ASSESSING THE BREEDING DISTRIBUTION AND POPULATION TRENDS OF THE ALEUTIAN TERN *ONYCHOPRION ALEUTICUS*

HEATHER M. RENNER[1], MARC D. ROMANO[1], MARTIN RENNER[2],
SANJAY PYARE[3], MICHAEL I. GOLDSTEIN[4] & YURI ARTUKHIN[5]

[1]*Alaska Maritime National Wildlife Refuge, 95 Sterling Hwy, Ste. 1, Homer, AK 99603, USA (heather_renner@fws.gov)*
[2]*Tern Again Consulting, 388 E. Bayview Ave, Homer, AK 99603, USA*
[3]*University of Alaska Southeast, 11120 Glacier Hwy., Juneau, AK 99801, USA*
[4]*US Forest Service, PO Box 21629, Juneau AK 99802, USA*
[5]*Kamchatka Branch of Pacific Geographical Institute of Far Eastern Branch RAS, Rybakov Prospekt 19a, Petropavlovsk-Kamchatsky, 683024, Russian Federation*

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SUMMARY

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We compiled survey data on 202 Aleutian Tern colonies throughout Alaska and Russia to assess the current status and colony sizes and to evaluate whether there had been changes in recent decades. We fit a Poisson generalized linear mixed model to all available counts of Alaskan colonies since 1960, excluding colonies in which the temporal spread of counts was < 6 years. Russian data were not included in the trend model due to our inability to resolve dates on a number of counts. We estimate that numbers at known colonies in Alaska have declined 8.1% annually since 1960 or 92.9% over three generations (33 years; 95% CI = 83.3%–97%), with large colonies experiencing greater declines than small colonies. Trends at known colonies within discrete geographic regions of Alaska (Aleutian Islands, Bering Sea, Chukchi Sea, Gulf of Alaska and Kodiak Island) were consistently negative. The most recent counts of all known Alaskan colonies summed to 5 529 birds. This estimate should be considered a rough minimum because it does not account for colonies that have not been surveyed in recent years — the size of which may have changed — or for the fact that the surveys conducted were neither systematic nor inclusive of all potential habitats. In Russia, the sum of the most recent count of all colonies was 25 602 individuals, indicating that Russia may host approximately 80% of the world population. Numbers in some regions in Russia appear to have increased substantially in recent decades, especially on Sakhalin Island and the southern coast of the Koryak Highland. We have no data to identify any population-level stressor that could explain the apparent reduction in numbers in Alaska. However, predation, egging and other anthropogenic disturbances, and degraded habitat may cause population change at local levels. If this overall pattern cannot be explained by other possible but unlikely factors (e.g. establishment of large colonies in new locations within Alaska, or major shifts between Alaska and Russia), then the observed trends in Alaska are, indeed, alarming. Therefore, we urge close monitoring of known colonies within Alaska, studies of dispersal, establishment of management practices to insulate colonies from human disturbance, and more concerted efforts among Alaskan and Russian partners.

Key words: Alaska, Aleutian Tern, colony counts, population change, Russia, world population

INTRODUCTION

The Aleutian Tern *Onychoprion aleuticus* is a poorly known seabird, with nearly all aspects of behavior, diet, migration, distribution and demographics limited largely to anecdotal information (Lee 1992, Hill & Bishop 1999, North 2013, but see Kaverkina 1986a, 1986b, Nechaev & Lobkov 1988, and Babenko 1996 for Russia). The species is known to breed throughout coastal areas of Alaska and the Russian Far East (North 2013) and to winter in Southeast Asia (Lee 1992, Hill & Bishop 1999, Carey *et al*. 2001, Poole *et al.* 2011).

The Alaskan breeding range of Aleutian Terns (Fig. 1) covers approximately 35% of the state's coast (Gotthardt *et al*. 2012). The northernmost documented breeding location is a small colony at Kasegaluk Lagoon on the Chukchi Sea coast, with colonies extending south along Kotzebue Sound, the Seward Peninsula, Norton Sound, the Yukon-Kuskokwim River delta, and into Bristol Bay along the Alaska Peninsula. Colonies range throughout the Aleutian islands and east into the Gulf of Alaska through the Kodiak Archipelago, Kenai Peninsula, Copper River Delta and as far east as Glacier Bay National Park.

In the Russian Far East, the breeding area of Aleutian Terns (Fig. 1) ranges from Sakhalin Island north to the coast of Anadyr Gulf (Nechaev and Lobkov 1988, Kondratyev *et al*. 2000). In the Sea of Okhotsk, the species is most abundant in Sakhalin, Khabarovsk region coast and Western Kamchatka, although small colonies are located in the Magadan area as well. The species is distributed along the eastern side of the Kamchatka Peninsula, on the southern coast of Koryak Highland (to the Apuka River) and in a few small isolated colonies near Anadyr.

Published estimates of Aleutian Terns breeding in Alaska have ranged from 9 000 to 12 000 birds (Sowls *et al*. 1978, Haney *et al*. 1991, North 2013). However, these estimates are based on counts that are now more than two decades old. Within the last decade, there have been reports of colony declines and disappearances at individual sites in Alaska (e.g. Corcoran 2012). In contrast, breeding populations in the Russian Far East apparently have increased from 10 000 birds in the 1970s and 1980s (Nechaev 1989) to 22 000–24 000 in the 1990s (Lobkov 2001) and 28 000–30 000 in the 2000s (Lobkov 2006).

Inter-related challenges that have always underpinned an assessment of the Aleutian Tern are its poorly understood breeding behavior, ambiguity in the definition of breeding sites and the general inadequacy of colony abundance data. For instance, nesting microhabitats can range from coastal sandy beaches, sandbars and sand dunes, to inland reticulate and string bogs, wet meadows and tundra, and coastal forest tundra with sparse larch trees (Baird 1986, Nechaev & Lobkov 1988, North 2013). Furthermore, although most Aleutian Tern colonies are <3 km from the coast, they also occur as far as 20 km inland (Nechaev & Lobkov 1988). Additionally, nesting may occur in localized clusters tens to upwards of a hundred kilometers apart, and a clear understanding of whether these clusters function interdependently, spatially or temporally, is lacking (Pyare *et al*. 2013). At the few specific colony locations where annual counts are available (all generated from unmarked individuals), colony size and numbers of breeding pairs may fluctuate from year to year (Nysewander & Barbour 1979, Corcoran 2012, Oehlers 2012). These observations and challenges are not unique and may be analogous to numerous seabird species nesting colonially throughout expansive and remote areas of the North Pacific.

To address the broader relevance of the anecdotal reports of colony decline and disappearance, and to evaluate region-wide breeding colony distribution and population status, we compiled current and past breeding colony information with the specific intent to (1) summarize historic and current colony locations, (2) evaluate Alaskan population trends and (3) review potential causal mechanisms for observed trends. To our knowledge, this represents the first analysis of population trends for this species.

METHODS

We compiled Aleutian Tern population estimates for 202 colonies using a combination of previously gathered and new information (Appendix 1, available on the website). Our primary source of published data for Alaskan colony (n = 110) size and locations was the North Pacific Seabird Colony Database (USFWS 2013). In 2012, we acquired additional colony information from a number of sources, including state and federal wildlife biologists, ornithological researchers, professional bird guides, birdwatchers and online databases, including the Alaska Natural Heritage Program's Biotics data portal (ANHPB 2015) and eBird (Audobon and Cornell Lab of Ornithology 2014). In 2013, we opportunistically surveyed 28 Aleutian Tern colonies across Alaska. These data were collected during the egg or chick period (approximately 10 June to 7 July), normally with replicate counts on multiple days and/or with multiple observers. Most counts were visual counts of birds in the air as the observer(s) stood at the edge of the colony; birds in the large colonies (e.g. Situk River/Black Sand Spit near Yakutat) were counted in groups of 20.

We also compiled counts from 92 Russian colonies, mainly from published sources (Appendix 2, available on the website). Russian data were not included in the trend model because we were unable to resolve dates to the year level on a number of important counts (and the surveys were on average much older), but these data were used for distribution information and minimum population estimates.

Screening of data

Aleutian Terns may nest in dispersed groups, so discrete colonies can sometimes be challenging to delineate. Whenever possible, we deferred to the original data source when determining the limits of a given colony. In a few cases when colonies were within the same general area, we arbitrarily defined birds nesting more than 1 km apart as separate colonies. In some locations, there were insufficient data to determine the spatial distribution of groups of nesting birds; in these cases we lumped nesting birds into broader areas by a common geographic denominator such as a river delta or entire island.

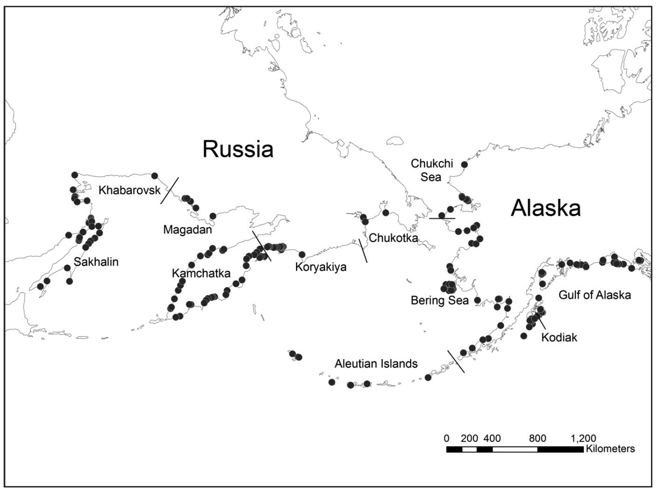

Fig. 1. Map of the current worldwide breeding range of Aleutian Terns. Dots represent known colonies that were still occupied during the most recent survey.

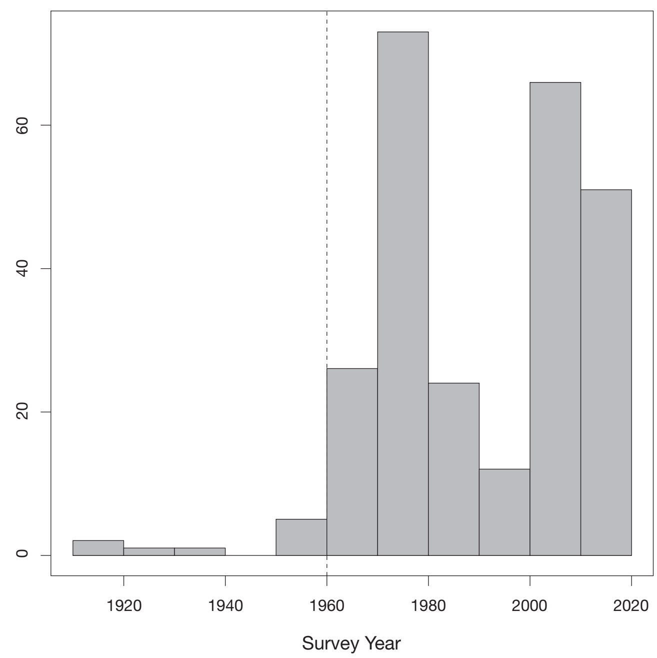

Fig. 2. Histogram showing timing of surveys of Aleutian Tern colonies in Alaska. The trend model included only data after 1960 (the dashed line). Single survey dates were used for each colony in a given year. Y-axis is number of colonies surveyed in each decade.

For counts in which observers reported a range in the number of nesting birds for a colony within the same year, based on separate counts, we used the greater number (i.e. if 25 birds were counted on 18 June 2008 and 35 on 23 June 2008, we used 35), since it was considered the closest to the actual number of birds using the colony that year. If the only estimate we had for one year was based on a single observation and reported as a range, we used the midpoint (i.e. if "150–200 birds" were reported on 19 July 2003, our value used for 2003 was 175).

Statistical analysis

Before fitting a population change model to the Alaskan data, we restricted our dataset in three ways. First, we omitted all colonies for which there was only a single year's count within the included time period 1960–2013 (n = 31) or for which only qualitative information was available (e.g. "present") because we could not determine a trend. Second, we omitted all counts conducted before 1960 (n = 18). Although datasets include observations from as early as 1914, data before 1960 were sparse (Fig. 2), and calculating a constant long-term trend over a time interval of 100 years did not appear to be biologically meaningful for a seabird of this body size. Third, because we observed that year-to-year colony counts often fluctuated widely, we restricted the dataset to colonies with counts spread over an interval of six years or more. A shorter interval would lead to some colonies having extreme trends over a short period of time, which was more likely to represent noise than changes in population. Ultimately, we used data from 64 Alaskan colonies with 261 total observations in the data set, ranging from 1960 to 2013, to model population trends.

We used a Bayesian framework to calculate a long-term population trend of Aleutian Terns in Alaska. We modeled the colony counts using a generalized linear mixed model (GLMM) with a Poisson error distribution and a log-link function. Markov chain Monte Carlo (MCMC) methods do not suffer the same numerical convergence issues found in approaches based on maximum-likelihood, making them suitable for fitting non-Gaussian GLMMs (McCulloch & Searle 2001). Random effects consisted of survey year and intercept, nested within a colony identifier. Survey year was also treated as a fixed effect (trend). We treated the median of each parameter's posterior distribution as the estimate. We specified uninformative priors, following defaults in package MCMCglmm v. 2.21 (Hadfield 2010). Posterior estimates were obtained based on 20 000 iterations, excluding a burn-in of 5 000 iterations. To reduce autocorrelation, the posterior sample was thinned by considering every tenth iteration. We used graphical checks and standard diagnostics to assess mixing of MCMC chains. Model fitting and all other computations were conducted in R 3.1.2 (R Core Team 2014).

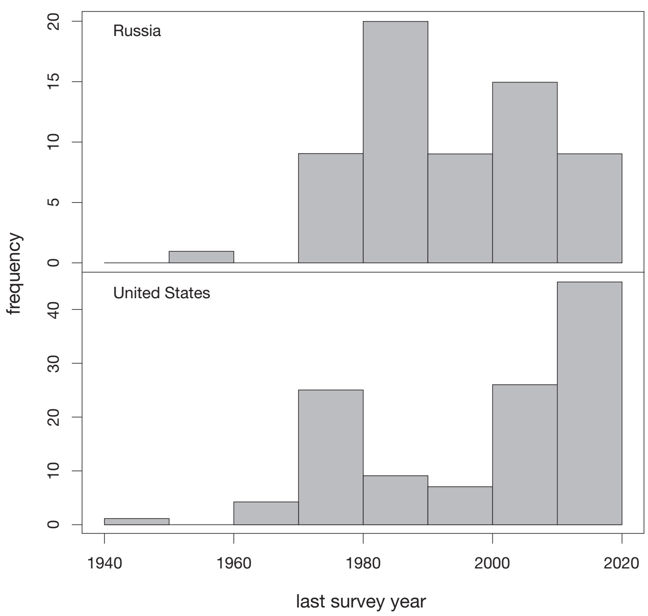

Fig. 3. Histogram showing timing of most recent surveys of Aleutian Tern colonies in Russia (top) and Alaska (bottom). Y-axis is number of colonies with their most recent survey in each decade.

Following the criteria used by the International Union for the Conservation of Nature (IUCN 2013), we transformed the rate of annual change, obtained from the parameter estimates, into the proportional change over three generations. Lacking demographic data for Aleutian Terns, we used a generation length (g) of the congeneric Sooty Tern *Onychoprion fuscatus*, reported at 10.9 years (BirdLife International 2014). We chose this value over the 13.4 years generation length calculated for the largely sympatric, similarly sized Arctic Tern *Sterna paradisaea* (BirdLife International 2014), to be conservative with our estimates.

We transformed the parameter estimate P of the overall year fixed effect into a rate of change over three generations d using:

$$d = e^{P^{3g}} - 1$$

We report 95% credible intervals based on the quantiles of the posterior distributions.

To examine whether the trends were consistent across geographic regions, we divided the Alaska data into five broad geographic areas (Gulf of Alaska, Kodiak Island, Aleutian Islands, Bering Sea and Chukchi Sea). We compared trends across these regions by adding the slope estimates of the random effect to the fixed effect and averaging over regions.

RESULTS

Based on the most recent counts available, we estimated a minimum worldwide breeding population of Aleutian Terns as 31 131 birds across 202 colonies, with 18% (5 529 birds in 110 colonies) in Alaska and 82% (25 602 birds in 92 colonies) in Russia. The most recent counts varied across colonies from 1959 to 2013 in Russia and from 1946 to 2013 in Alaska (Fig. 3). Our trend analysis indicated that colony counts of Aleutian Terns in Alaska declined on average 8.1% per year (95% credible interval 10.7%–5.5%) between 1960 and 2013. Over three generations (33 years) this equates to a 92.9% decline (95% credible interval 83.3% to 97% decline). The trend in Alaska was consistent across geographic regions (Fig. 4). Intercept and slope estimates of the random effects were negatively correlated (r = -0.70), indicating that, in general, larger colonies experienced greater declines than smaller colonies (Fig. 5). (However, the largest colony in Alaska at Situk River is an exception.) Supporting this quantitative trend, we found widespread disappearances of Alaskan colonies (zero birds observed on most recent visit). Twenty-nine of the 110 Alaskan colonies (26%) were not attended during the most recent visit (Table 1); many of these had at one time contained from hundreds to up to 3 000 individuals (e.g. Amee Island, Kodiak, in 1976). Although 26 colonies were newly reported in Alaska since 1995, they were all small (totaling 834 individuals), and fewer than five of those colonies were presumed to be new (e.g. sites where observers had regularly documented an absence of birds historically). We assume most of the newly documented colonies are not new but were discovered as a result of increased search effort.

For our trend analysis, we did not weight colonies by their relative size, but rather treated each colony equally (i.e. as if they typified a random sample of true colonies). If we assume that the surveyed colonies represent a high percentage of the total population, another approach to the analysis would be to weight colonies by their size, since a change in a large colony will have a greater impact on the total population than a change in a small colony. Had we done so, the estimated decline over three generations (98.3%) would be even more severe than our non-weighted estimate (92.9%). Similarly, the data restrictions we made led to a more conservative estimate of the decline. Reducing the required spread in data at an individual colony from > 5 to > 3 years resulted in a more severe decline. Changing the cut-off from 1960 to 1950 or 1970 had little impact on the parameter estimates.

In Russia, three of 92 colonies (3.3%) had a zero count on the most recent visit. Major colonies at Sakhalin Island and Koryakiya increased during the observation period, although we could not resolve dates on multiple observations sufficiently (i.e. to the year level) to calculate a trend.

Geographic summaries

The largest known Aleutian Tern colonies in Alaska are in the Gulf of Alaska (Table 1), with the single largest on Situk River/Black Sand Spit near Yakutat (Appendix 1, available on the website). While numbers of Aleutian Terns have remained stable in Yakutat since first reported in 1914, numbers in the Copper River Delta (also in the Gulf of Alaska region), have declined from approximately 2400 in the 1980s to three birds in 2013.

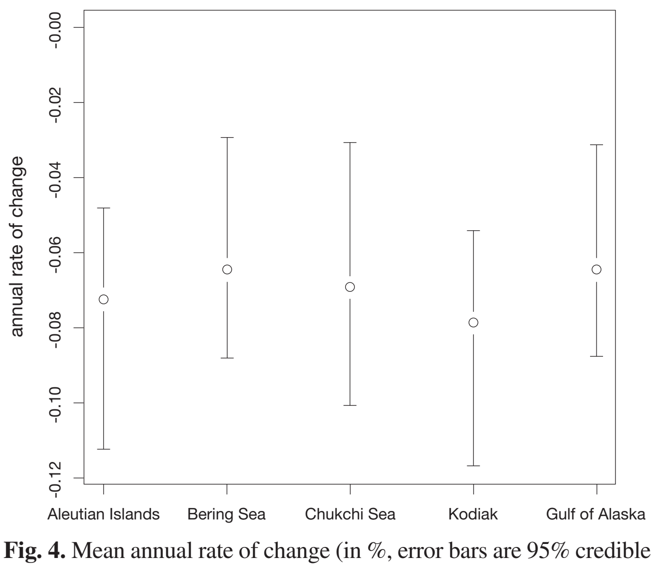

Fig. 4. Mean annual rate of change (in %, error bars are 95% credible intervals) in Aleutian Tern colony size in Alaskan geographic regions.

The Kodiak Archipelago supported over 4000 breeding Aleutian Terns as recently as 1995. However, recent counts for the area yielded only 525 breeding birds (Table 1). Aleutian Terns may have been extirpated from Kodiak between the 1890s and 1940s (Friedmann 1935, Gabrielson & Lincoln 1959), although we have little information on how widespread surveys were during that time. Because of their relative accessibility, the many colonies in this area have had more frequent surveys than much of the rest of Alaska.

The Aleutian Archipelago currently supports a minimum of 296 Aleutian Terns in six known colonies. Historically, this area supported 11 known colonies, but five of them have disappeared, and no new colonies have been discovered in this region since 1995. Colonies have persisted on Adak Island and Attu Island despite the presence of introduced mammals (e.g. Norway rat *Rattus norvegicus*) since World War II.

The Bering and Chukchi Sea regions have historically supported 40 known colonies and 4000 breeding birds, but the most recent count of all known colonies in the region totals only 1556 birds. Few contemporary survey data are available for the north side of the Alaska Peninsula, where there are substantial amounts of potential habitat. An observer in 2014 (Nat Drumheller, pers. comm.) noted large numbers of Aleutian Terns near Port Moller (but did not find a breeding colony); none were seen there in 2013 during a targeted survey. The region hosts large amounts of potential habitat that have not been surveyed for Aleutian Terns in recent years.

DISCUSSION

Our estimate of a minimum population size of 31140 birds in 202 colonies is low compared with other Northern Hemisphere tern

TABLE 1
Summary of Aleutian Tern colony status in Alaska and Russia, by geographic region

Region	No. of colonies (includes inactive)	No. of individuals	No. disappeared[a]	No. new[b]
Aleutian Islands	11	296	5	0
Bering Sea	32	1 248	6	7
Chukchi Sea	8	308	2	0
Gulf of Alaska	29	3 152	4	12
Kodiak	30	525	12	7
Alaska total	**110**	**5 529**	**29**	**26**
Chukotka	3	229	0	0
Koryakiya	15	1 560	0	9
Kamchatka	36	4 514	2	2
Magadan	8	467	1	5
Khabarovsk	14	2 972	0	0
Sakhalin	16	15 860	0	0
Russia total	**92**	**25 602**	**3**	**16**
Worldwide total	**202**	**31 131**	**32**	**42**

[a] Number of colonies with a zero on the most recent count.
[b] Number of colonies first recorded after 1995.

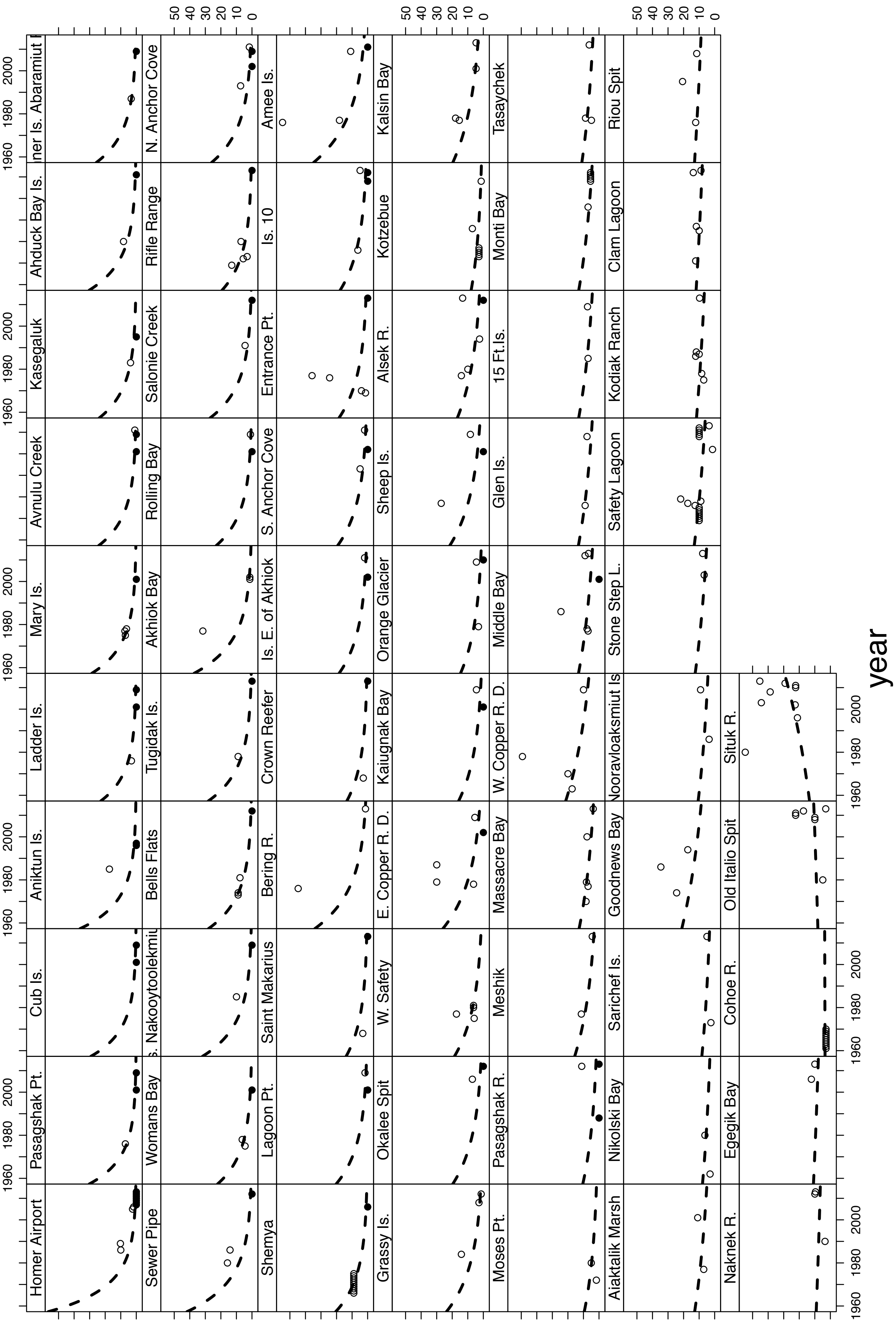

Fig. 5. Modeled trends in Alaskan Aleutian Tern colonies since 1960. For graphical visualization, colony counts were square-root transformed. Colonies were ordered by the size of the mean count.

species (e.g. Common Terns *Sterna hirundo* [1.6–4.6 million], Arctic Tern [>2 million] and Caspian Tern *Hydroprogne caspia* [240 000–420 000]; IUCN 2014). Globally, this estimate puts Aleutian Tern probably among the 10 (out of 41–43 species) rarest terns by population size (IUCN 2014). Our trend analysis indicates a large-scale change in previously documented populations in Alaska. To put this potential decline in perspective, one of the criteria for categorizing a species as Critically Endangered by the IUCN Red List program (IUCN 2013) is a decline of >80% over three generations (estimated near 33 years for Aleutian Terns), and our Alaskan data indicated a 92.9% decline over that time period. Although we were unable to complete a trend analysis on the available Russian Aleutian Tern colony data, it does not appear that the overall population there is declining. Local populations appear to be increasing in the South Koryakiya and Sakhalin Island regions, and they appear stable in Kamchatka. The northern end of Sakhalin Island may support half the world's population of breeding Aleutian Terns, with the majority found in the Piltun Gulf. Further surveys are needed across Alaska and Russia to confirm whether additional colonies exist.

Our estimates of population size are dependent on a number of underlying assumptions. A few Alaskan areas that we believe may still have nesting Aleutian Terns lack recent surveys; these include Goodnews Bay, Dillingham (Grassy Island), Izembek Lagoon and Port Moller, each of which has previously supported hundreds of birds. Likewise, the Alaskan and Siberian coastlines are vast, and these findings do not account for a significant amount of unsurveyed area that could potentially support nesting Aleutian Terns. Moreover, we do not know whether birds from colonies that have declined or are no longer active have moved to new locations and established colonies that have not yet been identified. Banding or satellite tagging studies are needed to understand intercolony movements.

Even where count data are available, inference is drawn from a relatively small number of sampling events in any one colony location. Until 2013, counts were not conducted following a formal protocol. Furthermore, counts were not conducted within a standard temporal window during the breeding season, a standardized metric was not used for counts (e.g. birds in the air, nests etc.), and data quality is low in many cases (e.g. estimates were occasionally guesses rather than counts and were rarely replicated). In addition, there is known variability in attendance, both within and among years (Pyare *et al*. 2013); as a result, the limited data are confounded by extreme variation in attendance, partly due to breeding failure, and occasional colony movement (Oehlers 2012). However, recognizing this limitation, we see no reason for directional bias in the estimates. The strength of our analysis is based on the large number of colonies combined into a single model, together indicating a trend.

We are unaware of any published data on dispersal or philopatry in Aleutian Terns. Limited evidence from Alaska and Kamchatka suggests that Aleutian Terns can visit potential breeding sites 10–100 km apart from one year to the next (Lobkov 1998, Pyare *et al*. 2013). Movement between breeding colonies is common in some tern species (but see Braby *et al*. 2012), and this movement complicates the interpretation of colony count data. Emigration from a breeding colony can be caused by a variety of factors, including predation (Brindley *et al*. 1999, Cuthbert and Wires 1999), human disturbance from egging (Feare and Lesperance 2002), food availability (Crawford 2003) and management actions (Roby *et al*. 2002). The resulting immigration to neighboring colonies by dispersing individuals can have a profound effect on colony growth rate (Szostek *et al*. 2014). Although dispersing terns may occasionally establish new colonies (Roby *et al*. 2002), it seems more common that they will move to a previously established colony (e.g. Feare & Lesperance 2002, Tims *et al*. 2004, Devlin *et al*. 2008, Spendelow *et al*. 2010). For some species of tern, high rates of fidelity to previous breeding colonies have been observed, particularly at colonies that experience low rates of predation and disturbance (Spendelow *et al*. 1995, Devlin *et al*. 2008). Given the limitations of our data, we cannot quantify the influence that dispersal may have on the population dynamics of Aleutian Terns. We acknowledge the possibility that some of the observed decline at individual Aleutian Tern colonies in Alaska may be due, in part, to dispersal and that Aleutian Terns in Alaska likely comprise a metapopulation of local populations distributed among patches of suitable habitat. However, we believe that the effect of dispersal alone may not be enough to explain the observed declines in known colonies, because (1) dispersal rates may be low for remote colonies in Alaska that do not have high levels of disturbance, (2) dispersing birds may be more attracted to established colonies (as opposed to establishing new colonies, thus making them more likely to be counted at a neighboring colony), and (3) there would have to be considerably more emigration from known colonies to unknown colonies rather than the other way around (i.e. dispersal would have to be biased). Disturbance could cause such a bias, and would likely lead to increased breeding failure and decreased productivity as well.

Clearly, there is a need to examine potential habitat areas outside known colonies to confirm our results. Nonetheless, within Alaska, from our experience searching large areas for these colonies, we think it is unlikely birds could have relocated in Alaska, to locations not subsequently discovered, sufficiently to counter the large decline observed in known colonies.

At an even broader scale, the question about connectivity between Russian and Alaskan populations is still open. Based on data collected from two birds equipped with geolocators, the migration route for Alaskan Aleutian Terns overlapped some of the coastline where Russian birds have established colonies (Pyare *et al*. 2013). Still, birdwatchers' reports suggest a highly pelagic migration is most likely, with birds seen from land only during or after major storms.

We have no evidence of a single stressor responsible for the apparent reduction in Aleutian Terns in Alaska. Several factors, including predation, traditional harvest of eggs and disturbance by humans likely play a role in population change at local scales and, cumulatively, may have wider population-level effects. Aleutian Tern eggs and chicks are taken by a large variety of avian and terrestrial predators, and heavy predation can negatively affect reproductive success, particularly when combined with other forms of colony disturbance (Nechaev & Lobkov 1988, Haney *et al*. 1991, Oehlers 2007, North 2013). Subsistence egging by Alaska natives occurs at many colonies (e.g. Yakutat, Cape Krusenstern, Dillingham, Goodnews Bay, Kodiak Island, Situk River). Aleutian Terns can be highly sensitive to human disturbance (Buckley & Buckley 1979, North 2013) and have abandoned colonies after just a single human visit (Haney *et al*. 1991). Some of the large tern colonies in Alaska as well as in the south Sea of Okhotsk and southwest Bering Sea are near areas of substantial human activity, and we received anecdotal reports of regular disturbance at many colonies (see also Nechaev & Lobkov 1988, Lobkov 1998). Sometimes disturbance and predation can have a strong effect on single colonies: for example, Babenko (1996) identified egging and disturbance as the main threats to Aleutian Terns in the Schastya Gulf.

The availability of suitable nesting habitat is not known to be a limiting factor for Aleutian Terns at the population level, although habitat change has created local-scale effects in a few instances that may influence long-term tern nesting success (e.g. tectonic uplift in the Copper River Delta [Holtan 1980], coastal and fluvial processes at Situk River, Yakutat [Oehlers 2007], and storm tides and erosion on coastal barrier islands in the Bering Sea [Gill 2008]).

Other factors that may impact Aleutian Terns, and have not been studied, include the status of the marine-based food supply within foraging distance of breeding colonies and habitat quality in wintering areas. Changes in food availability have been implicated in a 57% Arctic Tern decline in Maine in the last decade (Linda Welch, pers. comm.; Gulf of Maine Seabird Working Group 2014). On a local level, food availability has also been shown to significantly influence colony size and fidelity in Greater Crested Terns *Thalasseus bergii* (Crawford 2003). Although the wintering areas of Aleutian Terns are still largely unknown, some evidence indicates that some birds spend the winter in Southeast Asia and Oceania in the tropical western Pacific (Haney *et al*. 1991, North 2013, Pyare *et al*. 2013). In particular, there are a small number of old specimen records from the Philippines and Indonesia (Lee 1992, Hill & Bishop 1999, Carey *et al*. 2001). Since the early 1990s, the species has been recorded annually in the fall off Hong Kong and less frequently in spring (Hill & Bishop 1999). In addition, a wintering area has been found recently in the Strait of Malacca (Poole *et al*. 2011). Little is known about the potential habitat quality or threats to Aleutian Terns in these areas.

Apparent numbers of Aleutian Terns in Alaskan colonies have declined dramatically since the 1960s. If these counts were to reflect the population history of the species, it would represent an almost unparalleled population crash within Alaskan seabirds. Many unanswered questions remain, however.

Recommendations

Although some effort has been made to monitor Aleutian Terns in a few discrete locations in Alaska (e.g. Yakutat, Kodiak Island), a coordinated, range-wide monitoring program, including an appropriate sampling design and protocol development, is needed to track the population. Surveys should also be conducted at historical colonies, particularly in the Aleutian Islands and Bering Sea/Alaska Peninsula (north side), where limited contemporary survey data are available. Tagging studies to determine inter-colony movement, and broad food habits studies, are needed. In the interim, we urge management efforts to insulate colonies from human disturbance and more concerted efforts among Alaska and Russian partners, especially focused on understanding colony movements and dispersal.

Outside of the breeding grounds, priority should be given to collecting information on Aleutian Tern wintering locations and ecology. Current information is limited to a handful of sight records and is insufficient to determine whether potential threats on the wintering grounds could be negatively impacting the species.

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