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Post-breeding Shorebird Use of Salt Marsh on the Ikpek and Arctic Lagoon Barrier Island, Bering Land Bridge National Preserve

Natural Resource Data Series NPS/ARCN/NRDS—2014/669

ON THE COVER
Western Sandpipers (*Calidris mauri*)
Photograph by: Katie Dunbar

Post-breeding Shorebird Use of Salt Marsh on the Ikpek and Arctic Lagoon Barrier Island, Bering Land Bridge National Preserve

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Introduction

Population trends for migratory shorebirds show a global pattern of decline (Bart et al. 2007). The vulnerability of shorebird species is due in part to their dependence on intact networks of coastal and wetland habitats for completing long-distance migrations (Bart et al. 2007). The consequences of habitat loss and degradation at bottlenecks within migration systems (i.e., where a significant proportion of a population passes through) are likely severe (Iwamura et al. 2013). Thus, addressing the conservation needs of migratory shorebirds involves understanding habitat use and connectivity on a scale that spans wintering areas, migration routes, and breeding grounds (Gratto-Trevor et al. 2012).

During the post-breeding period in the Arctic, adult and juvenile shorebirds move to littoral habitats where they accumulate fat stores necessary for completing long migrations (Connors and Connors 1985). Previous studies have documented important foraging areas for post-breeding shorebirds along the Bering (Gill and Handel 1990, Tibbits et al. 1996), Chukchi (Connors and Connors 1985), and Beaufort Sea coasts of Alaska (Taylor et al. 2010, Brown et al. 2012). Littoral habitats along the Chukchi and Bering Sea coasts of Alaska have particular conservation importance given that they lie at the convergence of three flyways: the East Asian-Australasian, Central Pacific, and Pacific Americas Flyways.

Vessel traffic in the Chukchi and Beaufort Seas is expected to increase dramatically with the decreasing extent of sea ice along the Northern Sea Route and the implementation of plans for offshore oil and gas development and deepwater port construction (US Committee on the Marine Transportation System 2013). Given the potential for an oil spill, knowledge of post-breeding shorebird distribution is critical for forming a post-spill response and for understanding the implications of a spill for shorebird populations. Connors and Connors (1985) identify the barrier island system on the northern Seward Peninsula as receiving some of the highest use from post-breeding shorebirds along Alaska's northwestern coastline. Despite the presence of extensive salt marsh and tidal flat habitat, post-breeding shorebird use along this remote stretch of coastline has received little study. Our objective was to document post-breeding shorebird use of low salt marsh within the barrier system associated with Ikpek and Arctic Lagoons in Bering Land Bridge National Preserve.

Methods

Lying just north of the Bering Strait along the southern Chukchi Sea, Ikpek and Arctic Lagoons (Fig. 1) are micro-tidal, ice-dominated environments. High-relief dunes front the barrier island strip as it parallels Ikpek Lagoon but become less pronounced moving northeast along Arctic Lagoon. High and low salt marsh predominate from the island interior to the lagoon fringe. In our classification of the habitat, low marsh was characterized by inundated and periodically inundated depressions linked by tidal creeks and interspersed with patches of saline tolerant vegetation (Fig. 2), whereas high marsh was densely vegetated and inundated infrequently, generally by storm surge events.

Our sampling frame included patches of low salt marsh >0.1 ha along the barrier island strip overlapping Ikpek and Arctic Lagoons (Fig. 1). In ArcGIS 10.1(ESRI 2012), we delineated low marsh patches from aerial imagery. Survey plots were generally discrete wetlands. However, large patches that had prominent features (e.g., tidal channels) to orient observers in the field were cut into multiple plots using these features as plot boundaries.

We used the Generalized Random Tessellation Stratified (GRTS) procedure (Stevens and Olson 2004) to select a spatially balanced sample of 38 low salt marsh plots (1.0-8.2 ha). From 27 July-10 August, four people conducted area searches of plots, generally in 2-person crews. Plots were visited every 1-6 days (3 days on average). To facilitate orientation, observers carried maps with plot boundaries overlaid on aerial photos and GPS units uploaded with plot boundaries. Prior to conducting the survey, observers communicated the area they intended to survey in the plot using aerial photos and the perimeters of waterbodies to define their route. Typically, observers walked 30-100 m apart and kept a running tally of all waterbirds observed in their particular zone of coverage. During and immediately after the count, observers communicated detections of birds for which there existed a question of double-counting. Following these discussions, we excluded observations of birds for which there was any question of double-counting. For each observation, we recorded one of two detection types distinguishing observations of birds flying over the plot from observations of birds using the plot (i.e. birds in the water, on the ground, or foraging on the wing). Only the latter were used in analyses.

Western (*Calidris mauri*) and Semipalmated Sandpipers (*Calidris pusilla*) were recorded as "Western/Semipalmated Sandpiper". Given the number of birds we were recording and the similarity of juvenile plumage of these species, attempting to separate them would have come at the expense of maintaining an accurate count.

To qualitatively compare shorebird density at Ikpek and Arctic Lagoons with shorebird density along the greater Seward Peninsula, we conducted a single aerial survey on 26 July 2013 from the east side of Bering Land Bridge National Monument to a point approximately 6 km east of Wales. We surveyed in a Cessna 206 aircraft flying between 6 and 50 m altitude at approximately 140 km/hr and traveling parallel to the coastline. Within a strip approximately 100 m from the aircraft's path of travel, we estimated shorebird numbers and recorded a GPS waypoint for the location of each shorebird group. One observer counted from the right front seat while another observer counted from the left rear seat. We flew informal transects over large tidal flat or wetland areas that could not

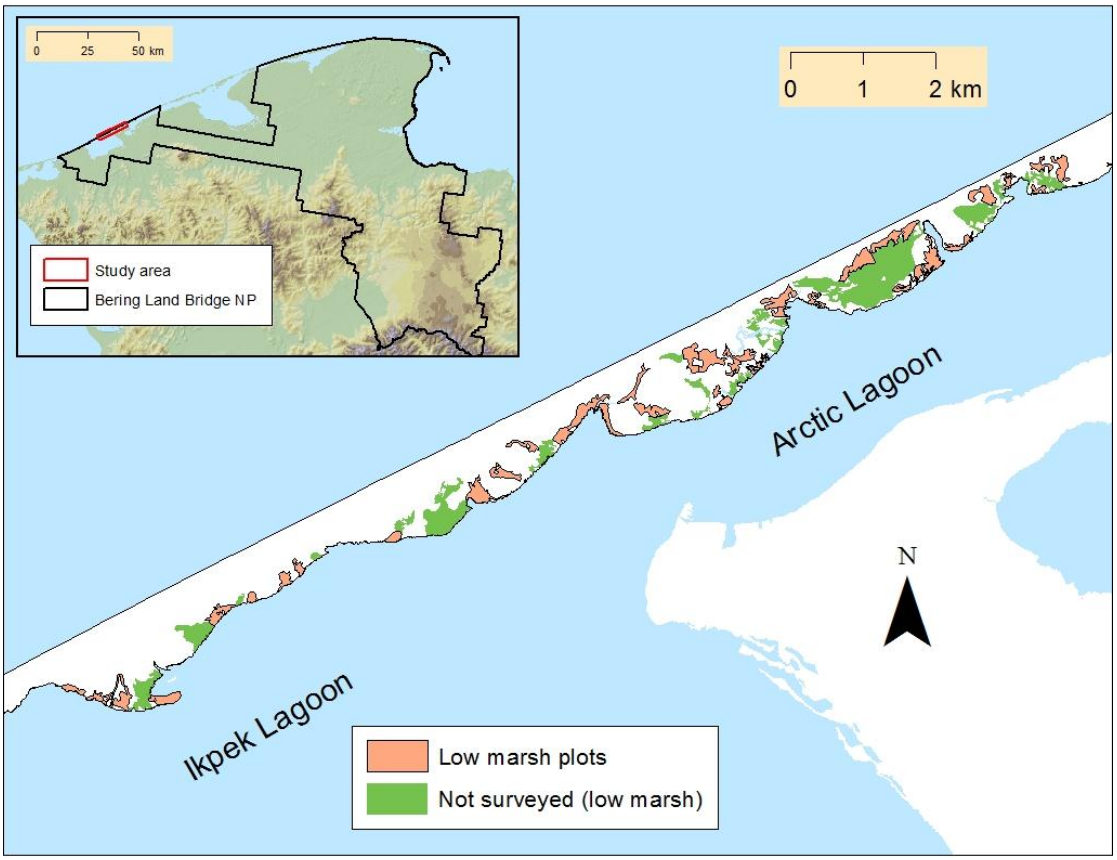

Figure 1. Study area on Ikpek and Arctic Lagoon barrier island, Bering Land Bridge National Preserve (2013).

Figure 2. Low marsh plot on Ikpek and Arctic Lagoon barrier island, Bering Land Bridge National Preserve. (Photo: Katie Dunbar)

be observed with a single overpass. The pilot watched the tracklog to be certain these areas were not overflown more than once. Individual birds were identified to species where possible; otherwise observations were categorized as "small peep" (likely Western and Semipalmated Sandpipers), "medium peep" (likely Dunlin (*Calidris alpina*), Pectoral Sandpipers (*Calidris melanotos*), and other similar-sized calidrids), "large peep" (likely Long-billed Dowitchers (*Limnodromus scolopaceus*), golden-plovers (*Pluvialis* spp.), and other large calidrids), and "phalarope" (Red (*Phalaropus fulicarius*) and Red-necked Phalaropes (*Phalaropus lobatus*)).

Analyses

We fit Bayesian hierarchical models for total shorebird density and for the density of the most common shorebird species that we observed: Western/Semipalmated Sandpipers (combined), Dunlin, Pectoral Sandpiper, and Red-necked Phalarope. We treated shorebird counts, N_i at site i, as overdispersed Poisson random variables. Site-specific density was modeled as:

$$N_i \sim Poisson\ (\lambda)$$

$$\log(A_i * \lambda_i) \sim \log(A_i) + \beta_0 + \delta_i + \beta_1 date_i + \beta_2 date_i^2 + \varepsilon_i$$

where β_0 is mean shorebird density and δ_i is a random effect for each site. We included the area of each plot (A_i) as an offset (i.e. log (A_i) was placed within the linear predictor with a coefficient equal to 1). Models included the quadratic effect of date as a fixed effect and an observation-level random effect (ε_i) to account for extra-Poisson variation. We scaled continuous covariates (mean = 0, SD = 1) to improve convergence.

For each date during the survey period, we included missing observations for all sites within our sampling frame including those that were not part of our random sample. Missing observations were parameters for which posterior samples were imputed via the Markov chain Monte Carlo (MCMC) algorithm. Through inclusion of missing values, we made inferences about all low marsh within the sampling frame over the entire survey period.

We used the expected counts (λ_i) as an index of the number of individuals using the low marsh within the sampling frame on a given day (i.e. shorebird-days) (Bart et al. 2005). Total shorebird-days for a given species was:

$$n = \sum_{i=1}^{m} \lambda_i$$

where m is the total number of sites in the sampling frame. Mean density for a species was n divided by the product of the number of survey days (15) and the total area of low marsh (311.4 ha). These derived quantities were estimated with full error propagation including that from random effects.

We fit models using WinBugs 1.4.3 (Spiegelhalter et al. 2004) via the R2WinBUGS package (Sturtz et al. 2005) in program R 2.15.2 (R Core Team 2012). We used diffuse priors for all parameters including: a normal distribution for the overall intercept, β_0~N(0,0.01), and uniform distributions for date effects β_1 and β_2, UNIF(-5,5), and the standard deviations of the random effects, σ~UNIF(0,100).

Summaries of the posterior distribution were calculated from three independent Markov chains run for 6,000 iterations with a 1,000 iteration burn-in and thinning every five draws. We assessed convergence using the Gelman-Rubin diagnostic (Brooks and Gelman 1998). We present the mean (expected) count/ha and the sum of the expected counts (i.e., total shorebird-days) with 95% Bayesian credible intervals ([CrI])..

These estimates do not account for incomplete detection. Some heterogeneity in detection due to vegetation patterns likely existed. However, we targeted low marsh in part due to the openness of the habitat and most observations were of multiple birds foraging on the water or barren substrate ensuring relatively high detection. We did not include covariates, specifically the tide effect, to account for variation in the probability of presence within the sample unit during a survey period (i.e., a 24 hour period). Tides are relatively insignificant within the Ikpek-Arctic Lagoon system, whereas storms may significantly increase water levels for several days possibly due to restricted exits and tidal frequency (T. Jones, unpubl. data).

Results and discussion

Shorebird density peaked at 20.1 shorebirds/ha (13.6, 31.4) on 31 July (Fig. 3). Similarly, Connors and Connors (1985) report a peak, post-breeding density of ~15 shorebirds/ha in salt marsh at Sisualik Spit near the Noatak River delta during late July-early August. We know of no other estimates of peak post-breeding shorebird use specific to salt marsh along the southern Chukchi coast.

Total shorebird-days for Western and Semipalmated Sandpipers across all low marsh in the study area (311.4 ha) over the 15-day survey period was 50,714.1 (35,649.5, 79,452.2), substantially higher than estimates for other species. During our surveys, we noted many still downy Western Sandpipers which indicates that juveniles from local breeding areas (i.e., the Seward Peninsula) likely use these sites extensively. Dunlin, Pectoral Sandpiper, and Red-necked Phalarope were found in relatively low numbers throughout the survey period (Table 1, Fig. 4). We detected 15 total shorebird species during surveys of plots and 5 additional species outside of plots (Appendices A-B).

A decline in Western and Semipalmated Sandpiper density coincided with a shift in the weather pattern (Fig. 4). Data from a weather station in Shishmaref, indicates that winds on average originated from the southwest from 27 July to mid-day on 31 July at which point they shifted to a northerly origin varying west-northwest to east for the remainder of the survey period. A number of studies have documented the important role of winds aloft in determining stopover decisions of migratory shorebirds (reviewed in Liechti 2006). Wind assistance appears to be necessary for Western Sandpipers to complete their migration along the Pacific coast in the spring (Iverson et al. 1996, Butler et al. 1997).

In addition, the wind shift was accompanied by intermittent rain for the remainder of the survey period. Depressions in the marsh which previously had exposed substrate were soon inundated with several inches of water making prey inaccessible to some species of shorebirds, Western and Semipalmated Sandpipers in particular. In contrast, there was limited evidence of a decline in the abundance of Dunlin, Pectoral Sandpiper, and Red-necked Phalarope following the weather shift (Fig. 4) possibly because they were initially uncommon and also have different bill morphology and foraging strategies relative to Western and Semipalmated Sandpipers.

The aerial survey on 26 July 2013, indicated hotspots of shorebird use along the central portion of the Arctic Lagoon barrier islands, along the east and west ends of the Cowpack Inlet barrier islands, at Cape Espenberg, and at the Nugnugaluktuk River delta (Fig. 5). Large groups of shorebirds were generally found on large tidal flats on the inner fringe of barrier islands. We recorded a total of 16,179 shorebirds during the survey including: 15,227 small peeps, 63 medium peeps, 19 large peeps, 837 phalaropes, 19 Black/Ruddy Turnstones, and14 Bar-tailed Godwits. These counts broadly correspond to species composition documented during the ground surveys on the Ikpek-Arctic Lagoon barrier island (Appendix A).

Table 1. Estimates and 95% credible intervals of the mean shorebird count/ha and the total shorebird-days for common shorebird species from surveys conducted at Ikpek and Arctic Lagoons during the post-breeding period. Total shorebird-days was derived by summing the expected counts for all low marsh in our sampling frame (311.4 ha) on each day during our 15 day survey period.

Species	Mean count/ha		Total shorebird-days	
Pectoral Sandpiper	0.65	(0.26, 1.86)	3036.07	(1237.00, 8684.07)
Dunlin	0.74	(0.48, 1.27)	3476.19	(2222.97, 5907.12)
Red-necked Phalarope	1.00	(0.61, 1.86)	4652.55	(2862.97, 8691.70)
Western/Semipalmated sandpiper	10.86	(7.63, 17.01)	50714.07	(35649.50, 79452.25)
All shorebirds	12.13	(9.37, 16.70)	56657.95	(43749.50, 78012.00)

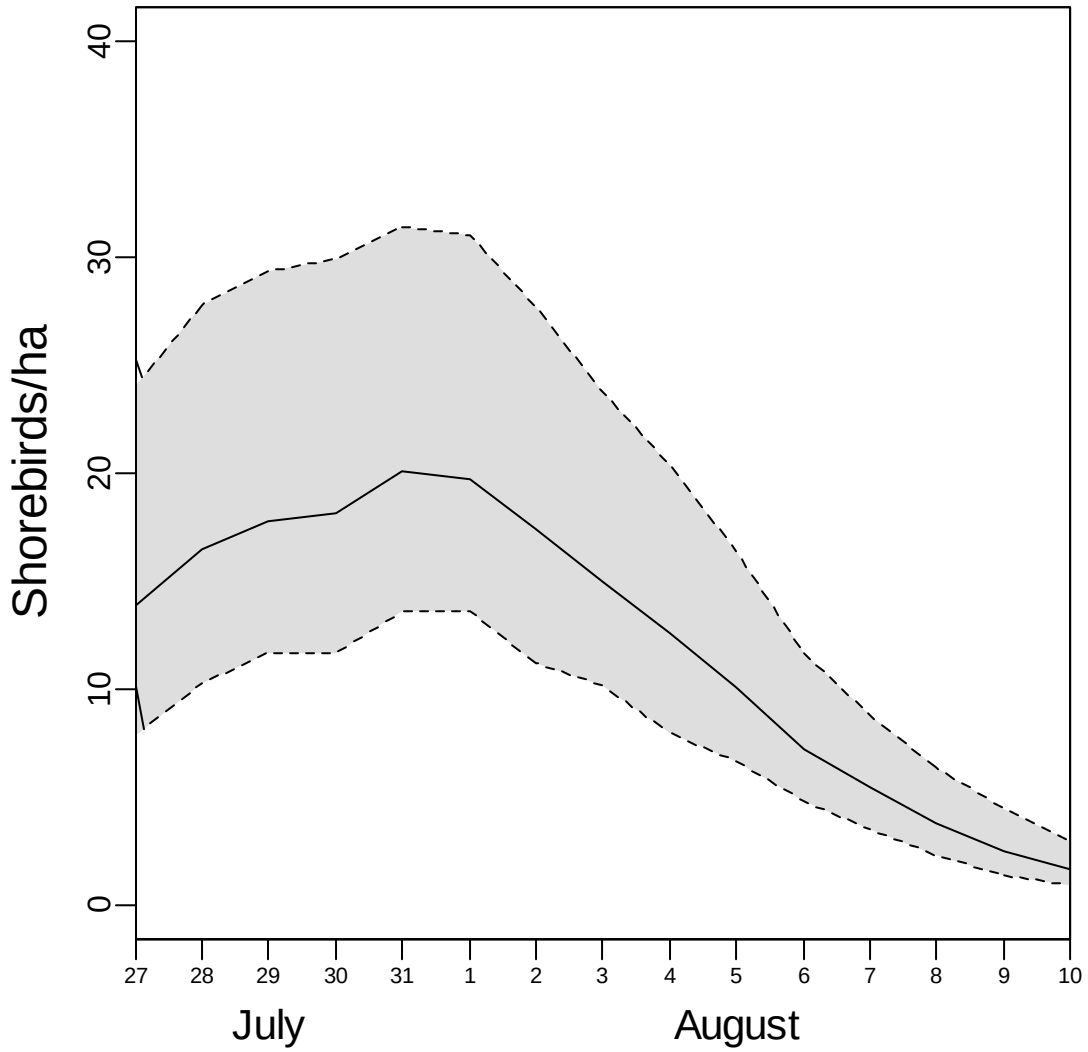

Figure 3. Temporal variation in total post-breeding shorebird density in low marsh on Ikpek and Arctic Lagoon barrier island, Bering Land Bridge National Preserve (2013). The solid line represents the mean (expected) count/ha for each day from 27 July-10 August. The dotted line and shaded region represent the 95% credible interval.

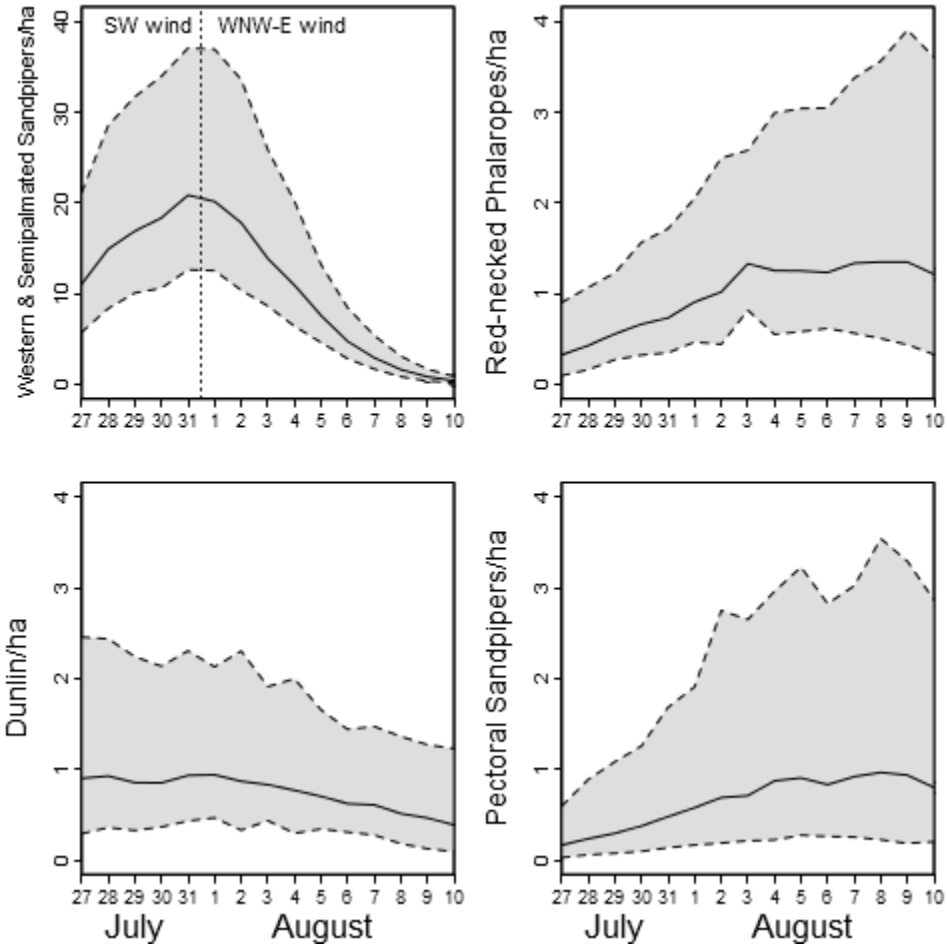

Figure 4. Temporal variation in post-breeding shorebird density in low marsh on Ikpek and Arctic Lagoon barrier island strip, Bering Land Bridge National Preserve (2013). The solid line represents the mean (expected) count/ha for each day from 27 July-10 August. The dotted line and shaded region represent the 95% credible interval. Vertical line in upper left figure indicates the point at which winds shifted from southwest to northerly (varying WNW-E).

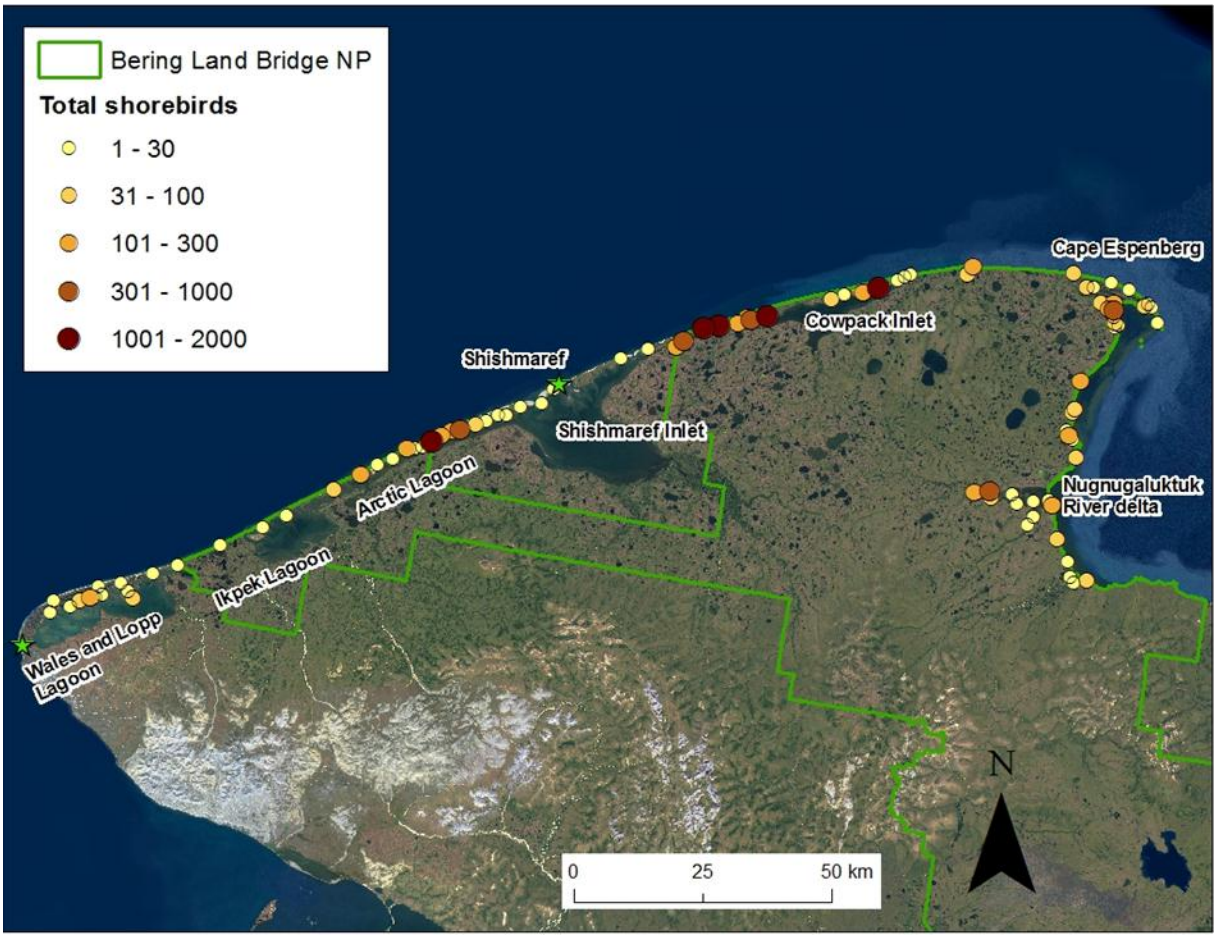

Figure 5. Shorebird counts from our aerial survey on 26 July 2013.

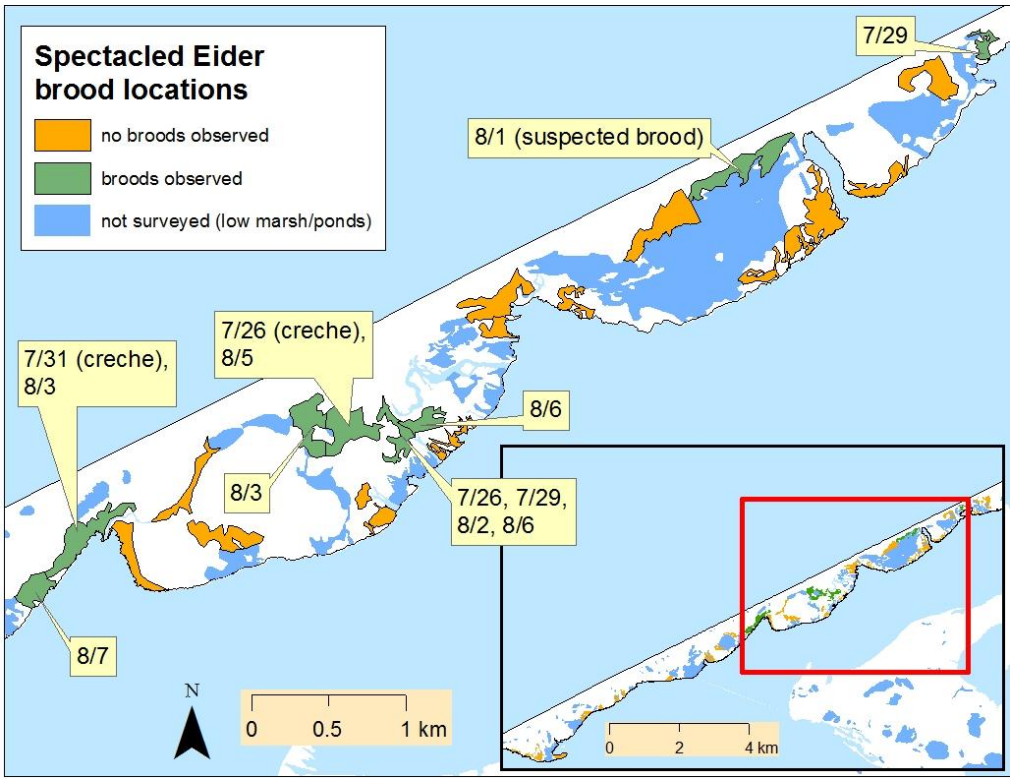

Figure 6. Observations of Spectacled Eider broods on the Arctic Lagoon barrier island strip.

Figure 7. Photo of Spectacled Eider brood taken during surveys. (Photo: Katie Dunbar

Notably, we had 13 observations of up to eight different Spectacled Eider broods (Fig. 6). Kessel (1989) notes only two confirmed breeding localities on the Seward Peninsula for this species: Cape Espenberg and the mouth of the Arctic River in Shishmaref Inlet. There have been nodocumented observations of breeding Spectacled Eiders (*Somateria fischeri*) on the Seward Peninsula since the 1970s (Walton et al. 2012) including on aerial surveys of breeding populations of Pacific Common Eider (*Somateria mollissima*) conducted on the Seward Peninsula from 2006-2009 (Bollinger and Platte 2012).

Future work

Although our ground effort allowed us to document large numbers of shorebirds using salt marsh, we were unable to efficiently sample tidal flats due to the wide dispersion of this habitat. Considering observations from our aerial survey of large numbers of shorebirds using tidal flats, failure to sample this habitat gives an incomplete characterization of post-breeding use within the park. Thus, park-wide, aerial surveys are the logical next step in documenting spatial variation in post-breeding shorebird use of littoral habitats within Western Arctic Parklands.

Literature Cited

Amano, T., T. Székely, K. Koyama, H. Amano, and W. J. Sutherland. 2010. A framework for monitoring the status of populations: An example from wader populations in the East Asian–Australasian flyway. *Biological Conservation* 143:2238-2247.

Bart, J., A. Manning, S. Thomas, and C. Wightman. 2005. Preparation of regional shorebird monitoring plans. Pages 902-906 *in*: C. J. Ralph and T. D. Rich, editors. Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, Volume 2 Gen. Tech. Rep. PSW-GTR-191. Albany, CA: U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station:

Bart, J., S. Brown, B. Harrington, and R. G. Morrison. 2007. Survey trends of North American shorebirds: population declines or shifting distributions? Journal of Avian Biology Bildstein, B.L., G.T. Bancroft, P.J. Dugan, D.H. Gordon, R.M. Erwin, E. Nol, L.X. Payne, and S.E. Senner. 1991. Approaches to the conservation of coastal wetlands in the western Hemisphere. *Wilson Bulletin* 103:218-254.

Bollinger, K. S., and R. M. Platte. 2012. Aerial population surveys of Common Eiders and other waterbirds during the breeding season–Northwestern Alaska, 2006-2009. Unpubl. Report. U.S. Fish and Wildlife Service, Migratory Bird Management, Waterfowl Management Branch, Fairbanks, Alaska.

Brooks, S. P., and A. Gelman. 1998. General methods for monitoring convergence of iterative simulations. *Journal of Computational and Graphical Statistics* 7:434-455.

Brown, S., S. Kendall, R. Churchwell, A. Taylor, and A. Benson. 2012. Relative Shorebird Densities at Coastal Sites in the Arctic National Widlife Refuge. *Waterbirds* 35:546-554.

Butler, R.W., T. D. Williams, N. Warnock, and M. A. Bishop. 1997. Wind assistance: a requirement for migration of shorebirds? *Auk* 114:456-466.

Connors, P. G. 1978. Shorebird dependence on arctic littoral habitats. Pages 84-166 *in* Environmental Assessment of the Alaskan Continental Shelf, vol. 2, NOAA-BLM, Boulder, CO.

Connors, P. G., and C. S. Connors. 1985. Shorebird littoral zone ecology of the southern Chukchi coast of Alaska. Pages 1-57 *in* Final Reports of Principal Investigators, Environmental Assessment of the Alaskan Continental Shelf, Biological Studies, vol. 35, NOAA-BLM, Anchorage, Alaska.

ESRI (Environmental Systems Resource Institute). 2012. ArcGIS 10.1, Redlands, California.

Gill Jr, R. E., and P. D Jorgensen. 1979. A preliminary assessment of timing and migration of shorebirds along the northcentral Alaska Peninsula. *Studies in Avian Biology* 2:113-123.

Gill Jr, R. E., and C. M. Handel. 1981. Shorebirds of the eastern Bering Sea. Pages 719-738 *in* D. W. Hood and J. A. Calder, editors. The eastern Bering Sea shelf: oceanography and resources, vol. 2. University of Washington Press, Seattle.

Gill Jr, R. E., and C. M. Handel. 1990. The importance of subarctic intertidal habitats to shorebirds: a study of the central Yukon-Kuskokwim Delta, Alaska. *Condor* 92:709-725.

Gotthardt, T. A., K. M. Walton, and T. L. Fields. 2012. Setting Conservation Priorities for Alaska's Wildlife Action Plan. Alaska Natural Heritage Program, University of Alaska, Anchorage, Alaska.

Gratto-Trevor, C., R. G. Morrison, D. Mizrahi, D. B. Lank, P. Hicklin, and A. L. Spaans. 2012. Migratory connectivity of Semipalmated Sandpipers: winter distribution and migration routes of breeding populations. *Waterbirds* 35:83-95.

Iverson, G. C., S. E. Warnock, R. W. Butler, M. A. Bishop, and N. Warnock. 1996. Spring migration of Western Sandpipers along the Pacific coast of North America: a telemetry study. *Condor* 98:10-21.

Iwamura, T., H. P. Possingham, I. Chadès, C. Minton, N. J. Murray, D. I. Rogers, and R. A. Fuller. 2013. Migratory connectivity magnifies the consequences of habitat loss from sea-level rise for shorebird populations. *Proceedings of the Royal Society B: Biological Sciences* 280: 20130325.

Liechti, F. 2006. Birds: blowin' by the wind? *Journal of Ornithology* 147:202-211.

Kessel, B. 1989. Birds of the Seward Peninsula, Alaska: their biogeography, seasonality, and natural history. University of Alaska Press.

Myers, J. P., R. G. Morrison, P. Z. Antas, B. A. Harrington, T. E. Lovejoy, M. Sallaberry, S. E. Senner, and A. Tarak. 1987. Conservation strategy for migratory species. *American Scientist* 75:19-25.

R Core Team. 2012. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.

Spiegelhalter, D. J., A. Thomas, N. G. Best, and D. Lunn. 2004. WinBUGS Version 1.4.1 User manual. MRC [Medical Research Council] Biostatistics Unit, Cambridge, UK.

Shields, G. F., and L. J. Peyton. 1979. Avian community ecology of the Akulik-Inglutalik River delta, Norton Bay, Alaska. Pages 150–205 *in* Principal investigators' reports, environmental assessment of the Alaskan continental shelf, biological studies, vol. 5. National Oceanic and Atmospheric Administration and the Bureau of Land Management, Boulder, Colorado.

Stevens Jr, D. L., and A. R. Olsen. 2004. Spatially balanced sampling of natural resources. *Journal of the American Statistical Association* 99: 262-278.

Sturtz, S., U. Ligges, and A. Gelman. 2005. R2WinBUGS: A Package for Running WinBUGS from R. *Journal of Statistical Software* 12:1-16.

Taylor, A. R., R. B. Lanctot, A. N. Powell, F. Huettmann, D. A. Nigro, and S. J. Kendall. 2010. Distribution and community characteristics of staging shorebirds on the northern coast of Alaska. *Arctic* 63:451-467.

Tibbitts, T. L., R. E. Gill Jr, and C. P. Dau. 1996. Abundance and distribution of shorebirds using intertidal habitats of Izembek National Wildlife Refuge, Alaska. Unpubl. Final Rpt. U.S. Geological Survey, Alaska Biological Sciences Center, Anchorage, Alaska, 38.

US Committee on the Marine Transportation System. 2013. US Arctic Marine Transportation System: Overview and Priorities for Action. 115 pp.

Warnock, N. 2010. Stopping vs. staging: the difference between a hop and a jump. *Journal of Avian Biology* 41:621-626.

Wilson, H. B., B. E. Kendall, R. A. Fuller, D. A. Milton, and H. P. Possingham. 2011. Analyzing variability and the rate of decline of migratory shorebirds in Moreton Bay, Australia. *Conservation Biology* 25:758-766.

Appendix A: Waterbird species detected during surveys.

Common name	Scientific name	Total count
Western/Semipalmated Sandpiper	*Calidris mauri/Calidris pusilla*	6934
Red-necked Phalarope	*Phalaropus lobatus*	563
Dunlin	*Calidris alpina*	422
Glaucous Gull	*Larus hyperboreus*	283
Pectoral Sandpiper	*Calidris melanotos*	249
Northern Pintail	*Anas acuta*	85
Unknown shorebird		53
Common Eider	*Somateria mollissima*	25
Parasitic Jaeger	*Stercoraria parasiticus*	24
Sandhill Crane	*Grus canadensis*	17
Sabine's Gull	*Xema sabini*	16
Spectacled Eider	*Somateria fischeri*	14
Loon spp.	*Gavia spp.*	9
Long-billed Dowitcher	*Limnodromus scolopaceus*	9
Black Turnstone	*Arenaria melanocephala*	9
Long-tailed Duck	*Clangula hyemalis*	8
Red-throated Loon	*Gavia stellata*	7
Ruddy Turnstone	*Arenaria interpres*	6
Red Phalarope	*Phalaropus fulicarius*	5
Greater White-fronted Goose	*Anser albifrons*	5
American Golden-Plover	*Pluvialis dominica*	4
Phalarope spp.	*Phalaropus spp.*	4
Long-tailed Jaeger	*Stercoraria longicaudus*	3
Bar-tailed Godwit	*Limosa lapponica*	3
Tundra Swan	*Cygnus columbianus*	3
Unknown duck		2
Baird's Sandpiper	*Calidris bairdii*	1
Emperor Goose	*Chen canagica*	1
Mew Gull	*Larus canus*	1
Whimbrel	*Numenius phaeopus*	Fly-over
Brant	*Branta bernicla*	Fly-over
Hudsonian Godwit	*Limosa haemastica*	Fly-over

Appendix B: Waterbird species detected outside of plots.

Common name	Scientific name
Surfbird	*Aphriza virgata*
Red Knot	*Calidris canuts*
Sanderling	*Calidris alba*
Semipalmated Plover	*Charadrius semipalmatus*
Pacific Golden Plover	*Pluvialis fulva*
Red-necked Grebe	*Podiceps grisegena*
Pomarine Jaeger	*Stercoraria pomarinus*
Slaty-backed Gull	*Larus schistisagus*