated with two slightly different stratification designs compared to the stratification used here. In addition, because some small strata were poorly sampled in certain years, we substituted a mean stratum population index value for any stratum and year that had an inadequate sample defined by a sampling fraction below 0.5%. The mean index was calculated with the combined data for that stratum from adjacent years, either 1989-1999 or 2000-2008. We kept these two periods separate so as not to diminish trend in the index, if one was present.

We calculated population growth rates using log-linear regression. Because the log of zero is undefined, we calculated slope by substituting for those years with no observations (zero population index) a value equal to 25% of the minimum index when the population was above zero. We combined the ACP and NSE estimates in the northern portion by averaging the two survey estimates weighted by the transect area observed in each year. Because the NSE eider survey was not designed to adequately sample the southern portion of the area, incomplete data from the NSE in the southern area were not included in population indices. We added the ACP estimate from the southern portion to estimate total population size.

Visibility correction

Aerial observers do not detect 100% of the birds present and therefore, all counts and estimates are indices to the unknown actual population size. The ratio of the aerial survey index to actual breeding population size of STEI can only be approximated. We

have no data from ACP or NSE surveys to estimate a visibility correction factor (VCF) specifically for STEI. The North American Waterfowl Breeding Pair and Habitat Survey routinely calculates visibility correction factors for various duck species based on ground crew observations on a subset of the aerial transects (Smith 1995). Because ground counts are not possible in extensive and continuous wetland tundra habitat, the ratio of survey counts made on the same transects flown by helicopter compared to fixed-wing aircraft has been used to correct aerial indices in Alaska (Smith 1995, Conant et al. 1991). Visibility correction factors for tundra waterfowl calculated by this method ranged from 1.167 (86% detection rate) for scoters to 8.358 (12% detection rate) for hard-to-detect green-winged teal.

Because no eiders were seen on these helicopter:fixed-wing transects, the VCF used for eiders was 3.58 (28% detection) based on earlier data comparing ground plots and aerial survey estimates of SPEI and COEI on the coast of the Yukon-Kuskokwim Delta (Lensink 1968). Similar data from the last 10 years (Fischer et al. 2008) estimated the ratio of 2 * nests (with correction for nest detection rate) to the indicated breeding bird aerial index as 2.13 (47% detection) for SPEI and 3.88 (26%) for COEI (Platte and Stehn 2007, Stehn unpubl. data). Ground counts of STEI observed on a portion of the Barrow Triangle survey area in 1999 and 2000 were used to estimate aerial detection rates of 22% (VCF = 4.55) and 59% (VCF = 1.69), respectively (Ritchie and King 2002 citing Obritchkewitsch et al. 2001). Because ABR survey procedures included STEI sightings as the highest priority with some recording of habitat and other ancillary data, and the ACP and NSE observers recorded all large waterbird species with somewhat different survey timing, the visibility rates are not necessarily the same. Steller's eider singles and pairs are likely easier to detect than teal species, but harder to detect than SPEI or COEI (W. Larned, pers. comm.). Based on these various sources of information, we selected a 30% detection rate for STEI as a reasonable number for the ACP and NSE surveys.

Accuracy and precision

While changes in survey timing and observers have occurred (Table 2), survey data recording and flight procedures have not changed. The STEI sightings and the resulting population indices are as reliable as for other infrequently observed species. A particular problem with rare species is that infrequent sightings may slow learning by new observers, i.e. establishing a search image requires seeing the species. Also, because sightings of rare species are few, the proportion of the variability associated simply with the chance of detection contributes a larger proportion to the total variance. With more common or easily detected species, the geographic variation in actual numbers of birds among transects is relatively more important. The sampling error for STEI may not be unusually large, but it is difficult to estimate with only a few sightings per year. The estimated standard error of the mean population index divided by a small population size causes the coefficient of variation (CV) to be large, and therefore the relative precision is low. When combined over several years, the average population index for STEI becomes more accurate (unbiased) and useful (relatively precise). Nevertheless, the estimated annual growth rate remained imprecise with a wide confidence interval reflecting the

combined effects of actual annual variation in population size and large sampling errors in the annual estimates.

Results and Discussion

Distribution of sightings

The geographic coordinates of each observation have been recorded with aerial survey data since 1992. As aircraft navigation instrumentation has improved with time, the average error in observation point locations has decreased from approximately 1000 m to 200 m. Observation coordinates in 1986-91 surveys were randomly assigned along each of the 16 mile segments (8 mile in 1991) on which they were recorded. We present points and a kernel density 75% volume contour showing the overall distribution of STEI on the arctic coastal plain, 1989-2008 (Fig. 10). The locations of STEI sightings (n = 188) are widely scattered and vary considerably from year to year (Figs. 1-4). No sightings were made east of Prudhoe Bay. Fewer sightings occurred in the southern portion farther from the coast and at slightly higher elevation. More STEI have been recorded in the general vicinity of Barrow than in any other single location. This supports the location of intensive surveys (Obritschkewitsch et al. 2008) and ground studies on STEI (Quakenbush et al. 2004, Rojek 2008).

We divided the ACP observation data into two periods (1989-96, 1997-2008) to examine potential change in geographic distribution of STEI sightings over time (Fig. 5). The years selected resulted with roughly the same number of observations in each period. Sightings from the ACP survey showed an apparent lack of birds in more southern parts of the survey area during the more recent years (Fig. 5). We used kernel density estimation with 50-95% volume contours for the ACP sightings to compare older and more recent distributions. The kernel density geoprocessing objectively extrapolated out from point locations and better illustrated the portion of the south-central region without STEI sightings in recent years (Fig. 7). No apparent change was discernible with observations from the NSE survey data (NSE 1993-97 vs. 1999-2006, Fig. 6) although there were relatively few observations and the NSE survey design did not sample the southern portion.

Several factors confound interpretation of the apparent shift in distribution noted in the ACP survey data. During recent years (2001-2008), the ACP survey was flown earlier in June (Table 3, Fig. 11). To examine the influence of survey timing on distribution directly, we divided the ACP data into years with a survey start date on or before 27 June and those started after 27 June. We could not discern a clear difference in distribution of STEI sightings between relatively early versus late calendar dates on which the surveys were flown (Fig. 8). This suggests that survey timing alone did not change the pattern of STEI locations. A second source of confusion in interpretation of the apparent shift in distribution is that, the breeding range is not necessarily as large as the geographic distribution of all STEI observations; sightings at some locations or times may not represent breeding birds. To investigate this, we mapped all sightings from all years and both surveys as partitioned by STEI group size and concluded that flocked birds did not differ in their distribution compared to singles and pairs (Fig. 9). A third source of confusion is that the pilot-observer and right-seat observer changed in 2000.

We do not have any additional data to investigate the effects of this potential confounding factor. It is important to note that in spite of these or other possible confounding factors, STEI have not been seen in the southern portion of the survey area since 2001.

At a local scale, the distribution of STEI sighting locations in the ABR surveys did not indicate selective use of particular habitat classes (Prichard and Ritchie 2005) although higher densities of STEI occurred in the northwest portion of the Barrow Triangle survey area compared to the southeastern area. The ACP and NSE aerial survey sightings in the Barrow area combined from 1992-2003 and converted to polygons of relative density, show a similar pattern of local distribution (R. Platte, unpubl. data) as did the ABR sightings.

From 1999-2004, ABR aerial surveys in the Barrow area found that STEI sightings were not clustered at the same locations in successive years (Prichard and Ritchie, 2005). Average distance between a sighting location and the nearest sighting in the prior year indicated low site fidelity. Solovieva (1999) found a similar absence of nest site fidelity based on the lack of resightings of 25 banded females during subsequent years of study on the Lena Delta, Russia. Solovieva (1999) postulated that plasticity in selecting nest sites is an adaptation related to a reduced frequency of nest depredation when in proximity to jaeger or snowy owl nests or high lemming populations. Ground studies near Barrow find some nests in areas used in previous years but also find nests that are in new locations (Rojek 2008). These studies suggest that STEI females may select nesting locations by a different mechanism than highly-localized natal philopatry typical of many waterfowl and shorebird species. Nevertheless, the low number of nests studied, the paucity of banded individuals, and extensive homogenous areas of apparently suitable nesting habitat could easily hide a pattern of philopatry that may occur at a slightly less localized scale.

Survey Timing

Aerial survey population indices can be affected by the timing of the survey relative to the chronology of bird migration. If surveys are timed either too early or too late, the estimates could have negative bias if some proportion of the resident breeding bird population was not present to be counted. It is also possible that if non-breeding or transient birds temporarily occupy the surveyed area, an overestimate of the population may result. A change in survey timing may also interact with seasonal changes in group size, habitat use, or visibility detection rate. Eiders are often in flocks on arrival, soon disperse into breeding pairs as conditions for nesting become appropriate, and then later again aggregate into flocks of males or unsuccessful breeders. Higher detection rates associated with larger group size or the open habitats favored by flocks could inflate the aerial index relative to surveys flown when the population has a high proportion of less visible single or paired birds. Earlier-flown surveys also have more remnants of snow and considerable ice remaining on the large lakes, therefore the white or patchy backgrounds may reduce the detection of light-colored male STEI.

Quakenbush et al. (2004) observed that STEI arrived near Barrow in the first week of June or that birds were already present the second week of June when field crews arrived. Birds arrived in flocks and spent approximately one week before dispersing as pairs. Most nest initiation occurred in mid-June. Hens laid an average of 5.4 eggs and

the incubation period was about 24 days. Hatch date averaged 19 July (range 14 - 28 July) and therefore, average incubation began about 25 June (range 20 June - 4 July). Male STEI departed from the nesting grounds beginning 21 June 1991 or 18 June 1993 (Quakenbush et al. 1995). During the last week of June 1991 and 1993, more than half of the male STEI departed from the Barrow region based on ground survey counts (Quakenbush et al. 1995). In general, most nest initiations were synchronized within the first week with a few individuals accounting for delayed nesting.

In summary, the best timing for aerial surveys for monitoring STEI should be 12 - 20 June (DOY 163-171). This is after arrival of most birds by the second week of June, before incubation starts for the majority of nests when birds are visible as pairs, and before many males depart beginning the last week in June. This timing is just a few days behind timing appropriate for SPEI (Larned et al. 2008) and corresponds closely with the timing of the NSE survey (Table 3, Fig. 11).

NSE observations were completed by 20 June (DOY 171) except in 1992 (Table 3). The average survey date (calculated as average date of observations of all species) was 14 June (DOY 165.0) for the NSE survey 1993-2006 (Table 3). The ACP survey was flown 1-2 weeks later with the survey completed by 28 June (DOY 179) in 1990, 1993, and 2001-2008 and even later in 1986-89, 1991-92, and 1994-2000 (Table 3). The average for ACP observations was DOY 180.2 for surveys flown 1989 - 2000, DOY 175.1 for 2001-2006, and DOY 165.6 for 2007-08 (Table 4). The annual survey timing, the relative timing of spring warm-up, and the annual deviation in the difference between survey timing and spring warm-up are displayed in Fig. 11. We did not find any pattern or correlation among size of the aerial indices and spring warm-up chronology, or the interaction of survey timing and spring warm-up.

Observers

Observations by Rod King (RJK), pilot/observer for ACP surveys 1986-1999, account for most (80%) of all STEI sightings on the ACP survey in all years. We have no reason to suspect problems with species identification by RJK or any other of the experienced observers (CPD, AJB, EJM) who also recorded STEI. Right-seat observers were relatively inexperienced during the first 4 years of the ACP surveys and they did not record any STEI. An experienced observer, AJB, still recorded fewer STEI than RJK on 1990-1996 ACP surveys. From 2000-2006, EJM was pilot-observer and recorded relatively few STEI and observer DKM recorded no STEI. Any assumption made about change in observer ability in the ACP survey is confounded by the change in survey timing in 2001.

Bill Larned (WWL) has flown the NSE survey in all years and he accounted for 60% of all STEI sightings. Each of the right-seat observers with a variety of experience levels also recorded STEI, and the proportion of sightings by right- and left-seat observers was more nearly equal for the NSE eider survey than the ACP survey. In both surveys, the greater percentage of sightings recorded by the more experienced of the observers was essentially the same for each group size. The more experienced observer (RJK/EDM or WWL) recorded 72% of the singles, 73% of pairs, and 79% of the total number of sightings in flocks.

Group size

The proportion of the indicated total birds recorded in singles, pairs, and flocks varies with date (Fig. 12). The proportion in flocks increased by 27-30 June and increased again 1-14 July. We recorded no STEI in flocks on the ACP surveys in all 9 years since 2000, as well as 1990, 1992, 1993, 1998. In the 7 other years, 16 flocks were sighted. Flock size averaged 7.1 birds and ranged from 3 to 20 birds. Only 2 flocks of STEI were recorded in the earlier-flown NSE survey, a flock of 5 in 1993 and a flock of 7 in 1999.

Population Indices

We tabulated the previously reported survey results (Mallek et al. 2007, Larned et al. 2008) for comparison with the revised population indices presented in this report (Table 5). We concluded that the indices are comparable (Table 5) and simple correlation coefficients between old and new annual indices were 0.974 for ACP and 0.999 for NSE. This confirmed the minor effect of the differing stratification and slightly improved analysis procedures. Even with the now identical analysis procedures, the ACP and NSE surveys still showed different average population size, opposite average growth rate, and annual estimates showing no correlation. In the previous sections, we identified and discussed those changes in sighting locations, survey timing, observers, and group size that could explain, or at least correlate with, the observed differences between the two surveys.

Based on the intensive 1999-2007 ABR survey observations in the Barrow Triangle region (Obritschkewitsch et al. 2008), the average indicated total bird aerial population index was 100 STEI with a range from 8 to 224 birds (Table 6). Growth rate averaged 0.934 (0.686-1.272, 90% c.i., Table 6).

Barrow Triangle indices from the ACP and NSE surveys were much less precise because of relatively few transects and 0 to 18 observations of STEI per year. Nevertheless, the broadly overlapping confidence intervals of means and growth rates suggested comparability among all three surveys when enough years are averaged to overcome the large sampling errors (Table 6). Correlation between the ABR survey indices and years with STEI nesting activity (Rojek 2008 Appendix H, coded 1 = year with nests, 0 = years with few or no nests) was significant ($r = 0.77$, $n = 9$). In contrast, for ACP or NSE survey indices from either the Barrow Triangle or the entire survey area, all correlations with either the ABR index data, or with those years having STEI nesting, were weak or absent (data from Tables 6, 7).

We calculated average population indices and growth rates from the ACP and NSE surveys in three independent sections, ACP-South, ACP-North, and NSE-North (Table 7, Figs. 14, 15). Keeping these separate avoided further masking the potential effects associated with change in survey timing and observers. The most closely matched subset for direct comparison was the northern portion sampled by both ACP and NSE surveys from 1993-2006 (Table 7). Here, the correlation between ACP and NSE annual indices of indicated total birds in the same area and years (1993-2006) was not significant at -0.077. The mean index from the ACP-north survey for these matched years was 632

indicated total birds, almost 4 times the population index of 172 based on NSE-north survey observations.

Conclusions

The extensive ACP and NSE aerial surveys resulted in few observations of STEI with none seen in many survey years. Certainly the population is small. Locations of all sightings indicated a widely-scattered distribution of single, paired, and flocked birds. Although aerial sightings even of single birds do not confirm nesting, the potential breeding range of STEI is large. Possible change from 1989 to 2008 in population size or distribution of STEI is difficult to separate from changes in survey timing, in observers, and imprecision of the annual aerial index estimates. We offer three possible interpretations of these data.

Interpretation #1

The Steller's Eider population declined significantly between 1989 and 2008 with an average annual growth rate of 0.837 (Fig.13), a 16% decline per year. This trend was estimated from the indicated total bird aerial index with all years of data and with the NSE and ACP survey results combined (Table 5, right column, growth rate = 0.837, 0.759-0.924 90% c.i.). When based on the breeding bird index (singles and pairs), the average growth rate was 0.877 (0.805-0.955, 90% c.i.). We noted a marked decrease in the number of STEI observed after 1999 (Fig. 13). The population index from 1989-1999 averaged 841 indicated total birds and then dropped to an average of 127 birds in 2000-2008, 15% of the earlier average population. The absence of flocked birds (Table 4) and the lack of any observations in the southern portion since 2000 (Table 4) add support to a marked change in population status and a reduction in the occupied range (Fig. 7).

Validity of this interpretation depends on several assumptions that are commonly made in analysis of aerial index data. Specifically, we assumed that visibility detection rate was constant (or at least without a trend over time) in spite of the known changes in survey timing, observers, and group sizes of birds observed. We assumed the average density of birds observed accurately indexed the size of the resident breeding population. We used all the data available from all years without further qualification or adjustment.

Given all these assumptions, this interpretation leads to the conclusion that the population of STEI has declined and the indexed population size is now very small. With a continued constant rate of decline, the log-linear best-fit equation predicts an aerial index of 38 indicated total birds for 2009 and <1 indexed STEI by 2030.

Interpretation #2

The decline in population indices from the ACP survey are the result of the change in survey timing. From 1989-2008, the northern portion of the ACP has been sampled in 35 surveys, 20 from the ACP and 15 from the NSE (Table 3). The seasonal timing of surveys has shifted over time (Fig. 11). Survey date is defined as the average day-of-year recorded for all observations of all species. For 10 surveys, all from the first 12 years of ACP surveys 1989-2000, average survey data was on or after day 177 (June

26 in non-leap years) with an average day of 181.2 (30 June). The average of STEI indices were 604 breeding birds and 1100 indicated total birds. The timing for another nine years of surveys (ACP 1990, 1993, 2001-06, and NSE 1992) was from day 172 to 177 (21-26 June, average 175.4, 24 June). For these surveys, the average STEI aerial indices were 157 breeding birds and 159 indicated total birds. The other 16 years of surveys (NSE 1993-2006 and ACP 2007-08), were flown with average dates ranging from 161 to 168 (10-17 June) and the average STEI indices were 155 breeding birds and 173 indicated total birds. Of the 10 highest population indices recorded, 8 were from surveys flown after 27 June, one was on 25 June, and one was on 13 June. Surveys flown after day 177 (26 June) recorded more birds, apparently because either more STEI were present or because they were more detectable. It is also true that from the 35 surveys all 10 of highest population indices were recorded before 2000, thus the later calendar dates of survey observations and the years before 2000 are confounded.

A possible mechanism that could account for higher STEI numbers in later-flown surveys assumes an increase in visibility of male STEI starting in late June. Following the more secluded behaviors associated with pre-nesting, laying, and early incubation, perhaps STEI males become much more visible as they leave incubating females and congregate into groups. The increased proportion of birds observed in flocks (Fig. 12) would also contribute to a higher detection rate. A change from 20% to 80% detection rate could account for the 4-fold increase in singles or pairs recorded late in June, even if the actual total population size did not change. This remains speculative because visibility detection rate has not been measured. Given an assumption of “high visibility late”, the aerial indices from late-flown surveys were closer to the actual total population size, and the observed decline in population indices after 2000 was due to reduced detection rather than smaller population size.

Another possible explanation is that STEI other than the nesting population, perhaps birds in a segment of the population such as failed- or non-nesting birds, or non-breeding younger birds that are future residents or even non-residents of Alaska, make scattered use of tundra habitat between 27 June and 10 July. These birds may be prospecting for nesting areas, feeding, or in transit between nearshore marine areas. Prior to about 27 June, this population segment is not present on the breeding grounds and may still be using near-shore marine migration staging areas. After 27 June, these late-arriving birds are present with about half observed in flocks (Fig. 12). Since 2001, no surveys have been flown after 27 June, and therefore the continued presence of these scattered additional birds is no longer documented, and the population appears to have declined. Without data on late-June movements of non-breeding birds, this explanation is also speculative. Given this assumption of “additional birds late”, the aerial indices from earlier-flown surveys are closer to the actual breeding population size, and the observed decline in population indices after 2000 could be accounted for by the removal of over-estimated population indices inflated by transient additional birds.

In late June and early July, if the detection rate increases or if additional birds are present, then assumptions critical to interpretation #1 are not correct. The calculated population trend from these data would be biased because the ACP results are confounded with the change in survey timing. Because the timing of the NSE survey has not changed since 1993, these data should result in unbiased estimates of population index and trend. The NSE population indices for the northern portion (excluding late-

flown 1992, Table 7, Fig. 14 bottom) estimated a STEI population of 173 indicated total birds with a positive growth rate of 1.011 (0.857 – 1.193, 90% c.i.).

Interpretation #3

Another factor confounded with the abrupt decrease in the ACP-north and ACP-south population indices (Tables 5, 7; Fig. 14) that was observed in 2000, but also confounded with the 2001 change in survey timing, is a change in pilot–observer in 2000. Rod King flew the ACP survey from its inception in 1986 until 1999 (Table 2). Ed Mallek, the right-seat observer in 1999, piloted the survey in 2000. Dennis Marks served as right-seat observer for the first time in 2000. If pilot-observer RJK differed by some increased ability to detect, or tendency to record STEI, this alone could account for the reduced number of STEI observed in years since he left the survey. Population trends estimated separately for 1989-1999, and then for 2000-2006, would avoid the potential bias caused by the change in pilot-observer. Using the ACP-north+south indicated total birds index data, the growth rate for the 11 years from 1989 to 1999 was 0.982 (0.869-1.110, 90%c.i.) and for the 9 years 2000 to 2008 was 0.923 (0.581-1.465, 90%c.i.) (Table 5). Both are quite different from the estimated 18-year growth rate over the entire period (0.777, 0.686-0.881, 90%c.i.) (Table 5).

Summary

Our ability to determine which of these speculative alternatives is most probable is limited by our lack of data. The alternatives are not mutually exclusive; any or all of the possible changes may have influenced the observations. We did not attempt more complex regression models using covariates such as survey timing or observer experience because change in these variables are confounded. Data are lacking on possible change in detection rates among years, days, or observers. In addition, we have little or no data on movements of breeding STEI or other segments of the STEI population in late June. Unidentified effects of weather or other environmental conditions in wintering, staging, or Siberian nesting areas could have an important influence on the number of birds arriving to use breeding habitat in Alaska. We do not know of data indicating that the Alaskan breeding population is independent of possible immigration from or emigration to with the much larger breeding population in Siberia.

Because the timing of the NSE survey matched the pre-incubation period for most breeding birds, the survey timing has not changed from 1993-2008, and because the survey was flown by the same pilot-observer (WWL), the potential for confounding factors to bias population trend in these data was reduced. We believe results from the early-flown NSE survey data are the most defensible. Likewise, the timing and observers on the intensive ABR survey have been consistent, and although flown for fewer years and over a smaller area, the ABR survey results support the NSE results. The NSE survey population index for the northern portion (excluding 1992) estimated the average STEI population index at 173 (88-258, 90% c.i.) indicated total birds (Table 7, Fig. 14). The southern portion of the area was estimated at 0 STEI based on all 2001-2008 data in years when the survey was appropriately flown prior to 26 June. The 1993-2008 growth rate was 1.011 (0.857–1.193, 90% c.i.). Using the average population index from the

NSE survey, and assuming a visibility detection rate of 30%, the corrected population at the time of nest initiation is approximately 576 (292-859, 90% c.i.) birds.

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Table 1. Total number of birds recorded for each eider species on arctic coastal plain aerial surveys. Lone and flocked hens are tabulated separately. Sampling effort varied among years and surveys.

survey	**year**	STEI	SPEI	KIEI	COEI	UNEI	STEIH	SPEIH	KIEIH	COEIH	UNEIH
ACP	**1986**			48	2	25					
	1987			28	16	48					
	1988			15	5	16					
	1989	42		82	3	25					
	1990	7		50	7	3					
	1991	23		134	6	4					
	1992	13		18	3						
	1993	20	15	70							
	1994	37	8	25	1						
	1995	15	4	17	10	2					
	1996	46	7	62	40						
	1997	20	10	96		10					
	1998	5	6	65			12	4	36		46
	1999	13	1	47		16	8		17		17
	2000	7		24	10	8	3			3	
	2001	4	8	125	10		1			1	2
	2002		10	81					3		
	2003		5	101	9						
	2004		12	85	19						
	2005	2	44	113	8						
	2006		4	100	4						
	2007	11	165	692	11		3	1	4		4
	2008	1	237	780	12			2	5		
ACP Total		266	536	2858	176	157	27	7	65	4	69
NSE	**1992**		37	99	2				9		
	1993	10	284	395	54			1	1		
	1994	4	238	443	9			4	11		
	1995	14	241	505	6			11	11	1	
	1996		171	490	10			4	13		
	1997	8	170	429	25				4		1
	1998		316	457	6			3	3		
	1999	31	240	471	1			4	3		
	2000		179	480	27	2			1		2
	2001	16	250	678	5			1	5		1
	2002		202	514	25			1	9		1
	2003	2	205	433	2			1			1
	2004	1	209	500	1		1		3		
	2005	3	280	639	14			6	12		
	2006	10	240	501	19			6	8		3
NSE Total		99	3262	7034	206	2	1	42	93	1	9
Total		365	3798	9892	382	159	28	49	158	5	78

Table 2. Observers and survey dates for aerial waterbird surveys on the arctic coastal plain, Alaska.

	Arctic Coastal Plain Survey			North Slope Eider Survey			ABR, Inc (Barrow Triangle)		
Year	Dates	Observer /Pilot	Observer	Dates	Observer /Pilot	Observer	Dates	Observer 1	Observer 2
1986	Jul 1-7	Rod King	Steve Cane						
1987	Jun 30 - Jul 9	Rod King	Steve Cane						
1988	Jun 30 - Jul 11	Rod King	Marta McWhorter						
1989	Jun 28 - Jul 6	Rod King	Barbara Gradin						
1990	Jun 21-27	Rod King	Alan Brackney						
1991	Jun 22-30	Rod King	Alan Brackney						
1992	Jun 27 - Jul 10	Rod King	Alan Brackney	Jun 20-29	Bill Larned	Greg Balogh			
1993	Jun 22-28	Rod King	Alan Brackney	Jun 9-18	Bill Larned	Greg Balogh			
1994	Jun 28 - Jul 2	Rod King	Alan Brackney	Jun 12-18	Bill Larned	Greg Balogh			
1995	Jun 28 - Jul 4	Rod King	Alan Brackney	Jun 9-18	Bill Larned	Greg Balogh			
1996	Jun 23-30	Rod King	Alan Brackney	Jun 7-16	Bill Larned	Greg Balogh			
1997	Jun 28 - Jul 3	Rod King	Chris Dau	Jun 11-20	Bill Larned	Tim Tiplady			
1998	Jun 25-30	Rod King, Chris Dau	Chris Dau, Rod King	Jun 7-15	Bill Larned, Tim Tiplady	Tim Tiplady, Bill Larned			
1999	Jul 2-4	Rod King, Chris Dau	Ed Mallek, Eric Taylor	Jun 7-17	Bill Larned, Tim Tiplady	Tim Tiplady, Bill Larned	Jun 18-22	Bob Ritchie	Jim King
2000	Jun 29 - Jul 6	Ed Mallek	Dennis Marks	Jun 11-19	Bill Larned	Julian Fischer	Jun 17-21	Bob Ritchie	Jim King
2001	Jun 23-27	Ed Mallek	Dennis Marks	Jun 9-18	Bill Larned	Julian Fischer	Jun 18-22	Bob Ritchie	Jim King
2002	Jun 20-24	Ed Mallek	Dennis Marks	Jun 9-14	Bill Larned	Alan Brackney	Jun 16-20	Bob Ritchie	Jim King
2003	Jun 24-27	Ed Mallek	Dennis Marks	Jun 9-18	Bill Larned	Alan Brackney	Jun 17-20	Bob Ritchie	Jim King
2004	Jun 23-27	Ed Mallek	Dennis Marks	Jun 11-17	Bill Larned	Alan Brackney	Jun 17-21	Bob Ritchie	Jim King
2005	Jun 24-27	Ed Mallek	Dennis Marks	Jun 10-19	Bill Larned	Tina Moran	Jun 18-22	Bob Ritchie, Tim Obritsch-kewitsch	Jim King
2006	Jun 23-28	Ed Mallek	Dennis Marks	Jun 10-16	Bill Larned	David Fronczak	Jun 17-20	Bob Ritchie	Tim Obritsch-kewitsch
2007	Jun 14-19	Bill Larned, Rob McDonald	Rob McDonald, Bill Larned				Jun 17-18	Bob Ritchie, Jim King	Tim Obritsch-kewitsch
2008	Jun 8-16	Bill Larned	Rob McDonald						

Table 3. Relative annual timing of aerial surveys and spring warm-up. Day-of-year (DOY or Julian date, 152 = 01 June) was used to adjust for the extra day of leap years. Timing of spring warm-up was indexed as the DOY when Thaw-Degree-Days first reached 33.

Survey	Year	First DOY	Last DOY	Average observation DOY	Deviation from average timing (all yrs & both surveys)	Avg. of station deviates for DOY when TDD>33
ACP	1986	182	188	184.6	11.2	6.85
	1987	181	190	185.1	11.7	9.65
	1988	182	195	187.6	14.2	7.65
	1989	179	187	181.3	7.9	-0.75
	1990	172	178	174.7	1.3	-6.49
	1991	173	181	177.7	4.3	4.54
	1992	179	192	183.8	10.4	-3.13
	1993	173	179	176.5	3.1	2.01
	1994	179	183	181.2	7.8	2.26
	1995	179	185	181.1	7.7	-2.36
	1996	175	182	179.9	6.5	-5.74
	1997	179	184	180.9	7.5	0.64
	1998	176	181	178.9	5.5	-13.74
	1999	183	185	183.6	10.2	3.24
	2000	181	188	183.4	10.0	6.74
	2001	174	178	175.2	1.8	2.41
	2002	171	175	172.2	-1.2	-8.26
	2003	175	178	176.2	2.8	3.07
	2004	175	179	176.1	2.7	2.74
	2005	175	178	176.0	2.6	8.57
	2006	174	179	175.0	1.6	-5.43
	2007	165	170	167.5	-5.9	-2.59
	2008	160	168	163.8	-9.6	-7.43
NSE	1992	172	181	176.8	3.4	-3.13
	1993	160	169	164.3	-9.1	2.01
	1994	163	170	166.7	-6.7	2.26
	1995	160	169	164.7	-8.7	-2.36
	1996	159	168	164.0	-9.4	-5.74
	1997	162	171	166.0	-7.4	0.64
	1998	158	166	161.9	-11.5	-13.74
	1999	162	168	164.2	-9.2	3.24
	2000	163	170	167.8	-5.6	6.74
	2001	162	168	164.6	-8.8	2.41
	2002	160	165	162.6	-10.8	-8.26
	2003	160	169	166.3	-7.1	3.07
	2004	163	169	166.2	-7.2	2.74
	2005	161	170	167.1	-6.3	8.57
	2006	161	167	163.7	-9.7	-5.43

Table 4. Numbers of single, paired, and flocked Steller's Eiders observed on the more northern or southern regions of the ACP and NSE surveys. Results combine sets of years with similar timing and observers. Observation date was averaged from sightings of all species.

					Primary observer / pilot				Secondary observer				Both observers			
Region	Years	Survey	Avg. observation DOY (all species)	Sum of km^2 observed (both observers)	Singles	Birds in pairs	Birds in flocks	Total birds	Singles	Birds in pairs	Birds in flocks	Total birds	Singles	Birds in pairs	Birds in flocks	Total birds
North	1989-1991	ACP	177.9	2123.2	7	4	48	59	0	0	6	6	7	4	54	65
	1992-2000	ACP	181.0	7267.0	35	36	54	125	9	12	7	28	44	48	61	153
	1992-2000	NSE	166.3	11478.7	2	34	5	41	1	16	7	24	3	50	12	65
	2001-2006	ACP	175.1	5862.7	0	6	0	6	0	0	0	0	0	6	0	6
	2001-2006	NSE	165.1	8337.6	4	10	0	14	6	6	0	12	10	16	0	26
	2007-2008	ACP	165.6	2773.7	1	2	0	3	4	4	0	8	5	6	0	11
South	1989-1991	ACP	181.8	1782.0	3	2	0	5	0	0	0	0	3	2	0	5
	1992-2000	ACP	181.0	7384.1	5	8	0	13	2	0	8	10	7	8	8	23
	1992-2000	NSE	166.3	7847.7	0	2	0	2	0	0	0	0	0	2	0	2
	2001-2006	ACP	175.1	3877.7	0	0	0	0	0	0	0	0	0	0	0	0
	2001-2006	NSE	165.1	887.7	0	0	0	0	0	0	0	0	0	0	0	0
	2007-2008	ACP	165.6	1203.3	0	0	0	0	0	0	0	0	0	0	0	0
				60825.4	57	104	107	268	22	38	28	88	79	142	135	356

Table 5. Comparison of previously reported population indices (Mallek et al. 2007, Larned et al. 2008) with the population estimates derived in this analysis for the ACP survey data and for the combined ACP + NSE survey data.

Survey	North Slope Eider (Larned 2007 report)	Arctic Coastal Plain (Mallek 2007 report)	NSE survey north	ACP survey north+south portions	Combined: wgtd avg of ACP+NSE north + ACP south
area km^2	30465	61645.2	30465	57335.9	57335.9
Year	Ind. total STEI index	Ind. total STEI index	Ind. total STEI index	Ind. total STEI index	Ind. Total STEI index
1986					
1987					
1988					
1989		2002		1776	1776
1990		534		493	493
1991		1118		960	960
1992	0	954	0	885	465
1993	260	1313	257	1310	971
1994	47	2524	47	2519	1119
1995	326	931	329	854	503
1996	0	2543	0	2566	968
1997	145	1295	181	990	486
1998	0	281	0	276	85
1999	791	1250	781	1329	1428
2000	0	563	0	252	152
2001	284	176	277	193	236
2002	0	0	0	0	0
2003	93	0	93	0	56
2004	48	0	49	0	26
2005	94	110	93	103	98
2006	296	0	300	0	217
2007	338		332		332
2008	25		25		25
N years	17	18	17	18	20
Mean	161.6	866.3	163	805.9	520
SD	206.4	841.9	204	830.3	515.5
SE	50.1	198.4	50	195.7	115.3
lo90%ci	79.2	539.9	81	484.0	330.0
hi90%ci	244.0	1192.7	244	1127.8	709.4
Growth Rate	1.059	0.778	1.058	0.777	0.837
lo90%ci	0.909	0.686	0.907	0.686	0.759
hi90%ci	1.235	0.882	1.234	0.881	0.924

Table 6. Comparison of aerial population indices for the Barrow Triangle area. The ACP and NSE indices were averaged weighted by observed area. Growth rate was calculated by log-linear regression substituting 25% of the minimum index >0 for the index value in all years estimated as 0.

	Barrow Triangle ABR survey		Barrow Triangle stratum – ACP survey		Barrow Triangle stratum – NSE survey		Wgtd. avg. ACP+NSE in Barrow Triangle	Nesting year near Barrow
Year	*Observed km²*	Ind. total STEI index	*Observed km²*	Ind. total STEI index	*Observed km²*	Ind. total STEI index	Ind. total STEI index	(Appendix H, Rojek 2008)
Stratum km²		2757		2733		2733	2733	
Year								
1986								
1987								
1988								
1989			*54.8*	0			0	
1990			*54.2*	0			0	
1991			*61.1*	90			90	Yes
1992			*64.1*	0	*113.7*	0	0	No
1993			*58.7*	652	*122.8*	45	241	Yes
1994			*66.3*	536	*113.7*	0	197	No
1995			*47.4*	0	*109.4*	50	35	Yes
1996			*64.4*	764	*117.3*	0	271	Yes
1997			*53.0*	0	*123.4*	133	93	No
1998			*63.3*	0	*122.0*	0	0	No
1999	*~ 1379*	224	*55.7*	0	*110.1*	323	214	Yes
2000	*~ 1379*	220	*60.0*	91	*111.6*	0	32	Yes
2001	*~ 1379*	88	*45.4*	0	*118.3*	277	200	No
2002	*~ 1379*	8	*63.6*	0	*116.8*	0	0	No
2003	*~ 1379*	16	*70.4*	0	*109.9*	0	0	No
2004	*~ 1379*	24	*60.1*	0	*112.6*	49	32	No
2005	*~ 1379*	124	*45.3*	0	*118.3*	46	33	Yes
2006	*~ 1379*	96	*63.6*	0	*120.4*	0	0	Yes
2007	*~ 689*	96			*116.8*	234	234	Yes
2008					*110.3*	0	0	Yes
n		9		18		17	20	
mean		99.6		118.4		68.0	83.6	
SD		80.5		249.6		107.2	100.6	
SE		26.8		58.8		26.0	22.5	
lo90%ci		55.5		21.7		25.2	46.6	
hi90%ci		143.7		215.1		110.8	120.6	
Growth Rate		0.934		0.926		1.024	0.983	
lo90%ci		0.686		0.834		0.912	0.889	
hi90%ci		1.272		1.029		1.149	1.087	

Table 7. Annual population indices of Steller's eider from 3 independent components of the ACP and NSE survey data.

survey	ACP south		ACP north		NSE north			
area km^2	26871.3		30464.6		30464.6			
year	Breeding bird index	Indicated total birds index	Breeding bird index	Indicated total birds index	Breeding bird index		Indicated total birds index	
1986								
1987								
1988								
1989	95	95	156	1680				
1990	260	260	232	232				
1991	0	0	343	960				
1992	172	172	712	712	0	(late)	0	(late)
1993	405	405	886	905	139	139	257	257
1994	372	372	1568	2147	47	47	47	47
1995	0	0	601	854	329	329	329	329
1996	0	0	942	2566	0	0	0	0
1997	16	16	614	975	181	181	181	181
1998	0	0	276	276	0	0	0	0
1999	16	700	629	629	607	607	781	781
2000	54	54	197	197	0	0	0	0
2001	0	0	193	193	277	277	277	277
2002	0	0	0	0	0	0	0	0
2003	0	0	0	0	93	93	93	93
2004	0	0	0	0	49	49	49	49
2005	0	0	103	103	93	93	93	93
2006	0	0	0	0	300	300	300	300
2007	0	0			332	332	332	332
2008	0	0			25	25	25	25
n	20	20	18	18	17	16	17	16
mean	70	104	414	691	145	155	163	173
SD	129	190.1	423	765.9	171	173	204.1	206
SE	29	42.5	100	180.5	42	43	49.5	52
lo90%ci	22	33.8	250	393.7	77	84	81.1	88
hi90%ci	117	173.6	578	987.5	214	225	243.9	258
Growth Rate	0.817	0.820	0.842	0.790	1.069	1.026	1.058	1.011
lo90%ci	0.728	0.720	0.757	0.700	0.921	0.874	0.907	0.857
hi90%ci	0.917	0.934	0.935	0.891	1.242	1.205	1.234	1.193

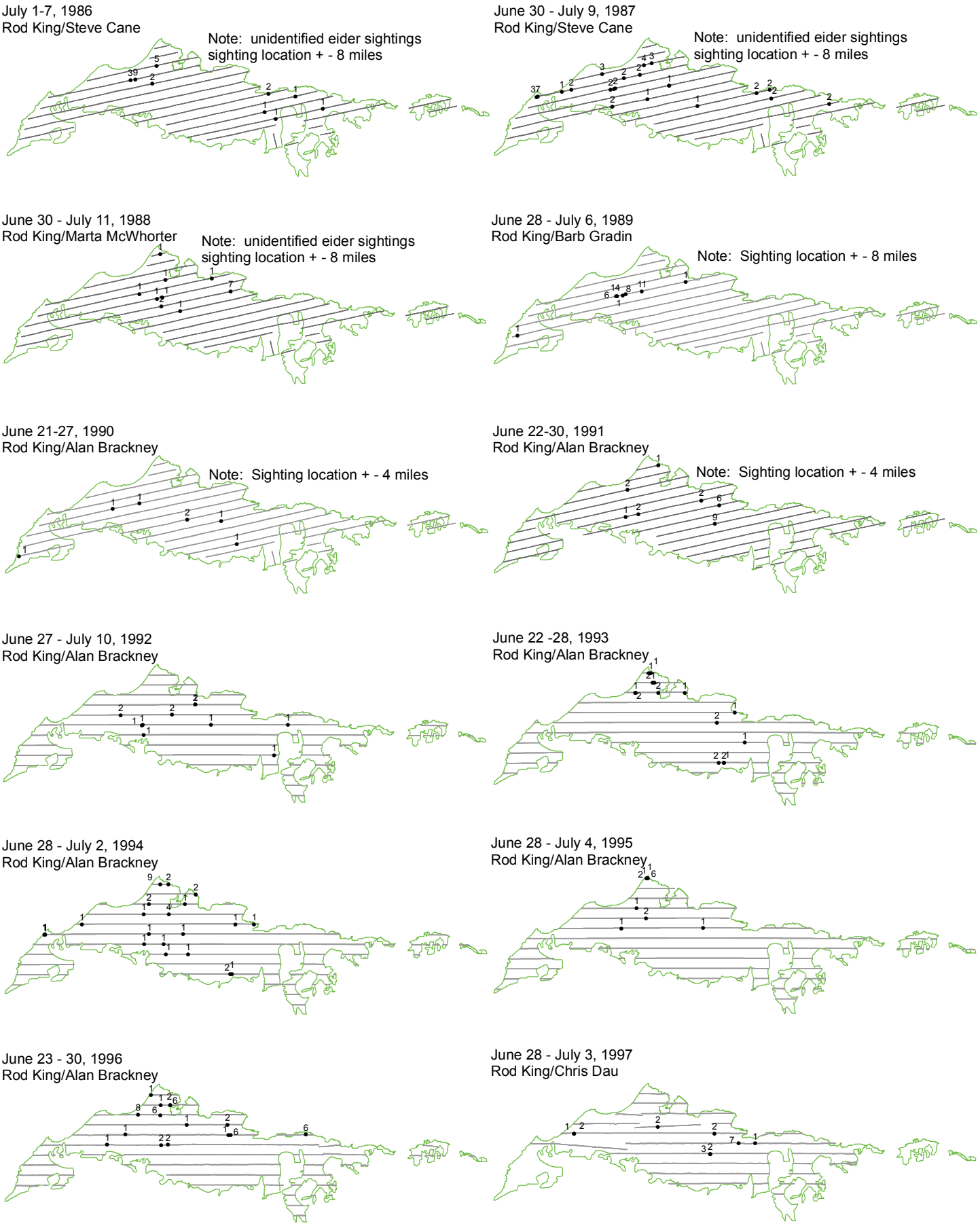
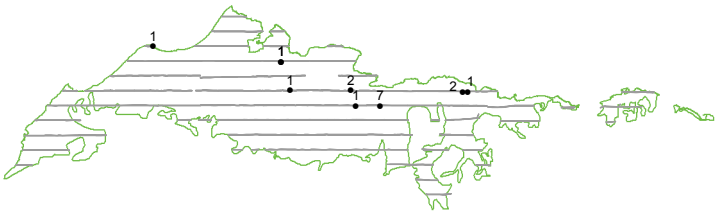
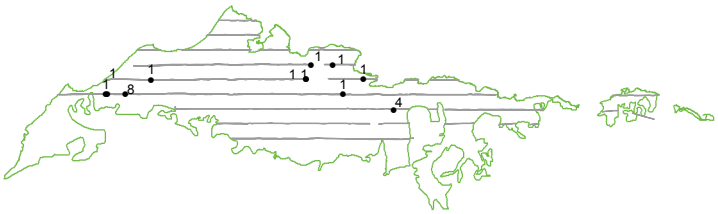


Fig. 1. Steller's eider sightings on the Arctic Coastal Plain Breeding Pair Aerial Surveys, 1986-1997. No Steller's eiders were recorded 1986-88, however some unidentified eiders were recorded during those years. Crews observed 400-meter-wide strip transects shown in gray.

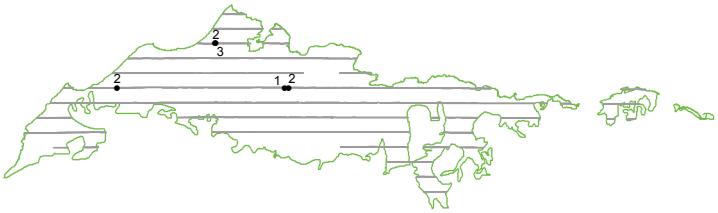
June 25 - 30, 1998
Rod King/Chris Dau



July 2 - 4, 1999
Rod King/Chris Dau, Ed Mallek/Eric Taylor

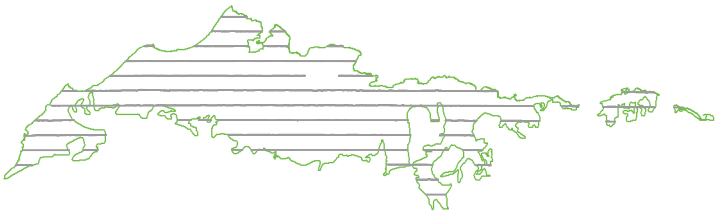


June 29 - July 6, 2000
Ed Mallek/Dennis Marks



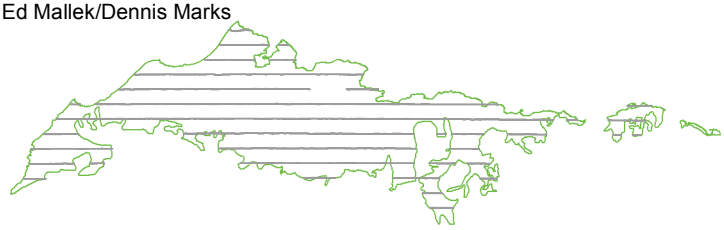
June 23 - 27, 2001
Ed Mallek/Dennis Marks

June 20 - 24, 2002
Ed Mallek/Dennis Marks



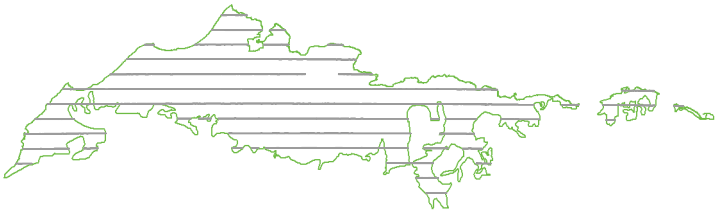
June 24 - 27, 2003
Ed Mallek/Dennis Marks

June 23-27, 2004
Ed Mallek/Dennis Marks



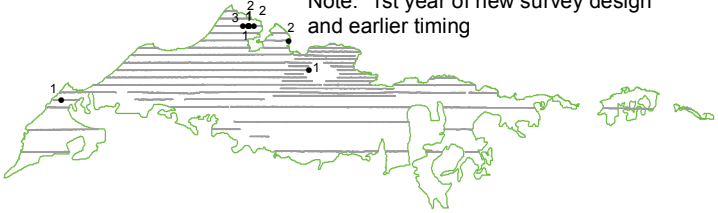
June 24 - 27, 2005
Ed Mallek/Dennis Marks

June 23 - 28, 2006
Ed Mallek/Dennis Marks



June 14 - 19, 2007
Bill Larned/Rob McDonald

Note: 1st year of new survey design and earlier timing



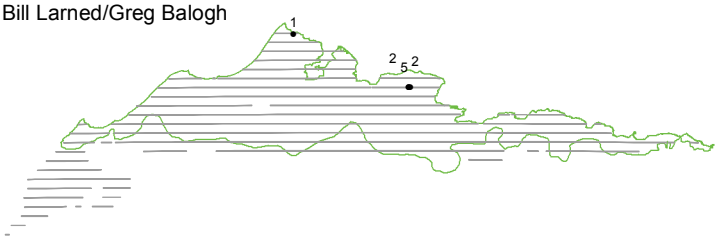
June 8 - 16, 2008
Bill Larned/Rob McDonald

All Steller's eider sightings 1986-2008

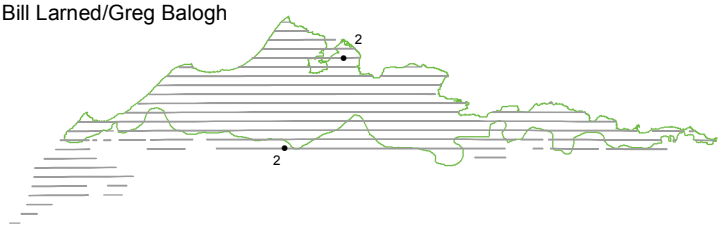
Fig. 2. Steller's eider sightings on the Arctic Coastal Plain Breeding Pair Aerial Surveys, 1998-2008. Crews observed 400-meter-wide strip transects shown in gray. Also, all sightings for all years shown in lower right corner.

June 20 - 29, 1992
Bill Larned/Greg Balogh

June 9 - 18, 1993
Bill Larned/Greg Balogh

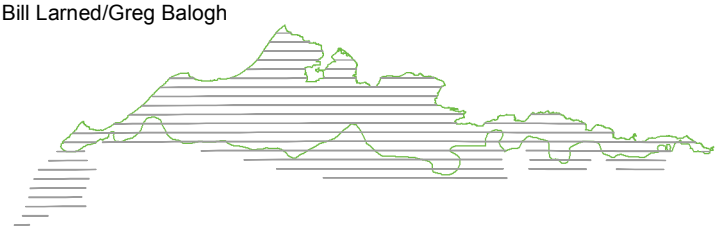


June 12 - 18, 1994
Bill Larned/Greg Balogh



June 9 - 18, 1995
Bill Larned/Greg Balogh

June 7 - 16, 1996
Bill Larned/Greg Balogh



June 11 - 20, 1997
Bill Larned/Tim Tiplady

June 7 - 15, 1998
Bill Larned/Tim Tiplady

June 7 - 17, 1999
Bill Larned/Tim Tiplady

June 11 - 19, 2000
Bill Larned/Julian Fischer

June 9 - 18, 2001
Bill Larned/Julian Fischer

June 9 - 14, 2002
Bill Larned/Alan Brackney

June 9 - 18, 2003
Bill Larned/Alan Brackney

Fig. 3. Steller's eider sightings on the North Slope Eider Aerial Surveys, 1992-2003. Crews observed 400-meter-wide strip transects shown in gray.

June 11-17, 2004
Bill Larned/Alan Brackney

June 10 - 19, 2005
Bill Larned/Tina Moran

June 10 - 16, 2006
Bill Larned/Dave Fronczak

Fig. 4. Steller's eider sightings on the North Slope Eider Aerial Surveys, 2004-2006. Crews observed 400-meter-wide strip transects shown in gray. Also, all Steller's eider sightings, 1992-2006 shown on lower right. All sightings from ACP and NSE surveys, all years, shown in bottom figure.

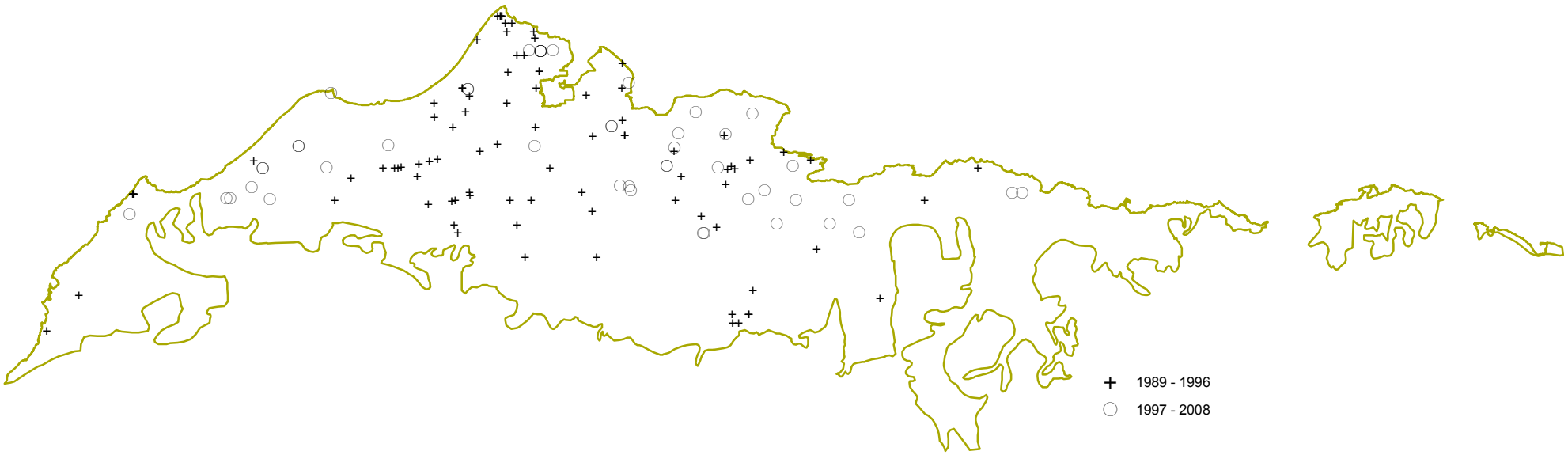


Fig. 5. Steller's eider sightings from ACP systematic aerial surveys grouped into 2 time periods, 1989-1996 and 1997-2008.

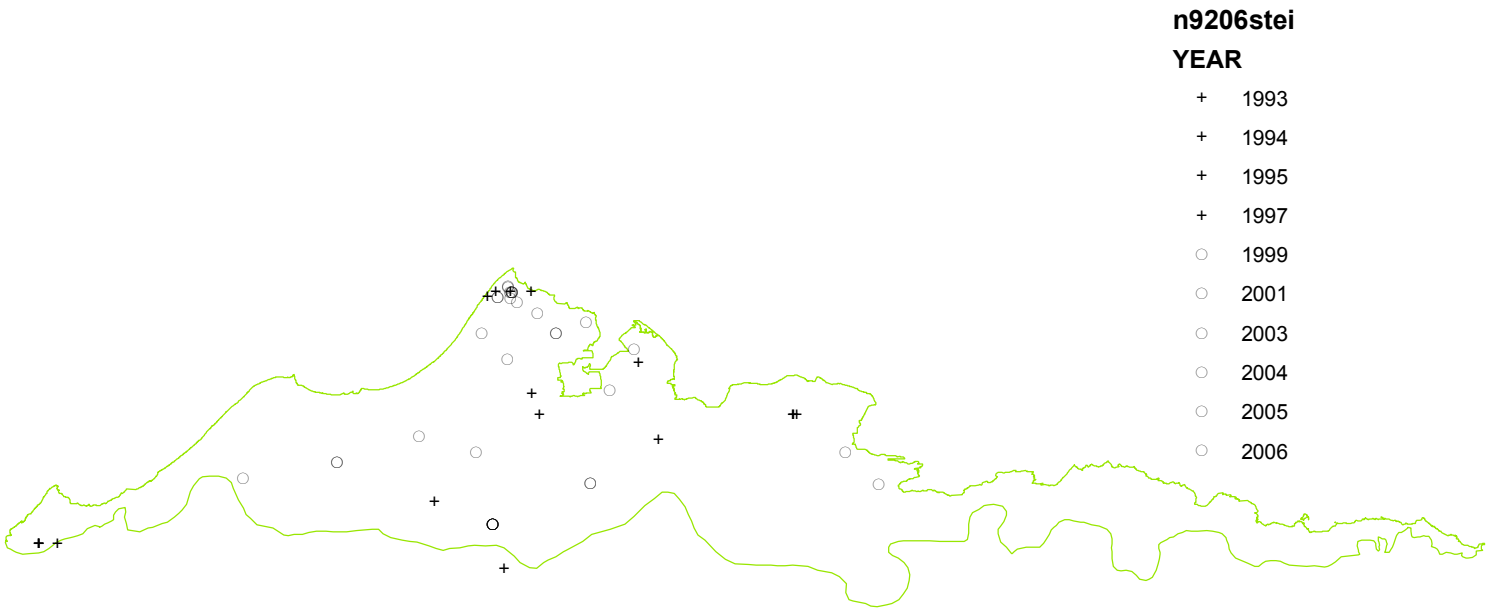


Fig. 6. Steller's eider sightings from NSE systematic aeiral surveys grouped by time periods.

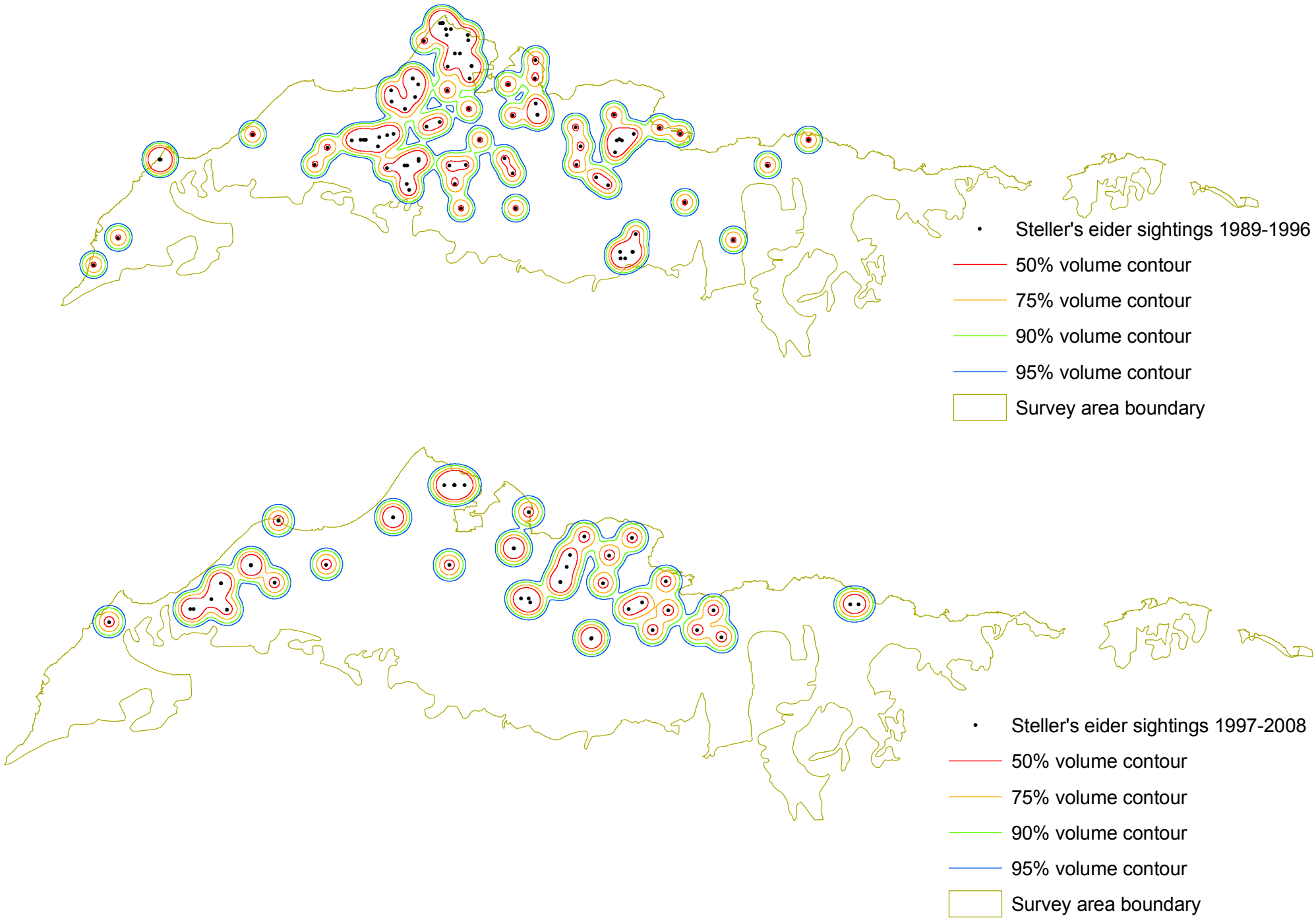


Fig. 7. Steller's eider sightings and percent volume contours derived from kernel density estimation with smoothing factor of 7500 meters (Hawth's Tools) from ACP systematic aerial surveys grouped by 2 time periods, 1986-1996 (top) and 1997-2008 (bottom).

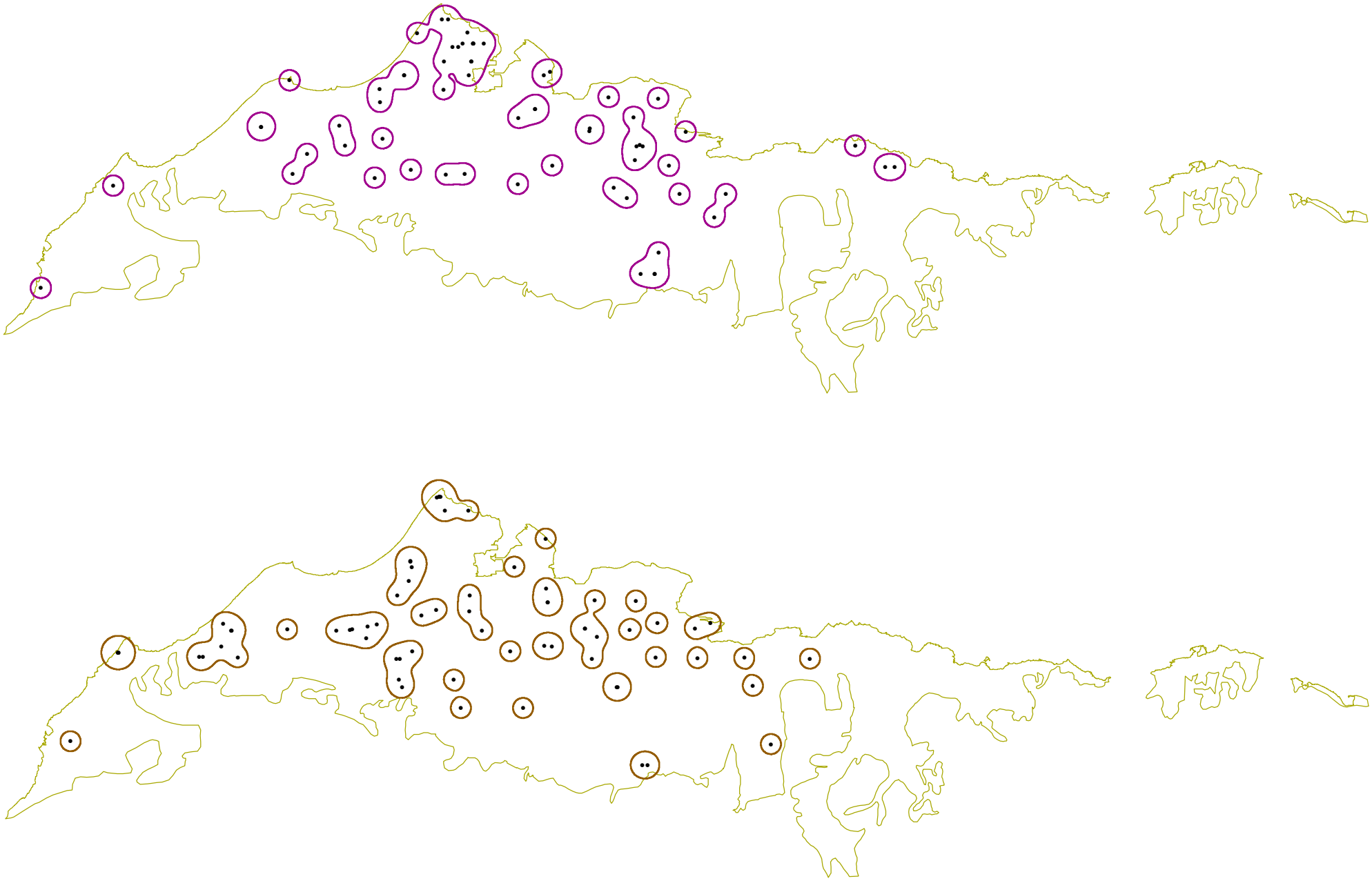


Fig. 8. Steller's eider sightings and kernel density estimates (75% volume contours) from ACP systematic aerial surveys grouped by whether survey was conducted relatively early (started before June 27, top) vs. relatively late (bottom).

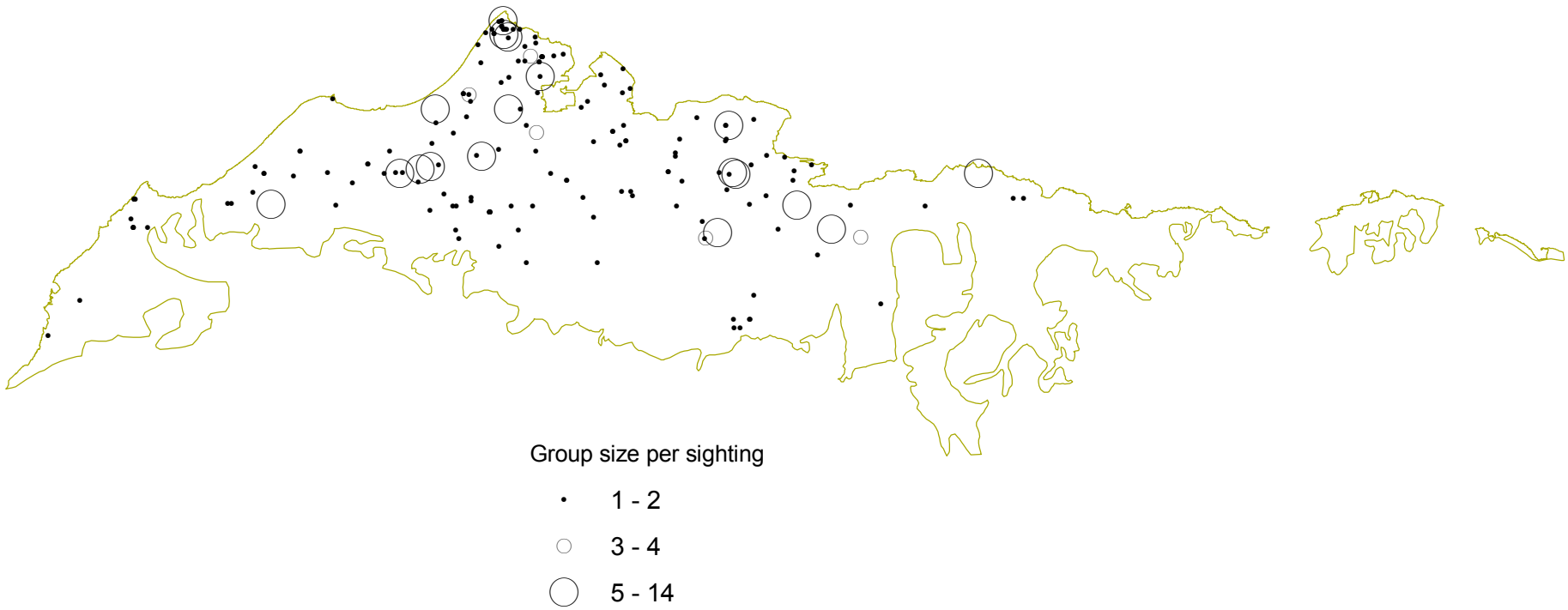


Fig. 9. All years ACP and NSE surveys Steller's eider sightings categorized by group size.

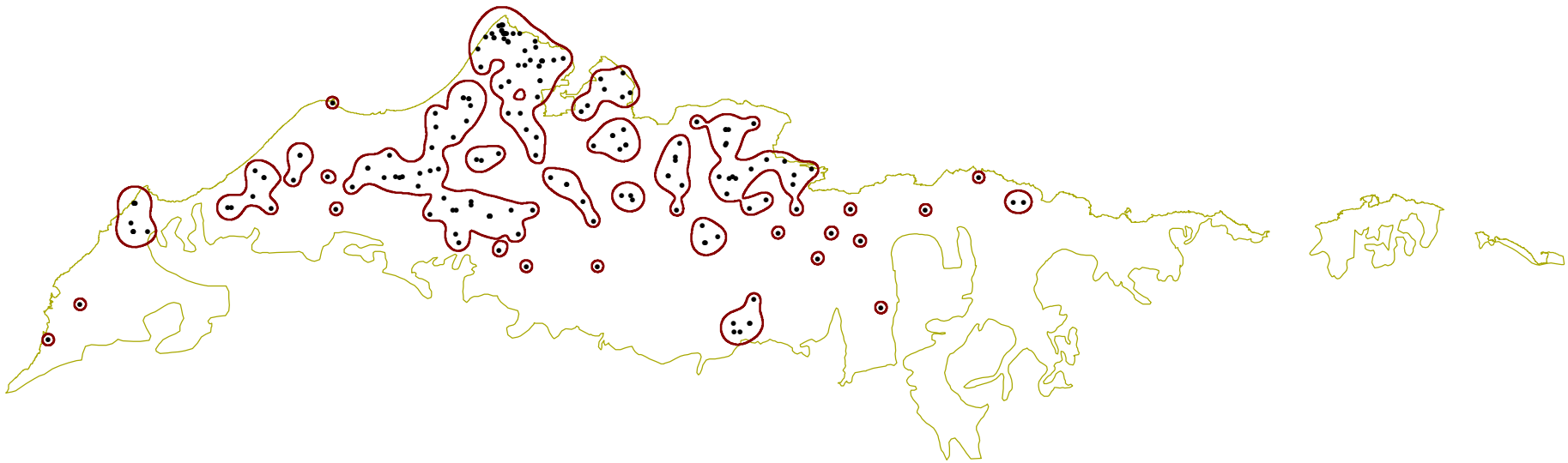


Fig. 10. Kernel density estimate 75% volume contours for all years ACP and NSE surveys Steller's eider sightings.

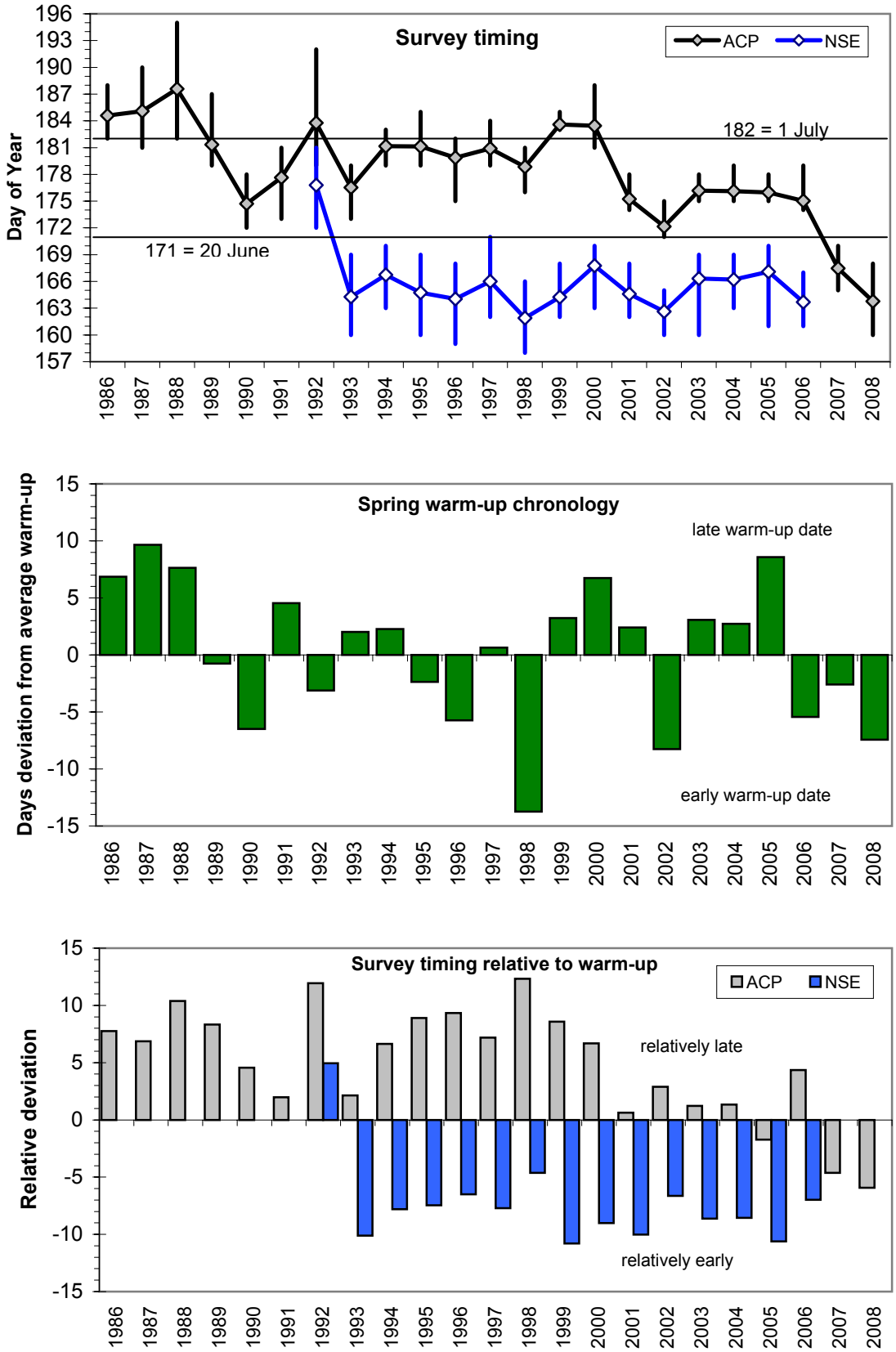


Fig 11. Survey timing, spring warm-up chronology, and survey timing relative to warm-up for ACP and NSE surveys.

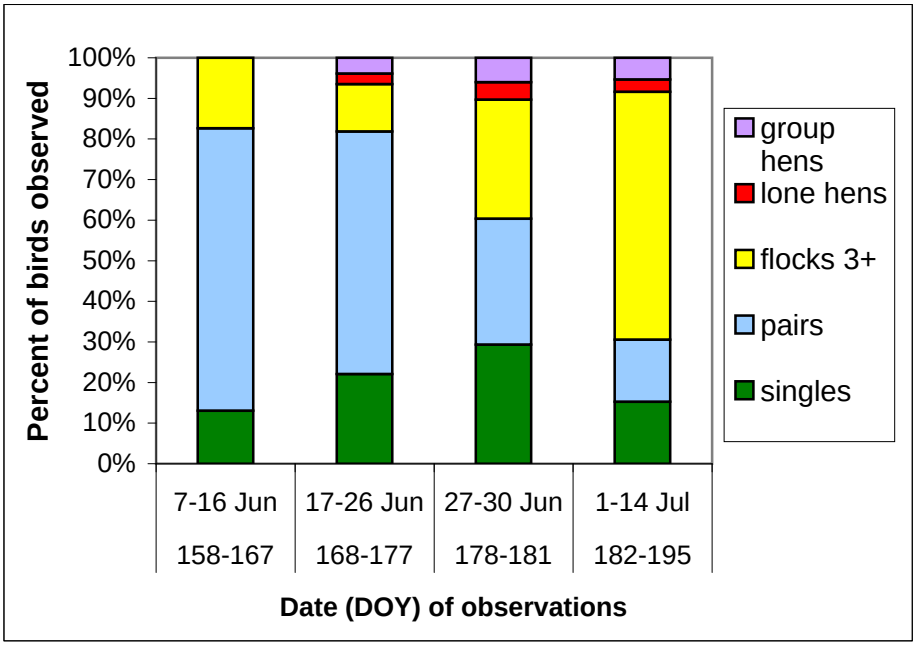


Fig. 12. Proportion of Steller's Eider birds observed in singles, pairs, or flocks on both the ACP and NSE aerial surveys in all years 1989-2008 as grouped by dates of observation.

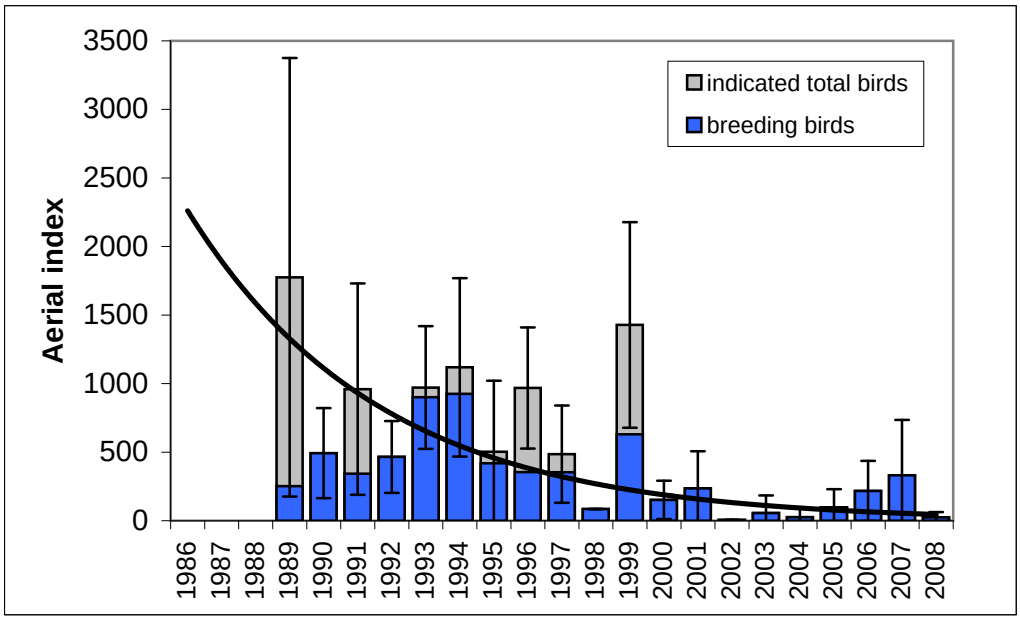


Fig. 13. Steller's Eider aerial population indices for indicated total birds and breeding birds after combining all years of data and both the ACP and NSE surveys. Vertical lines indicate 90% confidence intervals on the indicated total birds index. The curved line shows best log-linear fit with an average annual population growth rate of 0.837.

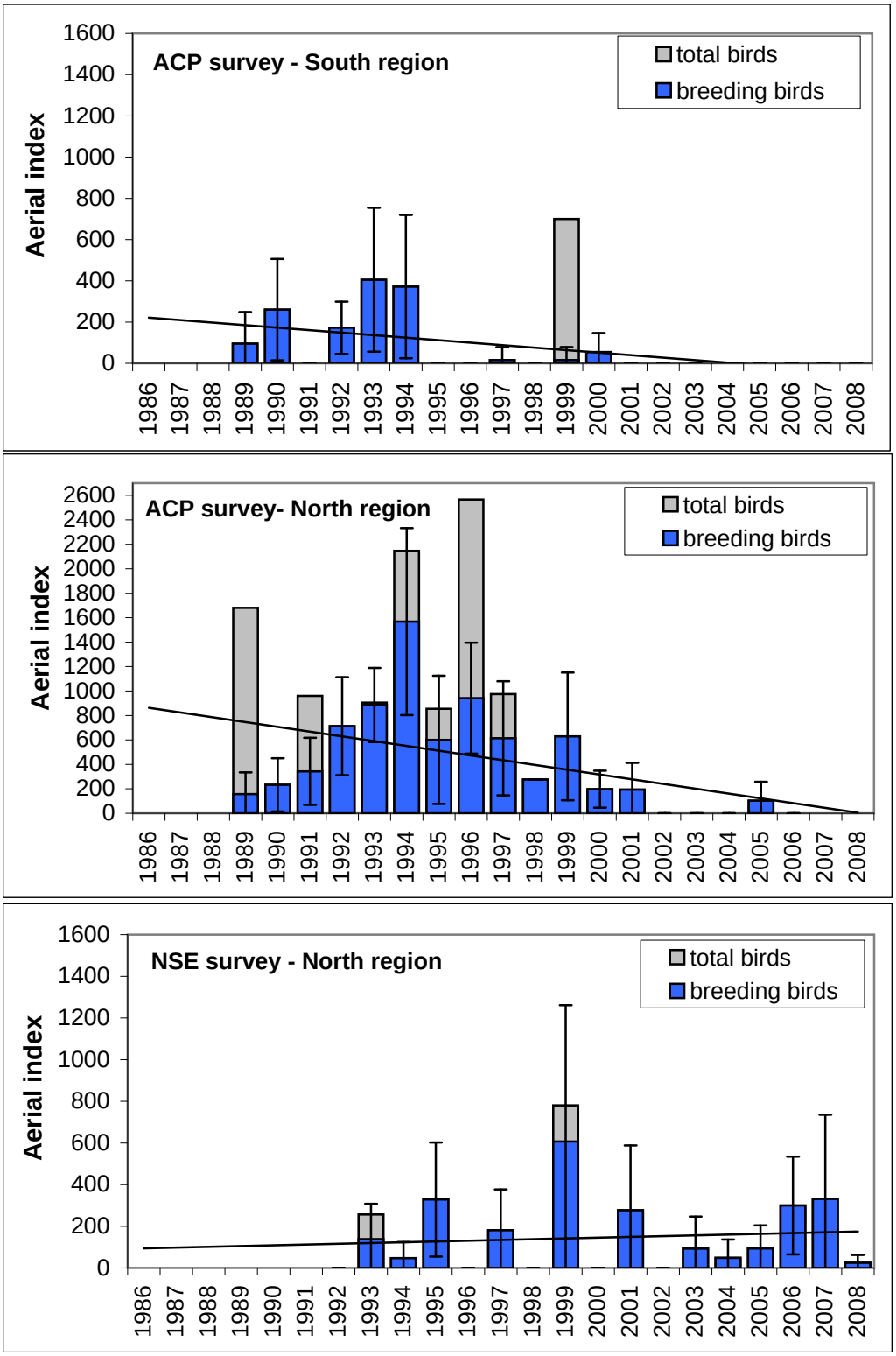


Fig 14. Steller's Eider aerial population indices for indicated total birds and breeding birds in ACP-south, ACP-north, and NSE-north survey regions. Vertical lines indicate 90% confidence intervals on the breeding birds index.

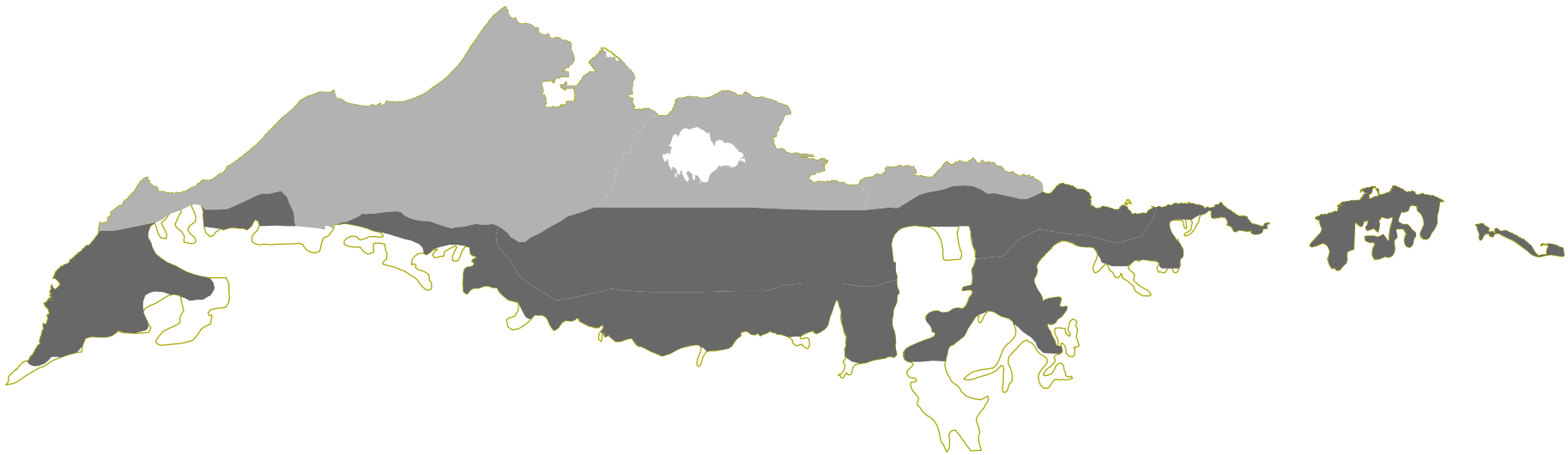


Fig. 15. Northern and southern strata used to calculate population size of Steller's eiders on the arctic coastal plain, Alaska.