Published in a special issue on albatrosses in the January issue of the Japanese journal Iden: the article was submitted by invitation from members of the Yamashina Institute for Ornithology, Hokkaido University Museum, and the Editor of Iden. The article is: Robert M. Suryan and Kathy J. Kuletz. 2018. *Distribution, Habitat Use, and Conservation of Albatrosses in Alaska*. Iden 72:156-164. It is available online, but is in Japanese; for an English version contact Kathy_kuletz@fws.gov or Rob.Suryan@noaa.gov

Distribution, Habitat Use, and Conservation of Albatrosses in Alaska

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All three North Pacific albatross species forage in marine waters off Alaska. Despite considerable foraging range overlap, however, the three species do show broad-scale niche segregation. Short-tailed albatross (*Phoebastria. albatrus*) range most widely throughout Alaska, extensively using the continental shelf break and slope regions of the Bering Sea and Aleutian Archipelago in particular, and the Gulf of Alaska to a lesser extent. Due to small population size, however, short-tailed albatrosses are generally far less prevalent than the other two species. Black-footed albatrosses (*P. nigripes*) are most abundant in the Gulf of Alaska, and in late summer near some Aleutian passes, occupying foraging habitat similar to short-tailed albatrosses. Laysan albatrosses (*P. immutabilis*) are the most abundant of the three species in the Aleutian Archipelago and the Bering Sea and use foraging habitat offshore and inshore of the continental shelf break-slope more extensively than the other two species. In recent decades, all three species have expanded northward, perhaps associated with warming seas, which may provide foraging opportunities that extend to higher latitudes and later in the fall. Range expansion for short-tailed albatrosses is also caused by continued population size increase (~7% yr^{-1}) and re-occupation of its former range. The wide-ranging distribution of albatrosses in Alaska results in overlap with commercial fisheries. The fisheries most threatening to albatrosses are hook and line gear (longlines) used for sablefish (*Anoplopoma fimbria*) and Pacific cod (*Gadus macrocephalus*). Albatrosses attempt to steal bait from hooks as longlines are deployed over the stern of the vessel. A large part of the interaction with the sablefish fishery is co-existence while using similar foraging habitat over deep waters of the continental shelf break-slope. Fortunately, the longline fishing industry in Alaska adopted the use of bird scaring lines over a decade ago and have drastically reduced albatross mortality in Alaskan fisheries. Although albatross breeding colonies are in distant, lower-latitude regions, all three species range widely throughout the North Pacific and Alaska in particular provides important year-round foraging habitat.

Introduction

Albatrosses are well-known for making long distance flights, often crossing entire ocean basins (Fernández et al. 2001, Croxall et al. 2005). Another aspect of albatross flight that is remarkable is the efficiency by which they accomplish such long distance travels (Weimerskirch et al. 2000b). High flight efficiency requiring relatively low energy expenditure for albatrosses is a combination of a body morphology designed for gliding flight and the use of wind that permits dynamic soaring of large-bodied birds (Rayleigh 1889, Pennycuick 1982, Sachs et al. 2012). These long distance travels locate productive feeding areas that can be very distant from their nesting colonies.

Three species of albatrosses regularly inhabit the North Pacific Ocean (Fig. 1). The short-tailed albatross is the largest, but also the least abundant (ca. 860 breeding pairs in 2013; USFWS 2014) after commercial harvesting led to near extinction by the middle of the 20th century (Hasegawa and DeGange 1982). The black-footed albatross (*P. nigripes*) is the second most abundant (ca. 61,700 breeding pairs in 2005) and Laysan albatross (*P. immutabilis*) is the most abundant (ca. 600,000 breeding pairs in 2005; Arata et al. 2009).

North Pacific albatrosses in particular exhibit long distance commutes between their relatively low latitude nesting colonies (compared to other albatross species) in oligotrophic waters off Hawaii and foraging areas in eutrophic waters along continental margins (Fernández et al. 2001, Suryan et al. 2008, Conners et al. 2015). This is particularly true for black-footed (*P. nigripes*) and Laysan (*P. immutabilis*) albatrosses that forage in waters off Alaska and the west coast of North America, traveling over 10,000 km round trip while feeding a chick at a nest in the Hawaiian Islands (Fernández et al. 2001). Short-tailed albatrosses (*P. albatrus*) have comparatively short foraging trips during the breeding season from their main nesting colony along the continental margin of the western Pacific Ocean (Suryan et al. 2008).

Within their North Pacific range, the waters off Alaska in particular provide important year-round foraging habitat for all three albatross species. Individually-tracked albatrosses spend most of the non-breeding period in waters off Alaska (Suryan et al. 2007, Fischer et al. 2009, Gutowsky et al. 2014). Indeed, other non-breeding seabird species forage in Alaska's productive marine waters as well (Shuntov 1993), including sooty and short-tailed shearwaters (*Ardenna grisea*, *A. tenuirostris*, respectively) that nest on islands in the southern hemisphere during the austral summer and migrate to Alaskan waters during the boreal summer (Shaffer et al. 2006). Additionally, Alaska's oceans support over 40 million breeding seabirds of 41 species (USFWS 2009)

The productive waters off Alaska also support large-scale commercial fisheries that have historically caused seabird mortalities ranging from 10,000 to over 25,000 birds in some years (Stehn et al. 2001, NMFS 2006). Albatrosses are particularly vulnerable to mortality in fisheries because they are natural scavengers taking advantage of food made available at the sea surface.

Albatrosses are in most danger when they attempt to scavenge bait off the hooks as the longline is deployed (Melvin et al. 2001, Dietrich et al. 2009). Albatrosses are long-lived, have a low reproductive rate (maximum of 1 offspring per year) and can therefore suffer population level effects from incidental mortality (Weimerskirch et al. 2000a).

For over a decade, investigators have used vessel-based surveys and individual tracking devices to study the at-sea distribution of North Pacific albatrosses with respect to marine habitats, national boundaries, and commercial fisheries. Through this sustained research effort we have gained novel insight into environmental factors affecting foraging destinations, migration, and interspecific differences in marine habitat use. Here we summarize some of these findings.

Methods

Study Area

There are three major marine regions used by albatrosses in Alaska, the Bering Sea, Aleutian Archipelago, and Gulf of Alaska (Fig. 2A). Each of these regions varies considerably regarding marine habitat. The Bering Sea has a broad continental shelf with a prominent slope current and region of high productivity along the shelf break-slope (Springer et al. 1996). In contrast, the Aleutian Archipelago has a very narrow continental shelf, with major currents that flow in opposing directions along the northern and southern borders. Furthermore, currents flow alternating directions through the numerous passes between islands during daily tidal cycles, producing persistent zones of productivity (Ladd et al. 2005). The northern Gulf of Alaska has a relatively narrow continental shelf in the east and a broader shelf with more islands in the west. Major currents with strong freshwater input from coastal mountain ranges generally flow east to west, interacting with island topography and bathymetry to cause enhanced productivity in the western regions of the Gulf (Stabeno et al. 2016). A fourth major marine region is the Arctic Ocean north of Bering Strait; albatrosses do not use this region, although a short-tailed albatross was sighted there in 2012 (Day et al. 2013).

Vessel-based Survey data

We obtained vessel-based line transect survey data spanning 10 years from the North Pacific Pelagic Seabird Database v3 (www.absc.usgs.gov/research/NPPSD; 2006-2012; Fig. 2) and from Kuletz et al. unpubl. data (2013-2015). Throughout all survey periods, standard observation protocol was used and consisted of a single observer recording all birds within 300 m to one side and in front of the ship's bow in a 90° arc , using strip transect methodology (Gould and Forsell 1989, USFWS 2008). During all surveys, we continuously recorded all albatrosses on the water or actively foraging. Flying birds were recorded during quick scans (snap-shot' method; Gould and Forsell, 1989) at intervals (typically ~ 1 min^{-1}), depending on vessel speed. Birds were recorded when first sighted, then ignored if they followed the ship. For more details on survey methodology, see Kuletz et al. (2014).

Albatross Tracking Studies

Tracking data for short-tailed albatrosses were collected over a 14-year period (2002-2015) with a total of 99 short-tailed albatrosses tracked during each portion of the annual breeding/nonbreeding cycle (Table 1). Short-tailed albatrosses were captured at the main breeding colony on Torishima, Japan, and tracked during incubation (November, December), chick-rearing (January –May), and post-breeding (May-September) periods. In addition, short-tailed albatross chicks were tagged just before fledging to study their behavior and track migration patterns after leaving the colonies and during their first years of life at sea (Deguchi et al. 2014, Orben et al. 2017). Six short-tailed albatrosses were also tagged on summer feeding grounds in the Aleutian Archipelago, and tracked during the non-breeding period (Suryan and Fischer 2010). We used satellite transmitters weighing 22 – 90 g (< 1 – 2% of body mass) attached with adhesive tape (Tesa®) to dorsal body feathers of al birds except 20 short-tailed albatross, for which transmitters were attached using harnesses. Tracking durations ranged from 1 – 6 months, with a maximum of 5 years (Suryan et al. 2006, Suryan et al. 2008, Suryan and Fischer 2010, Orben et al. 2017). From 2002 to 2008, we used position-only satellite transmitters (Toyocom Inc., Sirtrack Limited, Northstar Inc., and Microwave Telemetry, Inc.), at 30 – 90 g, 60 or 90 s transmission intervals, , using either continuous transmissions or duty cycles of 6 - 20 hr on and 4 - 24 hr off. From fledging 2008 to 2012, we used solar recharging, satellite-linked global positioning system (GPS) receivers (22g, Microwave Telemetry, Inc.). The GPS units acquired six fixes per day at 2-4 hr intervals and transmitted these positions via Argos satellites every three days.

Data treatment/analysis:

For vessel-based strip transect surveys, we first calculated albatross density (birds km^{-2}) for each species along transect segments ≤ 3 km, using purpose built computer programs written in R (R Core Team 2013). Using only transect segments (n = 65,486) south of 64°N (since albatross never occurred on transect farther north), we log-transformed density values and calculated average densities for each species for each month, for all years combined. For mapping purposes we averaged 3-km segment densities within each 30-km hexagonal cell for a grid covering the spatial extent of line transect surveys conducted in waters off Alaska.

Satellite-based tracking data were initially processed using slightly different methods for Argos PTT and GPS data, but final processing provided standardized datasets to map an integrated distribution. Argos data were processed using the Douglas Argos-Filter Algorithm (Douglas et al. 2012) with the standard filtering criteria specified in Fischer et al. (2009). GPS data were initially processed using manufacturer and custom-built programs to cull duplicates and erroneous locations (Deguchi et al. 2014), with final processing including the same maximum speed filter (80 km h^{-1}) used with the Argos PTT data (Orben et al. 2017). Tracking data were interpolated at 1 hr intervals when creating mapped distribution surfaces.

Results

Species occurrence patterns

Short-tailed albatrosses range widely throughout offshore areas of Alaska, especially the Aleutian Archipelago and Bering Sea (Figs. 2B & 3). Post-breeding adult short-tailed albatrosses have a more restricted distribution off Alaska compared to juveniles that range more widely throughout waters off Alaska and the North Pacific (Fig. 3). Short-tailed albatross occur in the highest densities at the outer continental shelf-slope regions, which brings them close to shore in the Aleutian Archipelago, much farther offshore in the Bering Sea, and intermediate distances from shore in the Gulf of Alaska. Higher densities occur along the edges of submarine canyons in the Bering Sea, particularly in the north during late summer and fall (Figs. 2B & 3).

Black-footed albatrosses are the most common species in the Gulf of Alaska (Fig. 2C), and they occur throughout the Aleutian Archipelago and are especially prevalent near Aleutian passes (Suryan, pers. obs.). Like short-tailed albatrosses, black-footed albatrosses are at highest densities along the outer continental shelf-slope regions.

Laysan are the most common albatrosses in the Aleutian Archipelago and Bering Sea (Fig. 2D). They also occur in the Gulf of Alaska, but in much lower densities than black-footed albatrosses. In contrast to short-tailed and black-footed albatross, Laysan albatross is the species least associated with continental shelf break-slope habitat, but instead ranges farther offshore of the shelf break, and across the outer and middle shelf domains.

Timing of occurrence

At-sea surveys indicate that in general, Laysan albatross density increases by early spring and is lower through December (Fig. 4), whereas black-footed albatross have low average densities in spring, which increase sharply in late summer and fall (Fig. 4). Short-tailed albatross densities are proportionally low in spring and early summer, higher from July to October with the exception of August, and were not recorded on transect from November through February (Fig. 4). Short-tailed albatross show a northward shift in distribution during fall, based on vessel-based and individual tracking studies. Notably, the surveys show very low densities of Laysan and black-footed albatross in June and July, and lowest densities of short-tailed albatross in August, despite high survey effort during summer. All three albatross species are present year-round in waters off Alaska, particularly within the Aleutian Archipelago.

Discussion

Distribution and Habitat Associations

Changes in at-sea densities of albatrosses and differences among species in seasonal patterns will require further analysis to determine if bias in spatial and temporal sampling partly explains observed patterns. Nonetheless, these patterns also are likely to reflect habitat preferences among the species, and different responses to the abrupt seasonal changes in hydrography and sea surface temperature in northern waters (Hunt et al. 2014). The early arrival and northern extent of Laysan albatross in Alaska's oceans suggest they occur in a wide range of ocean temperatures, whereas black-footed albatross do not move into the Bering Sea until late summer, and rarely go into central or northern Bering Sea. The short-tailed albatross has a northerly distribution, but like black-footed albatross their peak densities in the Bering Sea occur in late summer and fall, when water temperatures are warmest. Indeed, seabird species richness and abundance increases in general during fall in the southeastern Bering Sea, likely reflecting increases in prey availability (Suryan et al. 2016). Fall is when our tracking data show short-tailed albatrosses extend farthest into the northern Bering Sea. As winter approaches, short-tailed albatrosses move south into the southeastern Bering sea, Aleutian Archipelago, and Gulf of Alaska, where some spend the winter (Orben et al. 2017).

Habitat models of all three albatross species show importance of, after accounting for wind speed, seafloor depth and depth gradients (i.e., edges of the continental shelf and submarine canyons) when foraging in coastal regions of Alaska (Piatt et al. 2006, Suryan et al. 2006, Fischer 2008). Chlorophyll (an indicator of phytoplankton production) and sea surface temperature were also important for black-footed and Laysan albatrosses when foraging in offshore waters (Hyrenbach et al. 2002, Fischer 2008, Kappes et al. 2010). While Laysan albatrosses frequently forage over continental shelf regions like the other species, they more often use oceanic habitat beyond the continental margins compared to short-tailed and black-footed albatrosses, as indicated by use of bathymetric domains and stable isotope analyses of diets of individually tracked birds (Suryan and Fischer 2010).

The decrease in Laysan and black-footed albatross densities from fixed transect surveys in June and July, and for short-tailed albatross in August, suggests birds may be less widely dispersed during that time, perhaps due to aggregations in key foraging areas or near commercial fishing vessels and restricted movements during peak summer molting periods (Edwards 2008, Edwards et al. 2015). Their aggregation and reduced flight time during molt may decrease sighting probability during vessel-based surveys. Individual tracking studies indicate that all three species exhibit restricted movement patterns during peak molting periods in July and August (Gutowsky et al. 2014, Conners 2015). The Aleutian Archipelago, in particular, appears to be an area frequented by albatrosses during the summer molting period where some individuals remain weeks to over one month within a 100 km radius (Suryan unpubl. data).

Effects of Climate Change

The Pacific Arctic, including the Bering Sea, is predicted to continue the current warming trend, which will open more water and shelf break habitats earlier in the spring and extend the open water period later into fall (Overland et al. 2008, Stabeno et al. 2012). Additionally, many prey species have shifted northward in the Bering Sea with climate change (Mueter and Litzow 2008), and key albatross prey such as squid may become more abundant in Alaska as it warms, such as appeared to occur in the western Bering Sea (Kang et al. 2002). Therefore, not too surprisingly, all three albatross species have shown a northward shift in their center of distribution over the last four decades, coincident with warming ocean temperatures (Kuletz et al. 2014). Additionally, a long-term analysis of at-sea surveys in the Bering Sea found that these albatross species, as with other surface foraging seabirds, were distributed over shallower waters of the mid-shelf regions during years with earlier sea-ice retreat (warm years), in contrast to outer shelf distributions over deeper waters during cold years with late sea-ice retreat (Renner et al. 2016). For the most recent decade of at-sea survey data shown here, the distribution of albatrosses across the outer shelf and into the middle shelf is evident (Fig. 2B-D). The effect of ocean warming trends on prey noted above, along with the responses of albatrosses observed to date, indicate that these conditions could lead to increasing densities and longer presence of all three albatross species in northern Alaska waters, particularly in late summer and fall.

Bycatch and Conservation

Bycatch mortality of seabirds in longline fisheries was a major concern in the 1990s, with peaks of over 20,000 seabirds and 1,000-2,000 albatross mortalities annually in Alaskan longline fisheries (Stehn et al. 2001, Eich et al. 2016; Fig. 5). In 2002 there was widespread agreement within the longline fishing fleets to use paired bird scaring lines following recommendations from studies by Melvin et al. (2001), and this dramatically reduced bycatch mortality (Fig. 5).

Most albatross bycatch occurs in the Aleutian Archipelago and consists primarily of Laysan albatrosses (Dietrich et al. 2009). The second most common bycatch are black-footed albatrosses taken in Gulf of Alaska (Dietrich et al. 2009), and rare instances of short-tailed albatross bycatch have been primarily in the Bering Sea (Eich et al. 2016), consistent with the relative distribution and density patterns described above. The fact that most observed short-tailed albatross bycatch occurred in the Bering Sea is primarily a result of fewer fisheries observers on vessels in the Aleutian Archipelago compared to the Bering Sea (Eich et al. 2016). Additionally, however, particularly large aggregations of short-tailed albatrosses (> 130 birds) have been observed around vessels fishing along the edges of large submarine canyons in the northern Bering Sea (Piatt et al. 2006), especially in fall when the majority of short-tailed bycatch events occurred (Eich et al. 2016).

Bycatch in Alaskan trawl fisheries is also a concern, however it is not as easily quantified and mitigated as for longline fisheries, although solutions exist (Dietrich and Melvin 2007, Melvin et al. 2010). Fortunately, the current bycatch rate does not seem to be limiting the population growth rate of short-tailed albatrosses, although impacts to the other two species is uncertain, since their populations are so much larger and difficult to monitor.

Conclusion

Vessel-based surveys and individual tracking studies provide complimentary perspectives on the distribution of albatrosses in Alaska. Vessel-based surveys give a comprehensive view of all species and detailed habitat associations, while individual tracking studies provide detailed information on less abundant species such as short-tailed albatrosses, and for areas that surveys do not regularly cover (e.g, beyond the continental shelf in Alaska), nor are they limited to season or weather conditions. Observations of albatrosses behind fishing vessels provide another important perspective on albatross distribution that is relevant to fishery interactions and potential bycatch (Melvin et al. 2006). Collectively, these data highlight the importance of Alaska's marine ecosystems in providing important, year-round foraging habitat for North Pacific albatrosses, even though their breeding colonies are thousands of kilometers away.

Acknowledgements

We thank Elizabeth Labunski for assistance with at-sea surveys and data management and many dedicated observers who collected data over the years. At-sea surveys were supported with grants to KJK from the North Pacific Research Board and the Bureau of Ocean Energy Management, and support from the U.S. Fish and Wildlife Service. The maps of at-sea distribution were produced by Dan Cushing, Pole Star Ecological Research LLC. Short-tailed albatross tracking data were collected in collaboration with the Yamashina Institute for Ornithology with special thanks to K. Ozaki, F. Sato, and T. Deguchi, N. Nakamura. We also thank P. Sievert and G. Balogh for their important contributions to this work. Tracking studies were primarily funded by the U.S. Fish and Wildlife Service, Japanese Ministry of Environment, the North Pacific Research Board, the Japanese Ministry of Education, Culture, Sports, Science and Technology, the Suntory Fund for Bird Conservation, the Asahi Newspaper Company, and the Mitsui & Co., Ltd. Environmental Fund.

Literature Cited

Conners, M., E. Hazen, D. Costa, and S. Shaffer. 2015. Shadowed by scale: subtle behavioral niche partitioning in two sympatric, tropical breeding albatross species. Movement Ecology 3:1-20.

Conners, M. G. 2015. Comparative behavior, diet, and post-breeding strategies of two sympatric North Pacific albatross species (*Phoebastria* sp.). Ph.D. University of California, Santa Cruz.

Croxall, J. P., J. R. D. Silk, R. A. Phillips, V. Afanasyev, and D. R. Briggs. 2005. Global Circumnavigations: Tracking Year-Round Ranges of Nonbreeding Albatrosses. Science 307:249-250.

Day R.H., A.E. Gall, T.C. Morgan, J.R. Rose, J.H. Plissner, P.M. Sanzenbacher, J.D. Fenneman, K.J. Kuletz, B.H. Watts. 2013. Seabirds new to the eastern Chukchi and Beaufort Seas, Alaska: Response to a changing climate? Western Birds 44(3):174-182

Deguchi, T., R. M. Suryan, K. Ozaki, J. F. Jacobs, F. Sato, N. Nakamura, and G. R. Balogh. 2014. Translocation and hand-rearing of the short-tailed albatross *Phoebastria albatrus*: early indicators of success for species conservation and island restoration. Oryx 48:195-203.

Dietrich, K. S., and E. F. Melvin. 2007. Alaska Trawl Fisheries: Potential Interactions with North Pacific Albatrosses. WSG-TR 07-01, Washington Sea Grant, Seattle, WA., Seattle.

Dietrich, K. S., J. K. Parrish, and E. F. Melvin. 2009. Understanding and addressing seabird bycatch in Alaska demersal longline fisheries. Biological Conservation 142:2642-2656.

Douglas, D. C., R. Weinzierl, S. C. Davidson, R. Kays, M. Wikelski, and G. Bohrer. 2012. Moderating Argos location errors in animal tracking data. Methods in Ecology and Evolution 3:999-1007.

Edwards, A. 2008. Large-scale variation in flight feather molt as a mechanism enabling biennial breeding in albatrosses. Journal of Avian Biology 39:144-151.

Edwards, A. E., S. M. Fitzgerald, J. K. Parrish, J. L. Klavitter, and M. D. Romano. 2015. Foraging Strategies of Laysan Albatross Inferred from Stable Isotopes: Implications for Association with Fisheries. PLoS ONE 10:e0133471.

Eich, A. M., K. R. Mabry, S. K. Wright, and S. M. Fitzgerald. 2016. Seabird Bycatch and Mitigation Efforts in Alaska Fisheries Summary Report: 2007 through 2015. Page 47p. U.S. Dep. Commer. NOAA Tech. Memo. .

Fernández, P., D. J. Anderson, P. R. Sievert, and K. P. Huyvaert. 2001. Foraging destinations of three low-latitude albatross (*Phoebastria*) species. Journal of Zoology 254:391-404.

Fischer, K. N. 2008. Marine habitat use of black-footed and Laysan albatrosses during the post-breeding season and their spatial and temporal overlap with commercial fisheries. Oregon State University, Corvallis.

Fischer, K. N., R. M. Suryan, D. D. Roby, and G. R. Balogh. 2009. Post-breeding season distribution of black-footed and Laysan albatrosses satellite-tagged in Alaska: Inter-specific differences in spatial overlap with North Pacific fisheries. Biological Conservation 142:751-760.

Gould, P., and D. J. Forsell. 1989. Techniques for shipboard surveys of marine birds. U.S. Department of the Interior, Fish and Wildlife Service, Washington, DC.

Gutowsky, S., L. Gutowsky, I. Jonsen, M. Leonard, M. Naughton, M. Romano, and S. Shaffer. 2014. Daily activity budgets reveal a quasi-flightless stage during non-breeding in Hawaiian albatrosses. Movement Ecology 2:23.

Hasegawa, H., and A. R. DeGange. 1982. The Short-tailed Albatross, *Diomedea albatrus*, its status, distribution and natural history. American Birds 36:806-814.

Hunt, G. L. J., M. Renner, and K. Kuletz. 2014. Seasonal variation in the cross-shelf distribution of seabirds in the southeastern Bering Sea. Deep-Sea Research Part II 109:266-281.

Hyrenbach, K. D., P. Fernández, and D. J. Anderson. 2002. Oceanographic habitats of two sympatric North Pacific albatrosses during the breeding season. Marine Ecology Progress Series 233:283-301.

Kang, Y. S., J. Y. Kim, H. G. Kim, and J. H. Park. 2002. Long-term changes in zooplankton and its relationship with squid, Todarodes pacificus, catch in Japan/East Sea. Fisheries Oceanography 11:337-346.

Kappes, M. A., S. A. Shaffer, Y. Tremblay, D. G. Foley, D. M. Palacios, P. W. Robinson, S. J. Bograd, and D. P. Costa. 2010. Hawaiian albatrosses track interannual variability of marine habitats in the North Pacific. Progress in Oceanography 86:246-260.

Kuletz, K. J., M. Renner, E. A. Labunski, and G. L. Hunt Jr. 2014. Changes in the distribution and abundance of albatrosses in the eastern Bering Sea: 1975–2010. Deep-Sea Research Part II 109:282-292.

Ladd, C., J. Jahncke, G. L. Hunt, K. O. Coyle, and P. J. Stabeno. 2005. Hydrographic features and seabird foraging in Aleutian Passes. Fisheries Oceanography 14:178-195.

Melvin, E. F., K. S. Dietrich, S. M. Fitzgerald, and T. Cardoso. 2010. Reducing seabird strikes with trawl cables in the pollock catcher-processor fleet in the eastern Bering Sea. Polar Biology.

Melvin, E. F., J. K. Parrish, K. S. Dietrich, and O. S. Hamel. 2001. Solutions to seabird bycatch in Alaska's demersal longline fisheries. WSG-AS 01-01, Washington Sea Grant Program, Seattle.

Melvin, E. F., M. D. Wainstein, K. S. Dietrich, K. L. Ames, T. O. Geernaert, and L. L. Conquest. 2006. The distribution of seabirds on the Alaskan longline fishing grounds: Implications for seabird avoidance regulations. Washington Sea Grant Program, Project A/FP-7, WSG-AS-06-01.

Mueter, F. J., and M. A. Litzow. 2008. Sea ice retreat alters the biogeography of the Bering Sea continental shelf. Ecological Applications 18:309-320.

NMFS. 2006. Summary of seabird bycatch in Alaskan Groundfish fisheries, 1993-2004. National Marine Fisheries Service, Seattle.

Orben, R., A. O'Connor, R. Suryan, K. Ozaki, F. Sato, and T. Deguchi. 2017. Ontogenetic changes in at-sea distributions of immature short-tailed albatrosses, *Phoebastria albatrus*. Endangered Species Research.

Overland, J. E., M. Wang, and S. Salo. 2008. The recent Arctic warm period. Tellus A 60:589-597.

Pennycuick, C. J. 1982. The flight of petrels and albatrosses (Procellariiformes), observed in South Georgia and its vicinity. Royal Society of London. Philosophical Transactions. Biological Sciences 300:75-106.

Piatt, J. F., J. Wetzel, K. Bell, A. R. DeGange, G. Balogh, G. Drew, T. Geernaert, C. Ladd, and G. V. Byrd. 2006. Predictable hotspots and foraging habitat of the endangered short-tailed albatross (*Phoebastria albatrus*) in the North Pacific: Implications for conservation. Deep-Sea Research, Part II 53:387-398.

R Core Team. 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.

Rayleigh, J. W. S. 1889. The sailing flight of the albatross. Nature 40:34.

Renner, M., S. Salo, L. B. Eisner, P. H. Ressler, C. Ladd, K. J. Kuletz, J. A. Santora, J. F. Piatt, G. S. Drew, and G. L. Hunt. 2016. Timing of ice retreat alters seabird abundances and distributions in the southeast Bering Sea. Biology Letters 12.

Sachs, G., J. Traugott, A. P. Nesterova, G. Dell'Omo, F. Kümmeth, W. Heidrich, A. L. Vyssotski, and F. Bonadonna. 2012. Flying at No Mechanical Energy Cost: Disclosing the Secret of Wandering Albatrosses. PLoS ONE 7:e41449.

Shaffer, S. A., Y. Tremblay, H. Weimerskirch, D. Scott, D. R. Thompson, P. M. Sagar, H. Moller, G. A. Taylor, D. G. Foley, B. A. Block, and D. P. Costa. 2006. Migratory shearwaters integrate oceanic resources across the Pacific Ocean in an endless summer. Proceedings of the National Academy of Sciences 103:12799–12802.

Shuntov, V. P. 1993. Biological and physical determinants of marine bird distribution in the Bering Sea. Pages 10-17. Canadian Wildlife Service Special Publication, Victoria, B.C.

Springer, A. M., C. P. McRoy, and M. V. Flint. 1996. The Bering Sea Green Belt: Shelf-edge processes and ecosystem production. Fisheries Oceanography 5:205-223.

Stabeno, P. J., S. Bell, W. Cheng, S. Danielson, N. B. Kachel, and C. W. Mordy. 2016. Long-term observations of Alaska Coastal Current in the northern Gulf of Alaska. Deep Sea Research Part II: Topical Studies in Oceanography 132:24-40.

Stabeno, P. J., E. V. Farley Jr, N. B. Kachel, S. Moore, C. W. Mordy, J. M. Napp, J. E. Overland, A. I. Pinchuk, and M. F. Sigler. 2012. A comparison of the physics of the northern and southern shelves of the eastern Bering Sea and some implications for the ecosystem. Deep-Sea Research Part II 65–70:14-30.

Stehn, R. A., K. S. Rivera, S. Fitzgerald, and K. D. Wohl. 2001. Incidental catch of seabirds by longline fisheries in Alaska. Pages 61-77 *in* E. F. Melvin and J. K. Parrish, editors. Seabird Bycatch: Trends, Roadblocks, and Solutions. University of Alaska Sea Grant, Fairbanks.

Suryan, R. M., D. J. Anderson, S. A. Shaffer, D. D. Roby, Y. Tremblay, D. P. Costa, P. R. Sievert, F. Sato, K. Ozaki, G. R. Balogh, and N. Nakamura. 2008. Wind, waves, and wing Loading: morphological specialization may limit range expansion of endangered albatrosses. PLoS ONE 3:e4016. doi:4010.1371/journal.pone.0004016.

Suryan, R. M., K. S. Dietrich, E. F. Melvin, G. R. Balogh, F. Sato, and K. Ozaki. 2007. Migratory routes of short-tailed albatrosses: Use of exclusive economic zones of North Pacific Rim countries and spatial overlap with commercial fisheries in Alaska. Biological Conservation 137:450-460.

Suryan, R. M., and K. N. Fischer. 2010. Stable isotope analysis and satellite tracking reveal interspecific resource partitioning of nonbreeding albatrosses off Alaska. Canadian Journal of Zoology 88:299-305.

Suryan, R. M., K. J. Kuletz, S. L. Parker-Stetter, P. H. Ressler, M. Renner, J. K. Horne, E. V. Farley, and E. A. Labunski. 2016. Temporal shifts in seabird populations and spatial coherence with prey in the southeastern Bering Sea. Marine Ecology Progress Series 549:199-215.

Suryan, R. M., F. Sato, G. R. Balogh, D. K. Hyrenbach, P. R. Sievert, and K. Ozaki. 2006. Foraging destinations and marine habitat use of short-tailed albatrosses: A multi-scale approach using first-passage time analysis. Deep-Sea Research, Part II 53:370-386.

USFWS. 2008. North Pacific pelagic seabird observer program observer's manual. U.S. Fish and Wildlife Service, Migratory Bird Management, Anchorage, AK.

USFWS. 2014. Short-tailed albatross endangered species recovery plan: 5-year review. U.S. Fish and Wildlife Service, Anchorage, AK.

Weimerskirch, H., D. Capdeville, and G. Duhamel. 2000a. Factors affecting the number and mortality of seabirds attending trawlers and long-liners in the Kerguelen area. Polar Biology 23:236-249.

Weimerskirch, H., T. Guionnet, J. Martin, S. A. Shaffer, and D. P. Costa. 2000b. Fast and fuel efficient? Optimal use of wind by flying albatrosses. Proceedings of the Royal Society of London, Series B: Biological Sciences 267:1869-1874.

Table 1. Sample sizes (# of birds) for each stage of annual breeding/nonbreeding cycle and years when satellite tracking devices were deployed. Tracking of most individuals occurred during the same year of deployment, except that tags deployed during incubation 2008 continued transmitting into 2009 and some tags deployed on juveniles in 2009-2012 transmitted for up to 5-years after deployment (through 2015).

		Deployment Year										
Stage	# of Birds[1]	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Incubation	5							X				
Chick-rearing	26					X	X	X				
Post-breeding (adult/subadult)	40	X	X		X	X	X	X				
Juvenile, < 1 yr	59		X			X		X	X	X	X	X
Total	99	X	X		X	X	X	X	X	X	X	X

[1] With sufficient data for analysis. A total of 99 individual birds were tagged, but in some cases a single bird will contribute to samples in multiple categories (e.g., a bird that is tracked during chick-rearing and post-breeding).

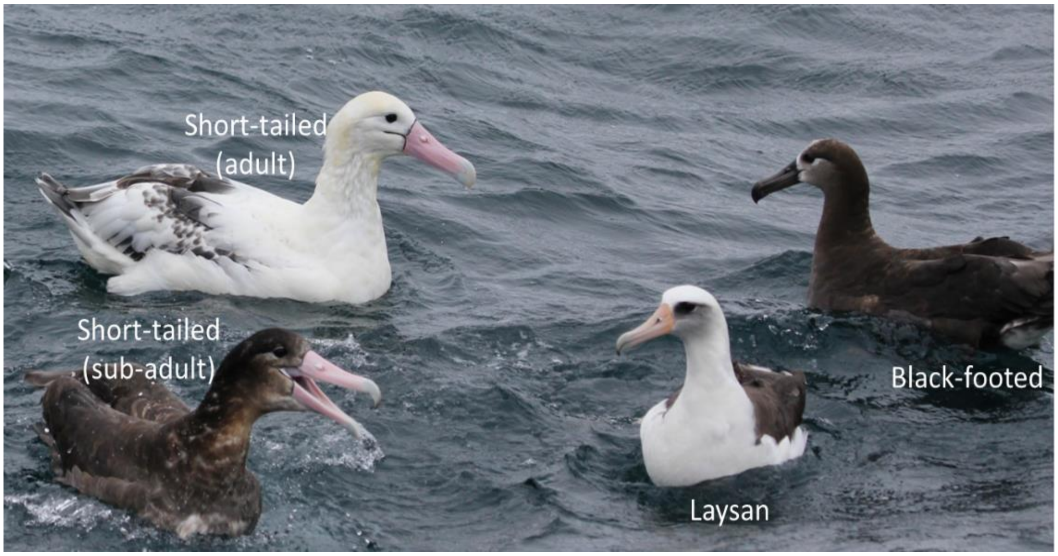

Figure 1. The three species of North Pacific albatrosses in the Aleutian Archipelago, Alaska. (photo R. Suryan, Oregon State University)

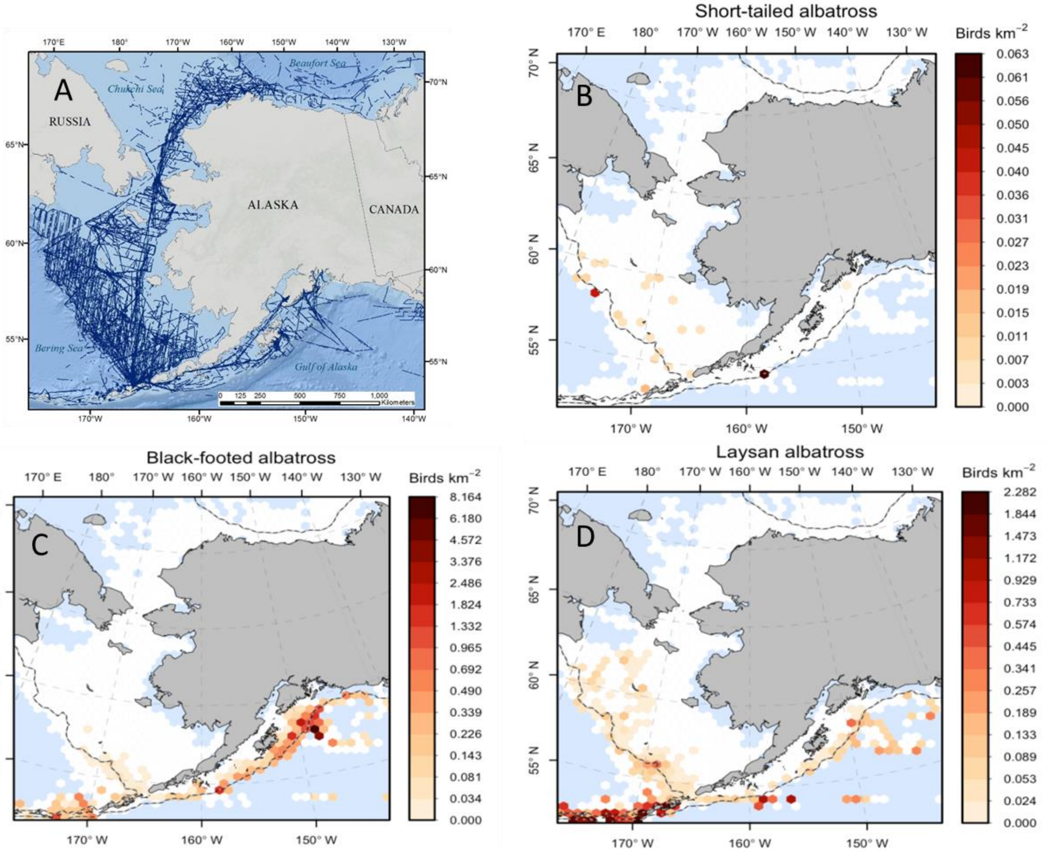

Figure 2. Distribution of the three species of North Pacific Albatrosses in Alaska from vessel-based surveys (A) conducted during 2006-2015. Density (birds•km^2) of short-tailed (B), black-footed (C), and Laysan albatrosses (D) within 30 km hexagonal cells.

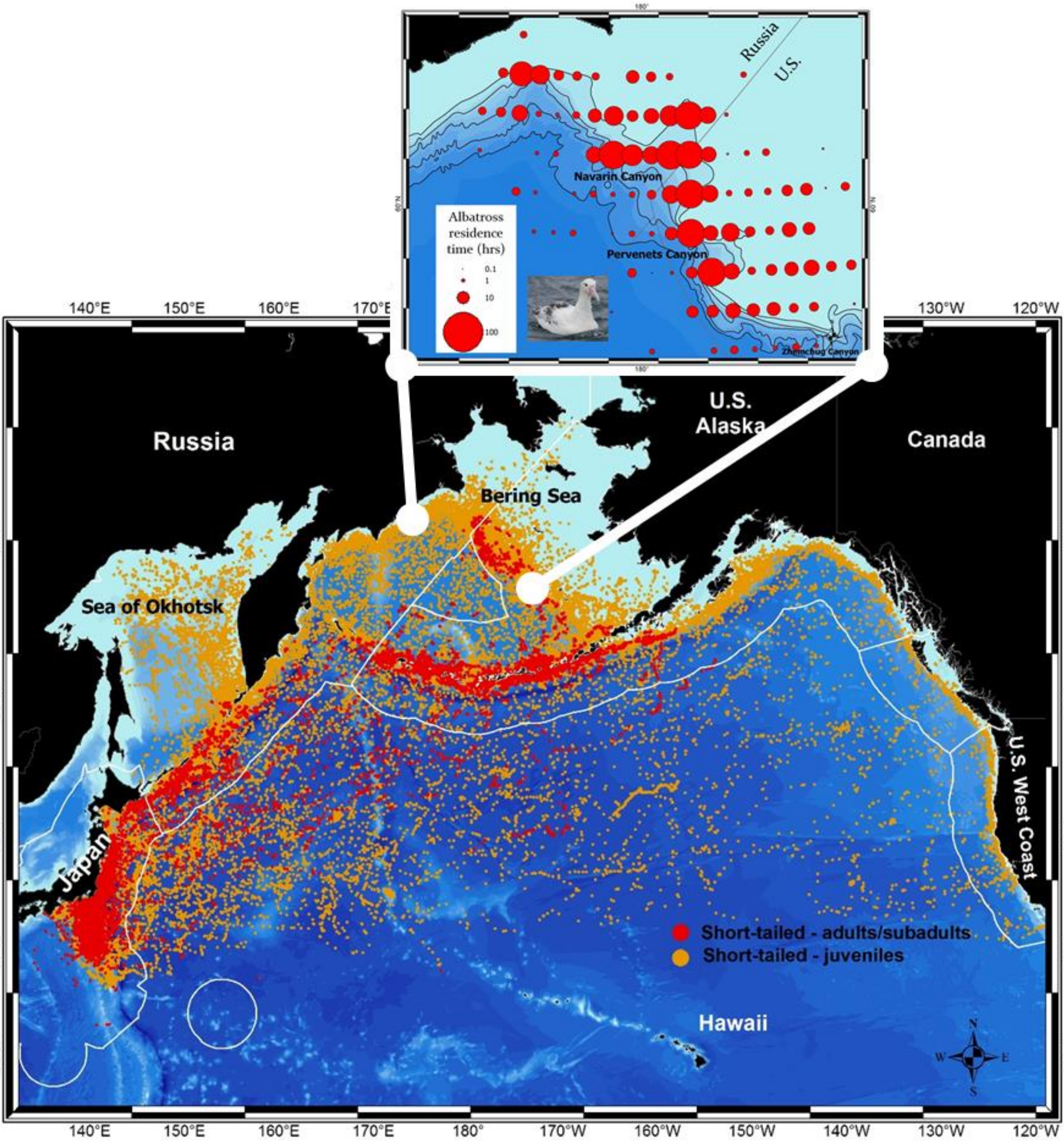

Figure 3. Argos satellite and global positioning system (GPS) tracking locations from 99 individual short-tailed albatrosses tracked during 2002-2003, 2006-2014. Inset shows the number of hours short-tailed albatrosses spent (residence time) within each 0.5 degree grid cell over major submarine canyons in the northern Bering Sea.

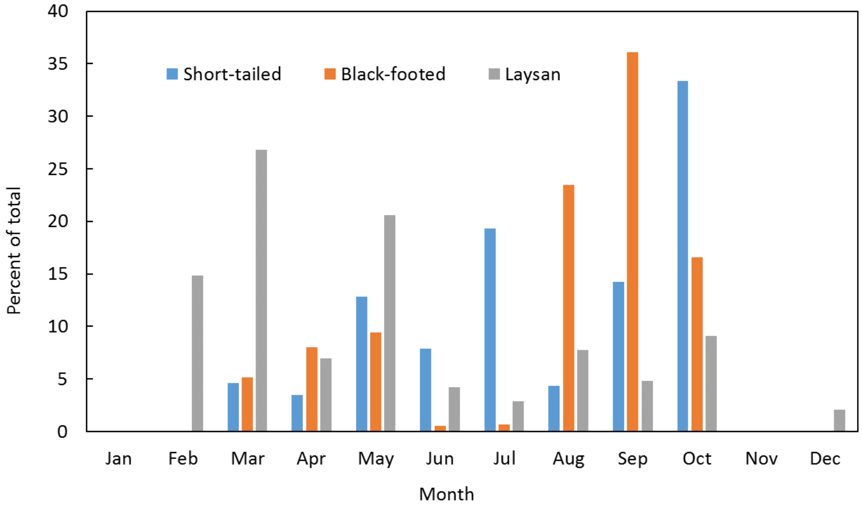

Figure 4. Percentage of total observations during vessel-based line transect surveys, for all three albatross species, by month. Data are from at-sea surveys in Alaska, 2006-2015, south of 64°N.

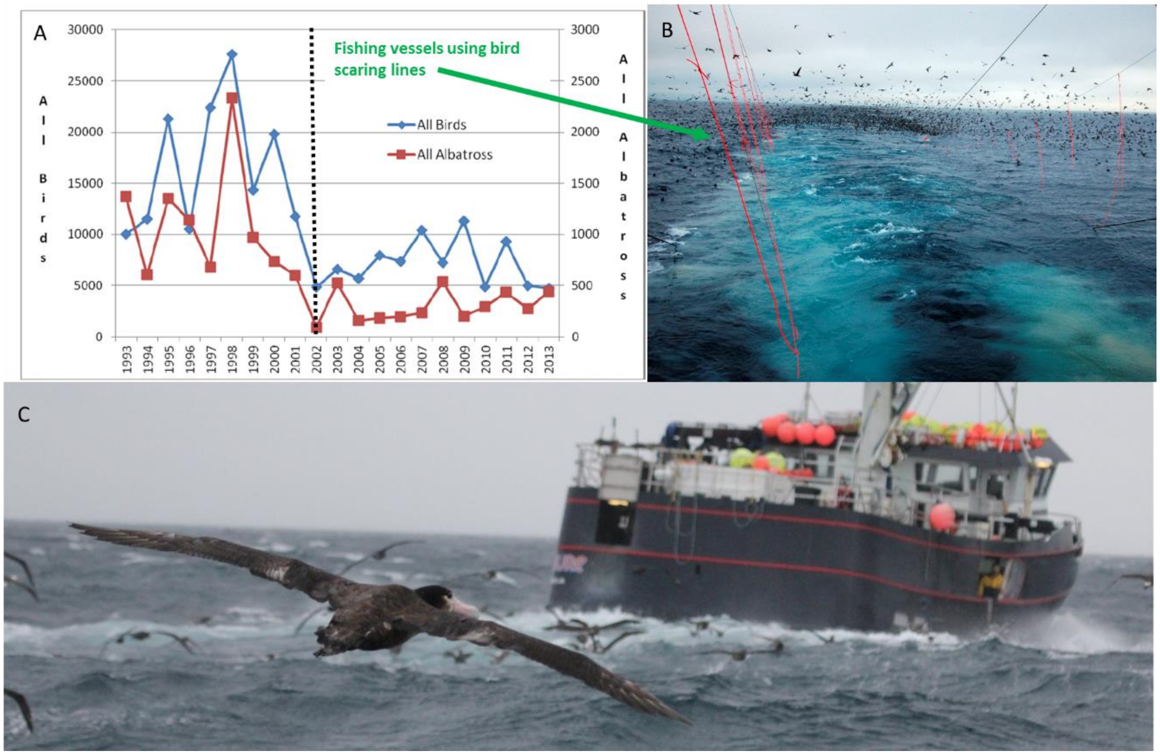

Figure 5. (A) Seabird (blue, left y-axis) and albatross (red, right y-axis) bycatch in Alaskan longline fisheries before and after (2002) the fishing fleet began using bird scaring lines to reduce seabird mortality in longline fisheries (Stehn et al. 2001, Eich et al. 2016). (B) Picture of bird scaring lines deployed and keeping seabirds away from the fishing gear in the Bering Sea (photo E. Melvin, Washington Sea Grant). (C) Short-tailed albatross following a fishing vessel in the Aleutian Islands (photo R. Suryan, Oregon State University).