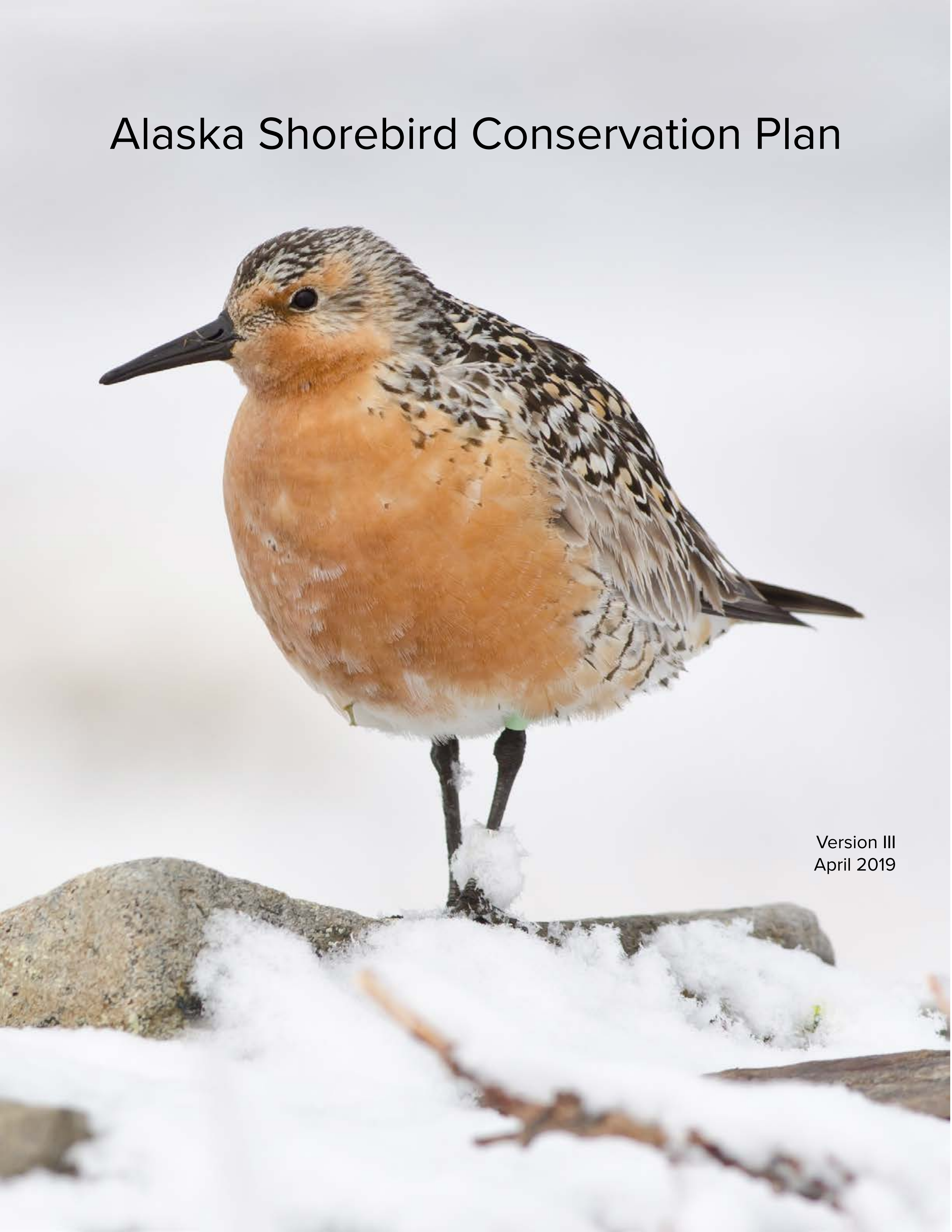
Alaska Shorebird Conservation Plan



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Cover: Male Red Knot on breeding territory, Seward Peninsula, Alaska. *Photo by Lucas DeCicco.*

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Lucas DeCicco

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Lucas DeCicco

Dedication

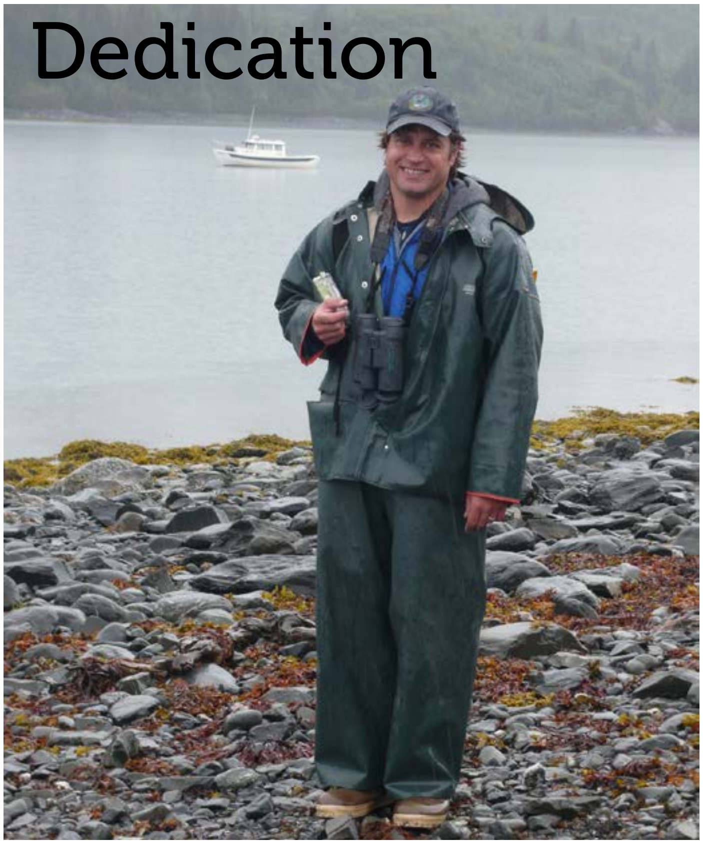

Photo credit: Marian Snively

This third version of the Alaska Shorebird Conservation Plan is dedicated to the memory of David Fair Tessler in appreciation for his contributions to shorebird science and conservation in Alaska. David approached his shorebird research like he did everything else in life—with deep passion, commitment, and an undeniable joy. He embraced his oystercatcher research with fearless enthusiasm, careful design, and his uncanny ability to have fun, no matter the weather or work conditions. His positive, can-do, and upbeat personality, as well as his quick wit and sense of humor are legendary. David often reduced people to tears of laughter with his antics; people loved to work and be around him. He was also highly intelligent and hardworking, as demonstrated by his many professional accomplishments.

As non-game Wildlife Biologist and Coordinator of the Wildlife Diversity Program at Alaska Department of Fish and Game, David's contributions advanced Black Oystercatcher research and conservation in Alaska. For example, David was instrumental in the formation of the Black Oystercatcher Working Group. He also mentored and supported several graduate

Photo credit: Alaska Department of Fish and Game.

students' work on the ecology of Black Oystercatchers. He published two key reports, "Black Oystercatcher Conservation Action Plan" for the U.S. Fish and Wildlife Service and "A Global Assessment of the Conservation Status of the Black Oystercatcher *Haematopus bachmani*" for the International Wader Study Group. He also co-authored several peer-reviewed journal articles, presented his findings at professional conferences, and wrote many agency reports on his oystercatcher work. David would often say, "My knowledge is a mile wide and an inch deep," but this modesty belied the tremendous scope and depth of Dave's interests, especially those related to biology or ecology. He was easy to talk to, curious about people and what they had to say, and was a good listener, traits that earned David many friends. David was a mentor to many and shared his knowledge and insight with easy enthusiasm.

Dave lived large, loved to travel, and was an outdoor enthusiast. He was an accomplished skier, climber, and avid surfer. He was a devoted father and husband, and was especially fond of camping in Prince William Sound with his wife, Tracey, and their two children, River and Sierra. David loved his family dearly, and was most happy when sharing the natural world together. In 2015, Dave and his family left Alaska to pursue new adventures in Hawaii, where he took a position with the U.S. Fish and Wildlife Service as the Deputy Field Supervisor for Geographic Operations. He and his family loved their new island life and spent time camping and island hopping. However, he remarked that part of his heart always remained in Alaska. Dave's humor, charm, enthusiasm, and love of life are greatly missed.

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Executive Summary

Semipalmated Sandpiper
Daniel Ruthrauff

Alaska's immense size, diverse habitats, and position at the terminus of several migratory flyways make it a critical region for breeding and migrating shorebirds. Seventy-seven species of shorebirds have been recorded in Alaska—over one-third of the world's species. Of these, 37 are regular breeders and 17 irregular. About one-third of the world's 100 million shorebirds reside in Alaska, and individual species' populations range in size from a few thousand to several million. Three species and seven subspecies breed nowhere else. Seven species are year-round residents of Alaska, but most shorebird species are migratory. These migratory species connect Alaska to sites in North, Central, and South America, Asia, and locations throughout Oceania. During migration, shorebirds concentrate in huge numbers at many coastal staging and migratory stopover sites throughout Alaska. Of particular note are the Copper River Delta and the Yukon-Kuskokwim Delta, sites that support millions of migrant shorebirds during spring and fall migration, respectively.

Shorebird populations in North America suffered dramatic population declines at the turn of the 20th century and many continue to decline. Of the 41 shorebird populations known to breed in Alaska, 7 have experienced a substantial decrease in population size and 12 a moderate decrease or suspected decrease. Many of these declines can be attributed to habitat loss and degradation, although climate change and other factors are also responsible. Shorebirds face threats throughout their annual cycles, and these threats have the potential to carry over and compound, complicating the conservation of the species group.

While shorebird habitats in Alaska are still relatively intact and conservation threats are mostly limited to local areas, concerns nevertheless exist here, especially for our highest priority species. To address ongoing and heightened concerns about Alaska's shorebirds and to take advantage of new knowledge gained over the last decade, the Alaska Shorebird Group (ASG) completed this revision of the 2008 version of the Alaska Shorebird Conservation Plan. This version has two sections. Part I presents an overview of shorebirds occurring within Alaska, describes the priority species, discusses real and potential conservation issues facing shorebirds throughout Alaska, and presents a conservation strategy focused on six major themes. Part II describes the priority species, important shorebird areas, and conservation issues and actions pertinent to each of Alaska's five Bird Conservation Regions (BCRs). We also have added an "emerging conservation issues" section within each BCR that describes threats that have the potential to negatively affect shorebirds in the near future. Anticipation of these looming threats to shorebirds should facilitate the implementation of conservation efforts that are more effective through time. Finally, we evaluated recent conservation progress in each BCR to inform the reader of studies conducted since the last version of the plan was written.

We identified 17 shorebird taxa of greatest (3) or high (14) conservation concern and 12 "Alaska Stewardship" taxa. The categories of conservation concern were based on the species prioritization process developed by the U.S. National Shorebird Conservation Partnership. In this process, species considered of greatest and high priority tend to have small or declining global populations, imminent threats or limited distributions during some phase of their annual cycle, and are thought to be vulnerable to climate change. The Alaska Stewardship taxa have lower conservation priority scores nationally, but ≥50% of their North American populations occur in Alaska during their annual cycles. Across Alaska, each BCR hosts about 16 (range: 11–20) priority taxa, nearly all of which are recognized as such by more than one BCR. To better describe the conservation issues facing these species, we prepared species accounts detailing the natural history of each of these taxa (see Appendix 8).

We identified three major conservation issues facing shorebirds in Alaska: climate change and severe weather, pollution, and actions related to energy production and mining. Other issues may negatively affect particular shorebird species, but currently tend to be of less significance in geographic scope or severity. These include residential and commercial development; agriculture and aquaculture; transportation and service corridors; biological resource use; human intrusions and disturbance; and invasive and problematic species, pathogens, and genes. In Alaska, these threats affect species in different ways depending on where and when shorebirds breed, migrate, or spend the winter. Unfortunately, logistical and financial constraints that limit data collection frequently make it difficult to estimate what effect these threats are having on local shorebird populations, let alone if there is a population-level effect. However, it is clearly important to continue evaluating the cumulative impacts of conservation threats to shorebirds both within Alaska and across their annual cycle.

We also developed a conservation strategy that focuses on a combination of research, population monitoring and inventory, habitat management and protection, education and outreach, international collaborations, and new to this version, an evaluation of conservation progress. The ASG suggests the most crucial need for research is to identify the predominant factor(s) limiting shorebird populations so the most effective conservation actions are implemented to stop and reverse population declines. This may require studies exploring effects of climate change, legal and illegal harvest, macro- and micro-scale habitat selection, and the adaptability to naturally occurring or human-induced changes on the landscape. Especially needed is a better understanding of the relative importance of each of these factors in limiting shorebird populations within Alaska and throughout their annual cycle. The ASG also recommends implementing rigorously designed protocols for monitoring the status and trends of shorebird populations in Alaska, with a focus on priority species with small or declining populations, or in regions or habitats where collecting accurate and precise trend information is possible. Particularly lacking is information for species residing in alpine and boreal biomes, areas where few surveys have been conducted to date. To better prioritize the management and protection of habitats, the ASG recommends collecting additional information on the abundance and distribution of shorebirds so that bird-habitat models can be developed that identify high-quality areas for protection. Education and outreach may be the most important thing Alaskans can do to conserve shorebirds. The ASG encourages efforts to raise the profile of shorebirds through public presentations, media outreach, support of shorebird festivals, and collaboration with education programs. In the international and national arenas, we must integrate the management, research, and conservation efforts throughout a species' annual cycle. This will require us to join, cooperate with, and actively participate in national and international research and monitoring efforts, partnerships, and planning efforts. Finally, we encourage research and conservation efforts that focus on the topics of high priority identified in this plan, and ask that interested parties update the objectives and action items as conservation issues change through time. This plan is intended to be dynamic and reflect current priorities as well as past achievements. The usefulness of this document relies upon the continued participation and commitment of the greater shorebird community.

Part II of the plan includes information on each of the five BCRs within Alaska. Below, we provide a short synopsis of the most relevant information for each BCR.

Rock Sandpipers feeding in the shadow
of Mt. Redoubt during winter
Kasilof River, Cook Inlet
Daniel Ruthrauff

The Aleutian/Bering Sea Islands BCR (1) is composed of hundreds of low-elevation islands in the Bering Sea, most of which are administered by the Alaska Maritime National Wildlife Refuge. This BCR is small in area (18,000 km^2) but covers a vast region of the northern Pacific Ocean, and includes the St. Lawrence, St. Matthew, Pribilof, and Aleutian island groups. Primarily noted for the abundance and diversity of its seabird avifauna, the region nonetheless supports several important breeding populations of shorebirds. The entire *ptilocnemis* subspecies of Rock Sandpipers breeds in the BCR, as well as significant numbers of the *couesi* subspecies of Rock Sandpipers, and Black Oystercatchers. In total, 11 priority species either breed, migrate through, or winter in the BCR in significant numbers. This region is very remote and has a small human population, and so the greatest potential threats to shorebirds arise from the relatively large effect that marine-derived pollution and invasive and problematic species can have on island ecosystems.

The Western Alaska BCR (2) extends across western and southwestern Alaska from Kotzebue Sound to Kodiak Island and includes coastal plains, mountains, and three of Alaska's largest islands. There are 20 priority shorebird populations in the BCR, 15 of which breed in the region, 15 that occur during migratory periods, and 1 that winters in the region. BCR 2 supports high densities of both breeding and migrating shorebirds. Key breeding areas include the vast Yukon-Kuskokwim Delta, the Alaska Peninsula, the Seward Peninsula, and the Kodiak Archipelago. Important migratory stopover areas include the immense intertidal flats, coastal meadows, and berry-rich tundra of the Yukon-Kuskokwim Delta; the lagoons, estuaries, intertidal habitats, and coastal meadows of Bristol Bay and the Alaska Peninsula; and coastal habitats from Cape Espenberg to eastern Norton Sound. Together these sites host a unique assemblage of shorebirds, including significant portions of the North American breeding populations of species such as Bristle-thighed Curlew, Bar-tailed Godwit (*baueri* subspecies), Marbled Godwit (*beringiae* subspecies), Black Turnstone, Red Knot (*roselaari* subspecies), and Western Sandpiper. The most significant conservation issues affecting BCR 2 include climate-moderated habitat changes and alteration of climatological patterns, pollution associated with increased shipping traffic and mineral extraction activities, and the potential effect of subsistence harvest activities. Priority actions in BCR 2 include developing habitat models that predict species distributions and future habitat changes, continued participation in planning for natural resource management and resource extraction, and developing ways to engage subsistence users in shorebird conservation efforts.

The Arctic Plains and Mountains BCR (3) includes the low-lying coastal tundra, drier uplands of the Arctic Foothills of the Brooks Range, and montane areas of the Brooks Range. There are 19 shorebird species identified as priority within the BCR, including 18 species that breed in the region and 11 that migrate through the region. The coastal tundra provides some of the world's best breeding habitat for many calidridine sandpipers, plovers, dowitchers, and phalaropes. Indeed, >6 million shorebirds are thought to breed across the Beaufort Coastal Plain. The river deltas and coastal lagoons are used extensively by hundreds of thousands of postbreeding shorebirds between July and September. Some of the most extensive research and monitoring work in Alaska has been conducted in this BCR, although little work has occurred in the Arctic Foothills and montane areas of the Brooks Range. Priority conservation issues include energy production and mining, development of new transportation and service corridors, changes in the distribution and abundance of predators, and climate change that is affecting habitats and phenology of shorebirds and their prey. Both local and atmospheric/oceanic pollution are real issues, although not well studied. Emerging issues include human population growth, expansion of wind turbines, and the development of hard rock and coal resources. Additional studies are warranted to mitigate potential effects on shorebirds from oil and gas development planned for the 1002 Area of the Arctic National Wildlife Refuge.

The Northwestern Interior Forest BCR (4) comprises Alaska's interior boreal forest and mountains, as well as the maritime-influenced Cook Inlet. There are 17 priority taxa within this region, 10 of which breed in the region, 10 that occur during migratory periods, and 2 that winter in the region. Breeding species tend to occur at low densities in the mountains (American Golden-Plover, Surfbird, Wandering Tattler), foothills and tundra-taiga interface (Bristle-thighed Curlew, Whimbrel, Hudsonian Godwit), and lowland forests and wetlands (Solitary Sandpiper, Lesser Yellowlegs). Cook Inlet is important to wintering Rock Sandpipers, but also to multiple species during migration, especially in the spring. Priority conservation threats include potential point-source effects of energy production (e.g., oil well spills in Cook Inlet) and mining, and associated pollution during transportation of energy products by tankers, trucks, trains, and pipelines. Expected effects of climate change include alteration of habitats due to ecosystem encroachment (e.g., elevational and latitudinal advance of treeline) and changes in temperature, precipitation, or hydrological regimes (e.g., wetland drying; more frequent, severer, and larger wildfires). Although most of Alaska's human population resides in this BCR, the residential, commercial, and industrial footprints therein are arguably small currently, especially given the vastness of the region. Nevertheless, an emerging issue is the likely incremental human encroachment, especially on important shorebird migration stopover sites and breeding areas. Designing, assessing, and implementing approaches to inventory boreal shorebirds and identify or refine their habitat associations are necessary to develop models for predicting species distribution and likely habitat changes. Such information is especially important for effective engagement in the region's substantial ongoing and anticipated natural resource development planning.

The Northern Pacific Rainforest BCR (5) encompasses the southeastern Alaska panhandle and portions of southcoastal Alaska. Of the 13 priority shorebird species that occur in the region, the majority (10 species) stop or stage there during spring migration, with fewer species remaining in the region during breeding (3 species) and wintering (3 species) periods. Key migratory sites such as the Copper River Delta, Controller Bay, Yakutat Forelands, Mendenhall Wetlands, and Stikine River Delta support millions of shorebirds, including globally significant numbers of Red Knots, Dunlin, and Western Sandpipers. Substantial numbers of Marbled Godwits, Black Turnstones, Surfbirds, Short-billed and Long-billed dowitchers, and Red-necked Phalaropes also migrate along the region's coast. Priority conservation issues include human intrusions (primarily in the form of recreational use) and disturbance, pollution (e.g., increased shipping traffic and coinciding risk of fuel and oil spills), and climate change. Emerging conservation issues include energy production and mining and introduction and expansion of non-native plants that can diminish and degrade intertidal habitats. Activities aimed at monitoring shorebird populations and describing habitat use at key sites used during spring migration are needed.

The overall goal of this plan is to keep shorebirds and their habitats well distributed not only across the Alaska landscape, but also throughout regions used by these populations during other phases of their annual cycle. Previous versions and updates of this plan can be found at https://www.fws.gov/alaska/mbsp/mbm/shorebirds/plans.htm.

Cotton Grass near Prudhoe Bay
Zak Pohlen

Part I: Alaska Shorebird Conservation Plan

Dunlin
Lucas DeCicco

INTRODUCTION

Shorebirds are among the world's most impressive avian migrants. Some species that nest in remote, high-Arctic regions undertake annual, one-way migrations of over 15,000 kilometers. To complete these long-distance flights, most species rely on sites along the way where they stop to rest and replenish reserves to fuel the next leg of their migration. At many of these sites, particularly coastal ones, shorebirds can be found in concentrations that number in the millions of individuals. The fact that many species fly such distances only to spend a few short months nesting and raising their young in often harsh northern regions only adds to the human fascination with this group of birds.

Shorebirds as a group are generally associated with water, and probably no other cover type in the world has been and continues to be affected more by human perturbations than wetlands and coastal habitats (i.e., beaches, intertidal flats, and rocky shorelines). The landscape of North America has been markedly altered through the loss of large expanses of estuarine, brackish, and freshwater wetlands. Not surprisingly, shorebird populations throughout much of North America are in decline. Indeed, of the 72 species and subspecies of shorebirds addressed in the United States and Canadian National Shorebird Plans, almost half (49%) appear to have experienced population declines since 1970 (Donaldson *et al.* 2000; Brown *et al.* 2001; Andres *et al*. 2012a). For many of these species, loss of habitat is the cause of their population decline; for others, it is less clear what factors are responsible. What is known is that any adversity shorebirds face during one phase of their annual cycle will likely manifest itself during subsequent phases of that cycle. Therefore, the ability to identify and assess threats and associated changes in shorebird populations, especially among those species migrating throughout the Western Hemisphere and the East Asia–Australasia Flyway, requires well-coordinated efforts at appropriate temporal and spatial scales.

The impetus for the U. S. Shorebird Conservation Partnership (https://www.shorebirdplan.org) came from heightened awareness of problems facing migratory birds in general and from several national and international conservation initiatives focusing on migratory songbirds and waterfowl. Although shorebirds have long been afforded protection under North American laws and treaties, such strictures have largely been ineffective in preventing declines in their populations brought about primarily through loss of habitat. Greater efforts are needed to conserve habitat, increase knowledge concerning factors that affect shorebird demographic rates, and heighten awareness regarding the plight of shorebirds. Such active conservation, research, and outreach will help halt the decline of many species and keep common species common. The vision of the U.S. Shorebird

Conservation Partnership, therefore, is to ensure that stable and self-sustaining populations of all shorebirds are distributed throughout their range and among a diversity of habitats across the Western Hemisphere.

To be effective, address shorebird conservation needs across each species' range and throughout the annual cycle. To accomplish this goal, the U.S. Shorebird Conservation Plan was developed around 11 geographical units, the same units used for other migratory bird conservation plans throughout North America (Brown *et al.* 2001). Alaska constitutes one of these units. Working with the national component of the U.S. Shorebird Conservation Plan, each of the regional working groups was charged with compiling information and making conservation recommendations for its region. Although academic and private researchers, federal and state agency staff, conservation organizations, and shorebird enthusiasts had accumulated knowledge about Alaska's shorebirds for more than half a century, the Alaska Shorebird Working Group was not officially formed until 1997. The goal of this group was to raise awareness about shorebirds in Alaska, develop conservation actions, and exchange information on issues and research findings. This group (later renamed the Alaska Shorebird Group) formulated the first Alaska Shorebird Plan in 2000.

Building upon the U.S. Shorebird Conservation national and regional efforts, flyway-specific shorebird conservation strategies/business plans gained momentum in bird conservation planning in 2013. This model integrates strategic conservation planning with full life-cycle conservation of shorebird populations across the Western Hemisphere. Winn *et al*. (2013) employed this approach for the Atlantic Flyway Shorebird Business Strategy, and Senner *et al*. (2016) produced a similar strategy for the Pacific Americas. Discussions are underway to develop a Midcontinental Shorebird Conservation Strategy. The main goals of these efforts are to outline effective strategies and actions that are needed to conserve shorebird populations and to coordinate conservation efforts across the life cycle of long- and short-distance migratory shorebirds.

Vision of the Alaska Shorebird Group

Given the importance of Alaska's landscapes to shorebirds throughout the annual cycle and the "overriding political and social responsibility to perpetuate this valuable resource," the Alaska Shorebird Group was founded in 1997 to: 1) raise the public's awareness of shorebirds, 2) promote research, monitoring, management, conservation, and education/outreach relevant to shorebirds, 3) integrate the goals and objectives of the Alaska Shorebird Group with regional, national, and international programs, 4) provide a structured forum to facilitate, coordinate, and enhance the exchange of shorebird information, and 5) promote range-wide management and conservation of shorebirds (Alaska Shorebird Group, Terms of Reference 2003). The Alaska Shorebird Conservation Plan represents the articulation of these objectives. The Alaska Shorebird Group has now revised the Alaska Shorebird Conservation Plan on two occasions, both times when group consensus recognized shortcomings, oversights, or omissions that did not accurately reflect current conservation needs. The first revision of the plan was completed in 2008, and included updated species conservation scores, revised population estimates, updated descriptions of conservation threats in Alaska, and a new framework for building a conservation strategy within a landscape context (i.e., by Bird Conservation Regions, BCRs). Unlike its predecessor, the 2008 plan had two parts; the first part included an overview of Alaskan shorebirds, descriptions of priority species, and threats to shorebirds throughout Alaska. The second part described the shorebirds, priority species, threats, and action items specific to each of the five Bird Conservation Regions within the state.

This third version of the plan follows the format of the 2008 version. Updated information can be found on the shorebird resources of Alaska, priority species, threats, and objectives and action items for Alaska, both state-wide and within each BCR. These recommendations, though based on regional priorities, are expected to reflect annual-cycle needs of species and as such will involve conservation actions across regions, countries, and in many cases, hemispheres.

SHOREBIRDS IN ALASKA

Seventy-seven species of shorebirds have been recorded in Alaska (Appendix 1), representing one-third of the world's shorebird species (del Hoyo *et al*. 1992, Colwell 2010). Population sizes of migrant and breeding shorebirds in Alaska range from a few thousand to several million (Table 1), and shorebirds occur in Alaska across the annual cycle. Most notably, Alaska hosts millions of shorebirds during the breeding season. Indeed, the highest densities of breeding shorebirds in North America occur in Alaska, with premier breeding grounds on the expansive tundra habitats of the Yukon-Kuskokwim Delta (McCaffery *et al*. 2012) and Arctic Coastal Plain (Bart *et al*. 2013; Figure 1). National Parks (e.g., Denali, Gates of the Arctic, Lake Clark) and National Wildlife Refuges (e.g., Kanuti, Yukon Flats; Figure 1) in Alaska's vast Interior include alpine and forested habitats that are also important shorebird breeding sites, supporting lower densities of a distinctive suite of montane- and boreal-breeding shorebirds (Tibbitts *et al*. 2006; Harwood 2016; Amundson *et al*. 2018; see Appendix 7 for a list of shorebird habitat associations). Shorebirds transit among Alaskan sites along countless migratory stopovers, and the region's productive bays, estuaries, and rocky intertidal habitats support millions of migrating shorebirds each spring and fall. Indeed, estuaries along the Yukon-Kuskokwim Delta and the Alaska Peninsula, and river deltas such as those at the mouths of the Copper and Stikine Rivers (Figure 1), rank as critically important stopover sites for migrating shorebirds in the region (Gill and Handel 1990; Gill and Senner 1996). And although most shorebirds depart Alaska as summer turns to fall and site conditions begin to deteriorate, Alaska nonetheless also hosts important nonbreeding sites for a handful of species at locations such as upper Cook Inlet, Kodiak Island, and the shores of islands throughout the Aleutian and Alexander archipelagos (Kessel and Gibson 1978; Gibson and Byrd 2007; Ruthrauff *et al*. 2013; Figure 1).

The shorebird fauna of Alaska is remarkably diverse, primarily because of the region's proximity to Asia and its paleogeographic history (Kessel and

Rock Sandpiper
Lucas DeCicco

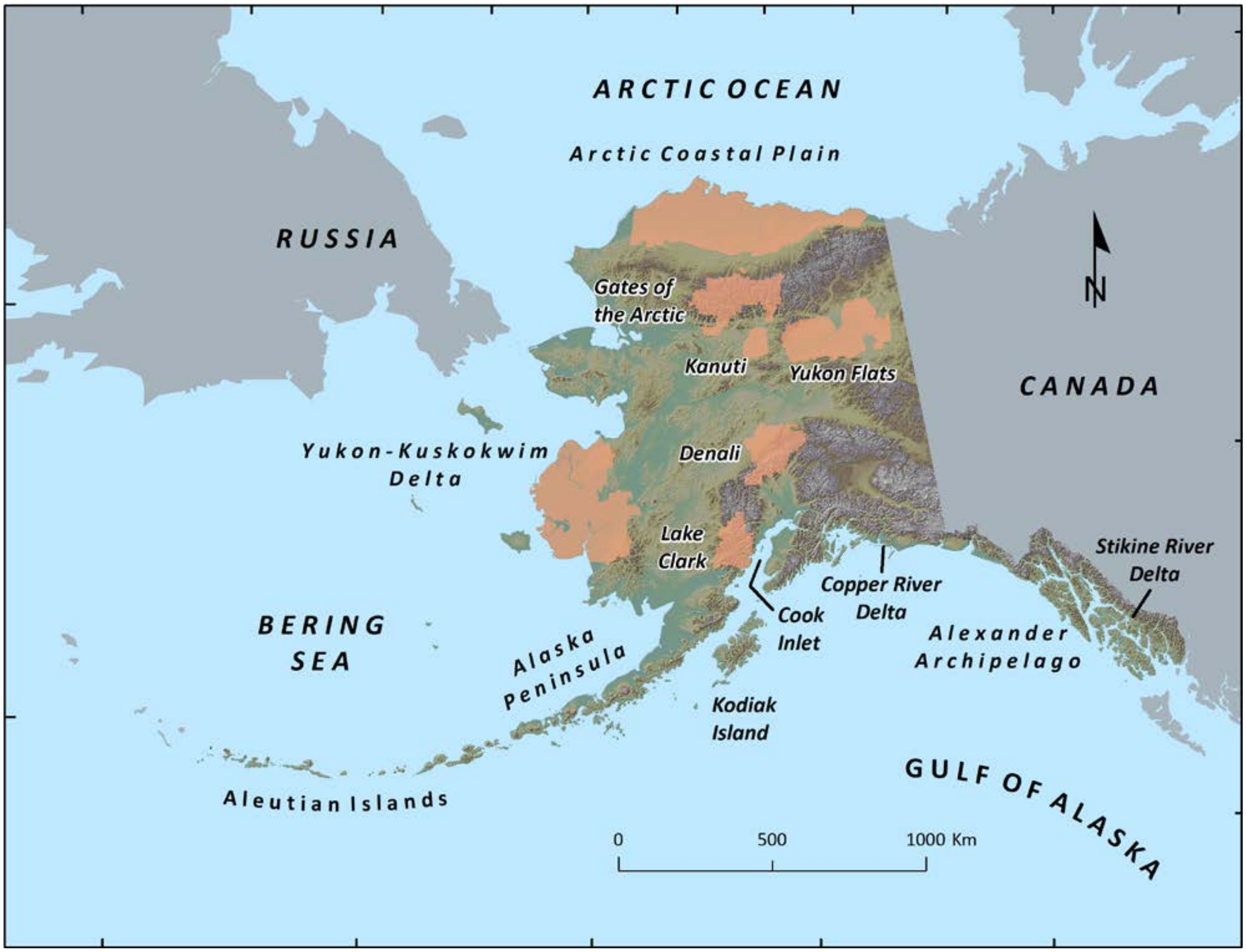


Figure 1. Overview of Alaska, detailing some of the state's important shorebird sites. See Appendices 3 and 7 for a comprehensive listing of important sites for shorebirds in Alaska.

Gibson 1978). More than 80% of Alaska's landmass is north of 60° latitude, where tundra and taiga habitats dominate the landscape. Shorebirds, more so than any other group of birds, have evolved in and radiated across these ecosystems. The same processes operating in Alaska also occurred over a large portion of northeast Asia. Thus, shorebird species that evolved in Asia are frequently seen in Alaska as accidental visitors, or occasionally as breeders. The same is true for many Alaskan species in the Russian Far East (Kessel and Gibson 1978).

The list of shorebird populations restricted wholly or in large part to Alaska is impressive (Table 1, Appendix 1). For example, the world's populations of three species (Bristle-thighed Curlew, Black Turnstone, and Western Sandpiper; see Appendix 1 for scientific names) and seven subspecies (Bar-tailed Godwit *L. l. baueri*; Marbled Godwit *L. f. beringiae*; Dunlin *C. a. pacifica* and *C. a. arcticola*; Rock Sandpiper *C. p. ptilocnemis* and *C. p. couesi*; and Short-billed Dowitcher *L. g. caurinus*) breed only within Alaska. As much as 75% of the world's breeding population of Surfbird and a third subspecies of Rock Sandpiper (*C. p. tschuktschorum*) also occurs in Alaska. Equally impressive is the large proportion of populations of several other species that occur in Alaska, including Black Oystercatcher, Pacific Golden-Plover, Wandering Tattler, and Red Knot *C. c. roselaari*.

Table 1. Estimated population size, population trend, conservation status, and percent occurrence of shorebirds that regularly occur in Alaska

				% Occurrence in Alaska[5]		
Species[1]	Population estimate[2]	Population trend[3]	Conservation status[4]	Breeding	Migration	Winter
Black Oystercatcher	11,000[2a]	STA[3a]	H	61[5a]	61[5a]	38[5a]
Black-bellied Plover (North America breeding)	362,700	dec	M	72	72	<5
American Golden-Plover	500,000	dec	H	58	58	0
Pacific Golden-Plover (North America breeding)	42,500	UNK	H	100	100	0
Semipalmated Plover	200,000	INC	L	19	19	0
Killdeer (*vociferus*)	2,000,000	DEC	M	<1[5a]	<1[5a]	<1[5a]
Upland Sandpiper	750,000	INC	L	<1[5a]	<1[5a]	0
Bristle-thighed Curlew	10,000	UNK	G	100	100	0
Whimbrel (*hudsonicus*, AK/SW Yukon Territory breeding)[1a]	40,000	UNK	H	>95[5a]	>95[5a]	0
Bar-tailed Godwit (*baueri*)	90,000	DEC	G	100	100	0
Hudsonian Godwit (AK breeding)[1b]	21,000	dec	H	100	100	0
Marbled Godwit (*beringiae*)	2,000	UNK	H	100	100	0
Ruddy Turnstone (*interpres*, AK breeding)[1c]	20,000	UNK	M	100	100	<1[5a]
Black Turnstone	95,000	STA	H	100	100	>25[5a]
Red Knot (*roselaari*)	21,800[2b]	dec	G	77	100[5b]	0
Surfbird	70,000	UNK	M	80	80	<5[5a]
Sharp-tailed Sandpiper (Global juvenile cohort)[1d]	24,000[2c]	dec	L	0	>60	0
Stilt Sandpiper	1,243,700	dec	L	10	10	0
Sanderling (North America breeding)	200,000	dec	M	<1[5a]	<10[5a, b]	<5[5a, b]
Dunlin (*arcticola*)	500,000	DEC	H	95[5a]	100[5a]	0
Dunlin (*pacifica*)	550,000	STA	M	100	100	<5
Rock Sandpiper (*ptilocnemis*)	19,800	UNK	H	100	100	>90[5a]
Rock Sandpiper (*couesi*)	75,000	UNK	L	100	100	100
Rock Sandpiper (*tschuktschorum*)	50,000	UNK	L	70	100[5b]	>50[5a, b]
Baird's Sandpiper	300,000	UNK	L	10	10	0
Least Sandpiper	700,000	STA	L	38	38	0
White-rumped Sandpiper	1,694,000	STA	L	<1	<1	0
Buff-breasted Sandpiper	56,000	DEC	H	25[5a]	26[5b]	0
Pectoral Sandpiper	1,680,000	DEC	H	68	75[5b]	0
Semipalmated Sandpiper (AK breeding)[1e]	1,450,000	STA[3b]	H	100	100	0
Western Sandpiper	3,500,000	dec	M	>95[5a]	100[5b]	0
Short-billed Dowitcher (*caurinus*)	75,000	dec	H	80	80	0

Table 1 (continued).

				% Occurrence in Alaska[5]		
Species[1]	Population estimate[2]	Population trend[3]	Conservation status[4]	Breeding	Migration	Winter
Long-billed Dowitcher	650,000	UNK	M	75	98[5b]	0
Wilson's Snipe	2,000,000	STA	L	25	25	<5[5a]
Spotted Sandpiper	660,000	STA	L	20	20	0
Solitary Sandpiper (*cinnamomea*)	63,000	UNK	L	79	79	0
Wandering Tattler	17,500	UNK	L	57	57	0
Lesser Yellowlegs	660,000	DEC	H	24	24	0
Greater Yellowlegs	137,000	STA	L	27	27	0
Red-necked Phalarope (North America breeding)	2,500,000	DEC	M	50	50	0
Red Phalarope (North America breeding)	1,620,000	dec	M	36	36	0

[1]See Appendix 1 for scientific names. Taxonomy follows AOU 7th edition (1998) and supplements through Chesser ***et al***. (2017). Subspecies (in italics) follow Gibson and Withrow (2015) and Andres ***et al.*** (2012b). Regional population categories are used when a species occurs outside of North America and follows Andres ***et al.*** (2012b) and B. Andres (unpubl. data); "North America" refers to birds breeding in North America; "AK Breeding" is used when a distinct population segment is thought to occur in Alaska; a lack of designation reflects species for which a unique population segment is not known to occur in Alaska. [1a]Band resightings (J. Johnson, unpubl. data) and migratory tracking studies (Johnson *et al*. 2016; D. Ruthrauff, unpubl. data; B. Watts, unpubl. data) indicate that the majority of Whimbrels breeding in Alaska represent a distinct population that segregates during the nonbreeding period from Whimbrels breeding in northwestern and eastern Canada. [1b]Band resightings (J. Johnson, unpubl. data) and migratory tracking studies (Senner 2012; Senner ***et al.*** 2014; B. Watts, unpubl. data) indicate that the majority of Hudsonian Godwits breeding in Alaska represent a distinct population that segregates during the winter from godwits breeding in northwestern and eastern Canada. [1c]The Alaska-breeding population (and a small number of birds breeding in eastern Siberia) appear to be a distinct population that segregates throughout the annual cycle from ***interpres*** breeding in Eurasia and eastern Canada (Nettleship 2000; J. Helmericks, unpubl. data). [1d]Sharp-tailed Sandpipers do not breed in Alaska, but juveniles commonly occur as migrants (Handel and Gill 2010). [1e]Three regional breeding populations (Alaska, western Canadian Arctic, and eastern Canadian Arctic) are recognized based on morphometric differences (Gratto-Trevor ***et al.*** 2012; Andres ***et al.*** 2012b). Migration tracking revealed varying levels of separation among Alaska-breeding birds and those breeding in the western and eastern Canadian Arctic during the nonbreeding period (Brown ***et al.*** 2016).

[2]Population size refers to global population size unless denoted in the species column as a subspecific or regional population estimate. Population estimates follow USSCPP (2016) and B. Andres (unpubl. data) except for: [2a]Weinstein ***et al.*** (2014), [2b]Lyons ***et al.*** (2015), [2c]Handel and Gill (2010).

[3]Population trend scores follow B. Andres (unpubl. data). Population trend scale is from Andres ***et al.*** (2012b). INC: substantial increase; inc: small increase or increase suspected; STA: stable or UNK: unknown; dec: moderate decrease or decrease suspected; DEC: substantial decrease. [3a]Weinstein ***et al.*** (2014), [3b]Andres ***et al.*** (2012b).

[4]Scores follow USSCPP (2016) and include species, subspecies, and regional populations. G = Greatest Concern, H = High Concern, M = Moderate Concern, L = Least Concern.

[5]Population size and percent occurrence values derive from population-specific estimates from B. Andres (unpubl. data) and often reflect a high degree of uncertainty. [5a]Estimates derived by the Alaska Shorebird Group. [5b]A portion of the population breeds in the Palearctic, most of which are assumed to either migrate through, or in a few cases remain in, Alaska during winter.

Semipalmated Plovers
Anne Schaefer

Of 37 shorebird species regularly breeding in Alaska, only 7 remain in Alaska in substantial numbers during winter (Black Oystercatcher, Black Turnstone, Surfbird, Sanderling, Rock Sandpiper, Dunlin, and Wilson's Snipe; Table 2). More than one-third of Alaska's species are extreme long-distance migrants. Shorebirds that breed in Alaska use numerous flyways to and from nonbreeding grounds in Australia, New Zealand, central and southern Oceania, southeast Asia, southern Canada, the contiguous United States, Mexico, and Central and South America (Boland 1991; Gill *et al.* 1994; Gill and Senner 1996; Appendix 2). Spring and fall concentrations of migrating shorebirds at coastal staging/stopover sites in Alaska are impressive. Notably, both the Copper River Delta and Yukon-Kuskokwim Delta support millions of migrant shorebirds annually, and numerous estuaries elsewhere along the coast of Alaska support more than 100,000 migrant shorebirds each year (Appendix 3). For several species, the majority of their populations concentrate at only a few sites in Alaska during certain periods of the annual cycle.

Table 2. Seasonal importance of Bird Conservation Regions to Alaska's regularly occurring shorebird species. B (in all forms) = breeding (nests in the BCR), M (in all forms) = migration (birds use the BCR for staging or stopover and not simply passing through the BCR), and W (in all forms) = wintering (birds use the BCR from November through March, and exhibit little movement between sites). **B, M, W** = high numbers of individuals occur within BCR relative to other BCRs in Alaska during seasons listed. B, M, W = common or locally abundant; BCR important to the species. b, m, w = uncommon to fairly common; BCR within species' range but species occurs in low abundance relative to other BCRs. B refers to breeding, M to migration, and W to wintering.

Species[1]	BCR 1[2]	BCR 2[2]	BCR 3[2]	BCR 4[2]	BCR 5[2]
Black Oystercatcher	**B**, W	B, W			**B**, M, **W**
Black-bellied Plover (North America breeding)	m	**B**, M	**B**, m	M	M
American Golden-Plover		B	**B**, m	B, m	m
Pacific Golden-Plover (North America breeding)	m	**B, M**		b	
Semipalmated Plover	b	b, m	b	B, m	B, **M**
Killdeer (*vociferus*)				b	b, w
Upland Sandpiper			b	**B**	
Bristle-thighed Curlew		**B, M**		**B**	
Whimbrel (*hudsonicus*, AK/SW Yukon Territory breeding)		**B, M**	B	B, M	m
Bar-tailed Godwit (*baueri*)		**B, M**	B	b	
Hudsonian Godwit (AK breeding)		**B, M**		**B, M**	
Marbled Godwit (*beringiae*)		**B, M**			**M**
Ruddy Turnstone (*interpres*, AK breeding)	M	**B, M**	b, m		M
Black Turnstone		**B, M**	b		**M**, w
Red Knot (*roselaari*)		**B, M**	b, m		**M**
Surfbird		B, w	b	**B**	**M**, w
Sharp-tailed Sandpiper (Global juvenile cohort)	m	**M**	m		
Stilt Sandpiper			**B, m**	m	
Sanderling (North America breeding)	w	m, w	b, m		m, w
Dunlin (*arcticola*)		**M**	**B, M**		
Dunlin (*pacifica*)		**B, M**	b	**M**	**M**, w
Rock Sandpiper (*ptilocnemis*)	**B**	**M**		**W**	W
Rock Sandpiper (*couesi*)	B, W	**B, M**, **w**			

Table 2. Continued.

Species[1]	BCR 1[2]	BCR 2[2]	BCR 3[2]	BCR 4[2]	BCR 5[2]
Rock Sandpiper (*tschuktschorum*)		**B**, **M**		W	**W**
Baird's Sandpiper		b	**B**, m	b, m	m
Least Sandpiper	b	B, m	b	B, m	B, M
White-rumped Sandpiper			b		
Buff-breasted Sandpiper			**B**		
Pectoral Sandpiper		b, M	**B**, **M**	M	m
Semipalmated Sandpiper (AK breeding)		B	**B**, **M**	m	m
Western Sandpiper	b, m	**B**, **M**	b, M	M	M
Short-billed Dowitcher (*caurinus*)		**B**, **m**		B, M	B, **M**
Long-billed Dowitcher	b	**B**, **M**	**B**, **m**	M	M
Wilson's Snipe	b	B	b	B	B, m, w
Spotted Sandpiper		B	b	**B**	B, m
Solitary Sandpiper (*cinnamomea*)		B		**B**	b, m
Wandering Tattler	b, m	**B**	b	**B**	b, m
Lesser Yellowlegs		B	b	**B**, M	b, m
Greater Yellowlegs		B, m		B, m	B, m
Red-necked Phalarope (North America breeding)	b, M	**B**, M	**B**, **M**	B, m	B, M
Red Phalarope (North America breeding)	b, **M**	b, m	**B**, **M**		M

[1]Refers to the global population unless noted otherwise for subspecies or population segments. Taxonomy follows AOU 7th edition (1998) and supplements through Chesser *et al*. (2017). See population definitions in Table 1.

[2]Characterizations of seasonal occurrence in Bird Conservation Regions (BCRs) and relative importance across BCRs within Alaska; scores based on expert opinion and often reflect a wide spectrum of uncertainties.

Surveying shorebirds on the Copper River Delta. *Mike Ausman.*

CONSERVATION ISSUES FACING SHOREBIRDS

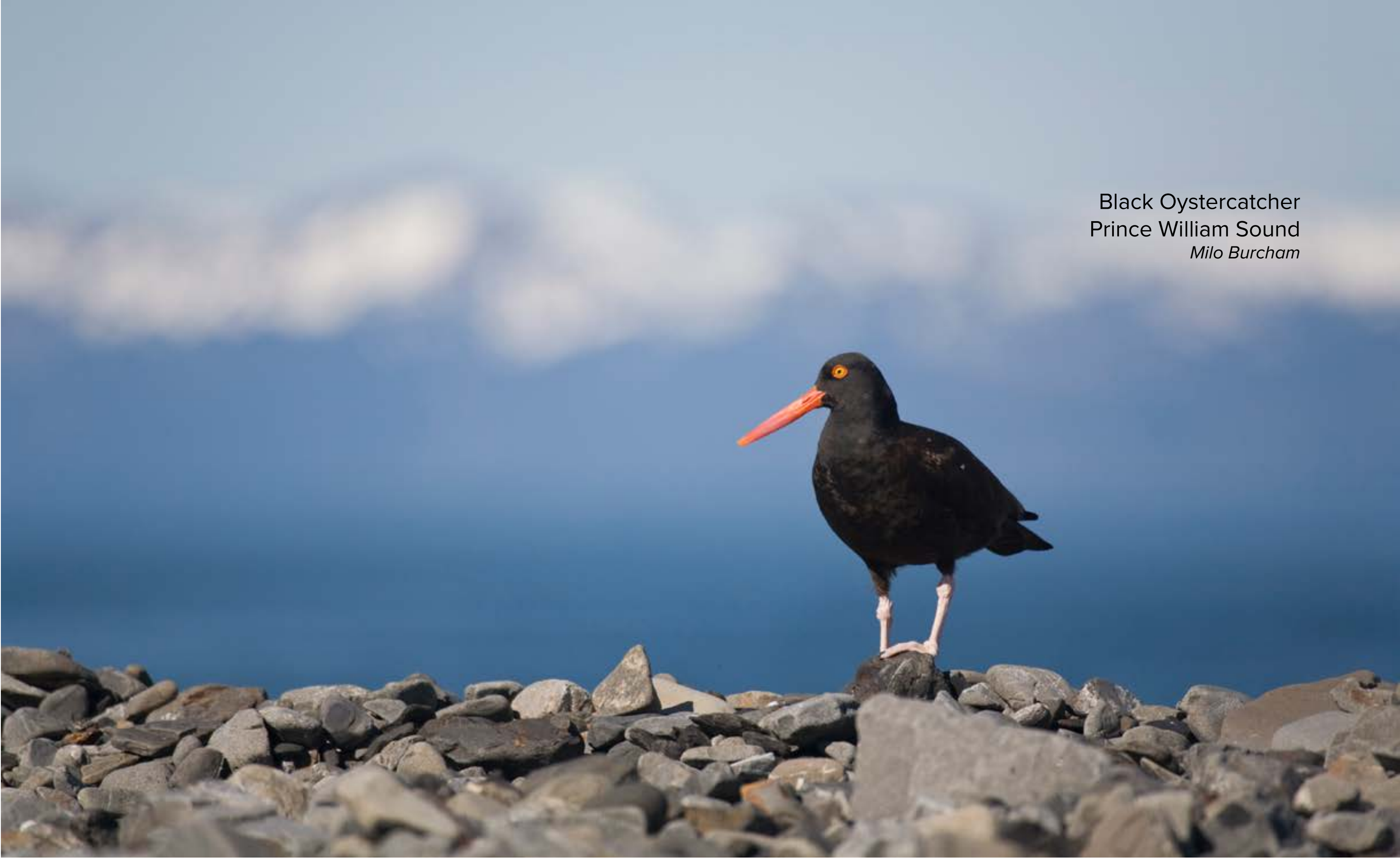
Because of its immense geographic size and small human population, Alaska provides relatively pristine habitats for shorebirds. Outside of Alaska, however, shorebird habitats are seriously threatened by reclamation, degradation, pollution, and human disturbance (Sutherland *et al*. 2012; Pearce-Higgins *et al.* 2017). For example, important habitats that are used by Alaska's shorebirds during the nonbreeding season are being eliminated or compromised by seawall construction and estuarine reclamation in the Yellow Sea, loss of native mangroves in Central America, alteration of grasslands in the Southern Cone of South America, the spread of invasive mangroves in New Zealand, and periodic oil spills in coastal waters. Shorebirds also face direct pressure from subsistence and sport hunting, and negative effects of climate change. These issues underscore the need for large-scale, annual-cycle approaches to conservation, and we emphasize the important role that members of the Alaska Shorebird Group can play in international efforts to conserve shorebirds. Because the Alaska Shorebird Group's primary role is to promote and facilitate shorebird conservation within our state's boundary, local and regional threats form the primary focus of this plan. Nevertheless, the numerous severe threats affecting migratory shorebirds outside of Alaska cannot be disregarded and are mentioned throughout the plan.

Conservation issues are examined in greater detail in Part II wherein we describe the issues and proposed actions specific to each Bird Conservation Region. Our taxonomy of conservation threats is adapted from the Conservation Measures Partnership's Open Standards for the Practice of Conservation (Salafsky *et al*. 2008; http://cmp-openstandards.org). This taxonomy provides a consistent framework for describing conservation issues across the region and forms an effective basis for discussing relevant mitigation and conservation actions. We categorized issues into nine groups, some of which pose serious threats throughout the state (e.g., pollution, habitat degradation), and others that are restricted to limited areas of the state (e.g., invasive species). Below, we describe actual and potential threats to shorebirds within these nine categories.

Climate Change

Global climate change can lead to habitat degradation and shifts, increased variability of climate, and

Buff-breasted Sandpiper
Kevin Karlson



Black Oystercatcher
Prince William Sound
Milo Burcham

disruption of seasonal phenology. Such impacts are particularly relevant to shorebirds in Alaska. Global sea levels are predicted to rise on the order of one-half meter over the 21st century (Church *et al.* 2013), making Alaska and parts of its 54,000 kilometers of coastline especially susceptible to concomitant ecological changes. Littoral-zone invertebrate communities will likely be affected by sea-level rise in terms of both species composition and total productivity (Rehfisch and Crick 2003). Increased frequency and intensity of storm surges could affect invertebrate communities and vegetation of low-lying coastal areas. Changes in temperature and precipitation have caused dwarf shrubs and boreal forests to expand farther north (Tape *et al.* 2006; Myers-Smith *et al*. 2011), changes that may displace tundra-breeding shorebirds into narrower coastal strips and alpine-breeding shorebirds into smaller and fewer fragments at higher elevations. Subsequent changes in the overall abundance and types of wetlands will likely affect prey abundance and distribution for both boreal- and tundra-nesting species. The degree to which the timing of shorebird breeding remains coupled to the life cycles of their prey is of key importance, since shorebird hatch appears synchronized with the availability of surface-active insects upon which the chicks depend (Holmes 1970, 1972). Recent studies suggest that timing of arthropod emergence has advanced with warming temperatures in recent years (Tulp and Schekkerman 2008), and whether shorebirds can likewise adjust their annual cycle to synchronize with arthropod abundance is unclear (Meltofte *et al.* 2007; Liebezeit *et al.* 2014). Changes in the distribution and abundance of predators and parasites may also occur in response to changing habitat and climatic conditions. Finally, changes in broad-scale climatological patterns could affect shorebirds that rely on predictable wind patterns for their annual migrations (Handel and Gill 2010; Gill *et al.* 2014). Long-distance migratory birds, like many of the shorebird species that breed in Alaska, are predicted to be disproportionately affected by many of these climate-mediated factors (Zurell *et al*. 2018). Outside of Alaska, most climate-related threats to shorebirds relate to adverse effects due to sea-level rise. Certain Alaska-breeding shorebirds, like Bristle-thighed Curlews and Ruddy Turnstones, winter on low-lying atolls and islands in the Pacific Ocean that are affected by even small rises in sea level. For many other species, the construction of immobile sea walls, dikes, and levees at coastal sites around the world (Gittman *et al.* 2014; Ma *et al.* 2014) will displace coastal habitats as sea levels rise without allowing such habitats to advance inland. In contrast, some climate-mediated impacts may be beneficial to certain species—for instance, increased temperatures may offer thermogenic relief to shorebird chicks (McKinnon *et al*. 2013), and longer, more benign breeding seasons (Post *et al*. 2009) may increase reproductive success—but by and large, most climate-mediated impacts on shorebirds are predicted to be negative (Galbraith *et al.* 2014; Saalfeld *et al.*, in review). Given the extent of such impacts, threats to Alaska's shorebirds posed by global climate change will likely be profound.

Energy Production and Mining

Oil and gas development continues to be the driving force behind Alaska's economy, with over 90% of the state's unrestricted revenue derived from this industry (Alaska Oil and Gas Association 2016). Mining is also important in Alaska, with several new large-scale developments under permit review. Renewable energies, especially small wind farms in remote communities, are also increasing due to the high cost of energy production in rural locations across Alaska. In addition, coastal sites used by shorebirds both within (e.g., Fire Island in upper Cook Inlet) and outside Alaska (e.g., Yellow Sea [Melville *et al.* 2016]) are also attractive locations for large wind farms. Such installations pose threats to shorebirds due to the potential for strike-related mortalities. These activities also have effects on habitats and wildlife specifically associated with the exploration, development, and production of these industries. The greatest potential impacts on shorebirds from these industries likely pertain to effluence and pollution (see *Pollution* below), but activities also can lead to substantial disturbance (direct and indirect) and habitat loss in coastal areas where these industries co-occur.

Pollution

This category includes the introduction of exotic, harmful materials into the air, land, or water, and includes chemical (e.g., oil, mercury), solid (e.g., garbage), and residual (e.g., beach-cast flotsam, plastic) wastes. Shorebirds as a group are particularly susceptible to the effects of chemical pollution because they predictably gather in large groups at coastal staging sites in the spring and fall where large numbers may be exposed simultaneously.

Tundra near Nome
Samantha Franks

Juvenile Hudsonian Godwit
Lucas DeCicco

As the adverse effects from previous spills demonstrates (e.g., Peterson *et al.* 2003; Henkel *et al.* 2012), this category poses a serious threat to shorebirds and the ecosystems that support them.

Residential and Commercial Development
Loss or damage of habitats due to urban or commercial development is generally minimal in Alaska. The future impacts of habitat degradation, however, particularly in wetlands and river deltas, will increase along with Alaska's human population. Alaska's population more than tripled over the period 1960–2015, and this rapid population growth has resulted in increased conversion of native habitats. Although it is tempting to discount these impacts due to the sheer extent of unaltered habitats throughout the state, Alaska is not without limit. The state's pristine landscapes will grow in importance to shorebirds as habitats outside Alaska undergo further development and degradation. Furthermore, many large human population centers occur at coastal sites outside of Alaska (e.g., the Yellow Sea, San Francisco Bay, Panama Bay) that are important to Alaska-breeding shorebirds.

Agriculture and Aquaculture
Farming, including aquaculture, mariculture, and silviculture, currently poses minimal threats to shorebirds within Alaska. However, aquaculture has greatly increased at coastal sites outside of Alaska, leading to the loss of native habitats such as mudflats (e.g., the Yellow Sea) and mangroves (e.g., Mexico, Panama) as coastal sites are reclaimed for these activities. Surprisingly, reclamation of salt farms installed during the last century in parts of the Pacific Coast is leading to a loss of habitats (e.g., hypersaline ponds), which may have negative impacts on shorebird populations. Increasingly, humans also harvest many of the invertebrate resources that shorebirds actually consume, either for direct human consumption or for use as feed in aquaculture and mariculture systems (Melville *et al*. 2016).

Transportation and Service Corridors
Installation of transportation and service corridors have led to the loss and degradation of habitats; direct mortality due to collisions with vehicles, power poles, and transmission lines; and changes in animal behaviors (e.g., avoidance) associated with these activities (Calvert *et al.* 2013; McClure *et al.* 2013). Alas-

ka's network of roads, railroads, shipping lanes, and utility lines is currently limited, but potential impacts will increase as the transportation network expands to support a growing human population. Particularly important are the projected increases in Arctic shipping traffic, which could affect critical staging areas along the coasts of the Beaufort and Chukchi Seas.

Biological Resource Use

The consumptive use of biological resources generally poses little current risk to shorebirds in Alaska. For instance, the effect of logging on Alaska's shorebirds is currently minimal because Alaska's vast boreal forests are largely intact, and the state's commercial timber harvest is restricted primarily to mountainous coastal zones supporting few shorebird species. Numerous shorebird species are also harvested for subsistence consumption in rural parts of Alaska. Two programs, the Alaska Migratory Bird Co-Management Council (AMBCC) and the Community Subsistence Information System (CSIS 2017) include shorebirds in their harvest assessments. The most recent estimate of the subsistence harvest by rural Alaskans indicates that shorebirds constitute <1% of the total harvest (L. Naves, unpubl. data). Notably, however, the average annual harvest of "godwits" is 1,115 birds/year, 98% of which occurs on the south coast of the Yukon-Kuskokwim Delta (L. Naves, unpubl. data). Because these birds are likely Bar-tailed Godwits (Gill and McCaffery 1999), a species which is currently experiencing population declines (Studd *et al*. 2017; Murray *et al*. 2018), shorebird harvest must be considered as part of any effective conservation action. Outside the state, the threats to Alaska's shorebirds from hunting are largely unknown, but may be significant. For example, both legal and illegal hunting are commonly practiced at many locations throughout the East Asia–Australasia (Melville *et al*. 2016) and western Atlantic flyways (Andres 2011; Watts *et al*. 2015), but information linking such actions to Alaska-breeding shorebirds is scant (but see Reed *et al*. 2018). In addition to direct harvest, the incidental take of shorebirds during other resource-use activities warrants investigation. For instance, fishing nets in the Yellow Sea accidentally snare shorebirds during low tides, and shellfish harvested for human consumption at these sites also depletes benthic resources for migratory shorebirds (MacKinnon *et al*. 2012). The effects of these actions have not been formally assessed.

Human Intrusions and Disturbance

Humans can affect shorebirds when working, camping, or sightseeing in terrestrial or marine environments. Habitats required by many shorebirds overlap with areas preferred for human recreation, with subsequent disturbance and degradation of these sites. Black Oystercatchers, for example, often nest and raise their chicks in coastal habitats that are frequently visited by people (Morse *et al.* 2006; Tessler *et al.* 2007). Such negative effects are likely to grow as tourism increases in Alaska. Indeed, tourism is one of Alaska's biggest industries, generating about $1.9 billion dollars in revenue from over 2.1 million visitors per year (State of Alaska 2016). As more visitors focus their trips in wilderness settings, additional pressure will be placed on shorebirds in sensitive natural habitats. Obviously, this threat also applies at sites outside Alaska. Increased human population growth will only increase the impact of intrusion and disturbance to shorebirds worldwide, a fact that underscores the need for reserves, refuges, and critical habitat designations where shorebirds can avoid such disturbance.

Invasive and Problematic Species, Pathogens, and Genes

Shorebirds may be negatively affected by the introduction, spread, or increase in abundance of invasive and problematic plants, animals, or pathogens and other microbes. These may be non-native species that negatively affect natural ecosystem equilibrium (e.g., rats [*Rattus* spp.] in the Aleutian Islands), or native ones that, due to anthropogenic disturbance, increase in population unnaturally and become "out of balance" in their natural setting (e.g., red fox [*Vulpes vulpes*], Common Raven [*Corvus corax*] on the Arctic Coastal Plain; Powell and Backensto 2009; Savory *et al*. 2014). Effects of these problematic species are usually restricted in geographic scope but may be profound in their impact. For instance, reproductive effort of Black Oystercatchers was extremely low on islands with introduced populations of arctic foxes, but breeding resumed following the removal of foxes (Byrd *et al.* 1997). Diseases related to shorebirds also pose concerns. Recent outbreaks of highly pathogenic H5N1-type avian influenza around the world raise the specter of outbreaks via migratory birds carrying the virus to Alaska. Because Alaska hosts numerous sites where shorebird species gather in huge numbers during migration, Alaska's shorebirds are potentially susceptible to both direct effects (e.g., mortality) and indirect effects (e.g., selective culling) of disease outbreaks.

Summary of Conservation Threats Across Alaska
We summarized the prevalence and severity of these conservation threats across the five BCRs (Table 3). The effects of climate change and severe weather and pollution were considered relevant across all five BCRs, while threats related to energy production and mining were also considered a wide-spread issue, occurring across four of the five BCRs (Table 3). Other threats were limited in geographic scope but were nonetheless considered to be of primary importance for particular BCRs (e.g., invasive and problematic species in BCRs 1 and 3, recreational activities in BCR 5; Table 3). This demonstrates that each BCR faces a unique suite of conservation issues, and that effective conservation actions for shorebirds in Alaska must consider the geographic scope and severity of relevant conservation threats.

Black Oystercatchers
Milo Burcham

Table 3. Identification and characterization of primary (P), secondary (S), and emerging (E) conservation issues affecting shorebirds among Alaska BCRs. The relative importance of threats was determined by BCR authors; the importance of a threat should be viewed relative to other threats within a BCR as opposed to across BCRs. See discussion of each threat within the appropriate BCR section in Part II of the plan.

Conservation issue/threat[1]	BCR 1	BCR 2	BCR 3	BCR 4	BCR 5
Climate change					
Ecosystem encroachment		P	P	S	S
Changes in geochemical regimes		E			E
Changes in temperature regimes		S	P	S	E
Changes in precipitation and hydrological regimes		S	P	S	
Severe/extreme weather events	E	P	S		
Energy production and mining					
Oil and gas drilling[2]			S	P	
Mining and quarrying		E	E	S	E
Pollution					
Industrial and military effluents[3]	S	S	P	S	P
Air-borne pollutants	S	E	S		
Residential and commercial development					
Housing and urban areas		E	E	E	
Commercial and industrial areas			E		
Agriculture and aquaculture					
Transportation and service corridors					
Roads and railroads				E	
Utility and service lines			E	S	
Biological resource use					
Hunting and collecting terrestrial animals		S			
Human intrusions and disturbance					
Recreational activities					S
Invasive and problematic species, pathogens, and genes					
Invasive non-native plants and animals	P				
Problematic native plants and animals			S		

[1]http://cmp-openstandards.org/tools/threats-and-actions-taxonomies/

[2]Includes point-source spills (e.g., at drill sites).

[3]Includes spills during transportation (e.g., pipelines, tankers).

Bar-tailed Godwit
Ted Swem

CONSERVATION STRATEGY FOR ALASKA

The following section outlines the five topics by which we orient our conservation plan. We also discuss the implementation, coordination, and evaluation of the plan to ensure its efficacy and relevance.

Research

Vast gaps exist in our knowledge of Alaska's shorebirds. The most crucial research need is to identify factors that are limiting shorebird populations to stop and reverse population declines. Potential limiting factors include climate change, unsustainable legal and illegal harvest of shorebirds, increasing predator populations, environmental contamination, increased human disturbance, and habitat loss and degradation.

The rapid rate of climate change will require additional research to assess how shorebirds are affected both directly and indirectly throughout their annual cycle (Galbraith *et al.* 2014). Climate models forecast large-scale changes in the distribution of species (Wauchope *et al.* 2017), but the ways in which species may adapt and compensate for projected changes are unknown. Longer and warmer summers are resulting in drier and shrubbier landscapes in the Arctic (Lin *et al.* 2012), and changes in Arctic phenology potentially threaten shorebirds by creating trophic mismatches with their prey (Senner *et al.* 2017; Saalfeld *et al.*, in review). Sea-level rise and coastal erosion are reducing the amount and quality of habitats available to shorebirds (Galbraith *et al.* 2002; Mars and Houseknecht 2007; Gibbs and Richmond 2015), and changes in the number or intensity of severe storms may disrupt short- and long-distance migration (Gill *et al.* 2009). Little is known about whether shorebirds can adapt to these changes, and there is a great need to understand the resilience of shorebirds to these rapid changes (Kwon *et al.* 2017; Saalfeld *et al.*, in review).

Legal and illegal harvest have also been identified as major factors potentially reducing population sizes of some shorebirds, especially within the Caribbean (Watts *et al.* 2015; Reed *et al.* 2018) and in parts of Asia (Turrin and Watts 2016). The estimated number of shorebirds annually harvested in Alaska averages <3,000 birds (L. Naves, unpubl. data), but the population-level effects of such harvest remain largely unknown. The increase in avian predator numbers, most likely due to banning of DDT and other pesticides (Ydenberg *et al.* 2017), is also affecting shorebirds by altering their migration tactics, distribution, and potentially their mortality rates (Lank *et al.* 2003; Ydenberg *et al.* 2017). And despite the banning of some chemicals, shorebirds likely remain vulnerable to persistent contaminants because they forage in wetlands where contaminants accumulate in sediments. Many shorebirds are also exposed to pollutants throughout their annual cycle over a large geographic range (Saalfeld *et al.* 2016). For example, there is evidence that shorebirds may be exposed to high levels of mercury at some Arctic sites (Perkins *et al.* 2016), and species such as phalaropes may be exposed to plastics during the nonbreeding season (Drever *et al.* 2018). Similarly, there is a need to evaluate how population increases of sympatric species such as Snow Geese (Flemming *et al.* 2016; Burgess *et al.* 2017; Hupp *et al.* 2017) or range expansions of red fox (Elmhagen *et al.* 2017) may influence ecosystem dynamics where shorebirds breed.

Red Knot
Lucas DeCicco

More research is needed to understand macro- and micro-scale habitat selection by shorebirds (see e.g., Saalfeld *et al.* 2013b; Cunningham *et al.* 2016), and whether shorebirds can adapt to rapid habitat changes. Little information is currently available for species occupying alpine, boreal, or other habitats that are difficult to access. Such information, when combined with habitat changes occurring due to climate change, is necessary to model habitat suitability and inform where future refugia might occur. Understanding the habitat needs and distribution of species will also help mitigate proposed oil and gas developments (e.g., 1002 area of the Arctic National Wildlife Refuge, National Petroleum Reserve–Alaska), roads (e.g., King Cove to Cold Bay, Ambler), mining (e.g., Pebble, Donlin), and other land-altering changes likely to occur in Alaska. Outside of Alaska, vast expanses of wetlands and estuaries important to shorebirds have been reclaimed and degraded (e.g., Murray *et al.* 2014). Perhaps most destructive has been the construction of sea walls in association with vast reclamation projects of Yellow Sea intertidal habitats (Ma *et al.* 2014). Such actions threaten many waterbirds (Conklin *et al.* 2014), including Dunlin and Bar-tailed Godwits that breed in Alaska. There is a need to better understand the cumulative effects of direct habitat loss or alteration in conjunction with the effects of direct and indirect disturbance, increased predator densities, exposure to contaminants, and mortality associated with birds striking buildings and power transmission lines.

To understand possible effects of these factors, research programs are needed that evaluate the relative importance of each of these factors in limiting shorebird populations within Alaska and throughout their annual cycle. Relevant factors, and their relative influence, are likely to differ among species, depending on where the species breeds, migrates, and winters. Focus should be on high-priority species that may already have small or declining populations, or occupy rare or vulnerable habitats. Identifying discrete populations is also important since they are the units upon which conservation actions must be based.

One of the most exciting avenues of current shorebird research is the variety of new ways to track their movements. Light weight geolocators, GPS, and satellite telemetry tags are now available for use on virtually every shorebird species. These new tools provide an opportunity for researchers to gather critical natural history information, including the timing and routes of migration, temporal and spatial use of stopover and staging sites, and habitat needs of each species in a way not possible before. Refinements in population genetics and stable isotope analyses are also elucidating links among breeding, staging, and nonbreeding areas for species that are difficult to track with

Whimbrel on nest
Kanuti National Wildlife Refuge
Christopher Harwood

Male Pectoral Sandpiper
Zak Pohlen

conventional markers or where tracking is not possible (e.g., origin of harvested birds). These studies establish the biological connections between Alaska and areas at risk elsewhere in the flyways, allowing targeted conservation at areas of greatest need. Other technological developments are also evolving that help define such links. DNA barcoding and genomic analyses are gaining use in diet studies, aerial drones are increasingly used to count birds and find nests, and audio and video recording equipment offer new surveying and monitoring opportunities. These technologies may facilitate research and potentially enable a better understanding of shorebird ecology.

Of equal importance to these technological tools are the personal connections among shorebird conservationists across the globe. United, comprehensive efforts are essential to conduct range-wide biological conservation and enable the effective protection of breeding, migration, and wintering sites. Understanding how shorebirds are distributed in space and time throughout their annual cycle, as well as what factors potentially limit shorebirds in these locations, is essential for protecting critical habitats and focusing conservation on issues that will do the most good.

Research Objectives

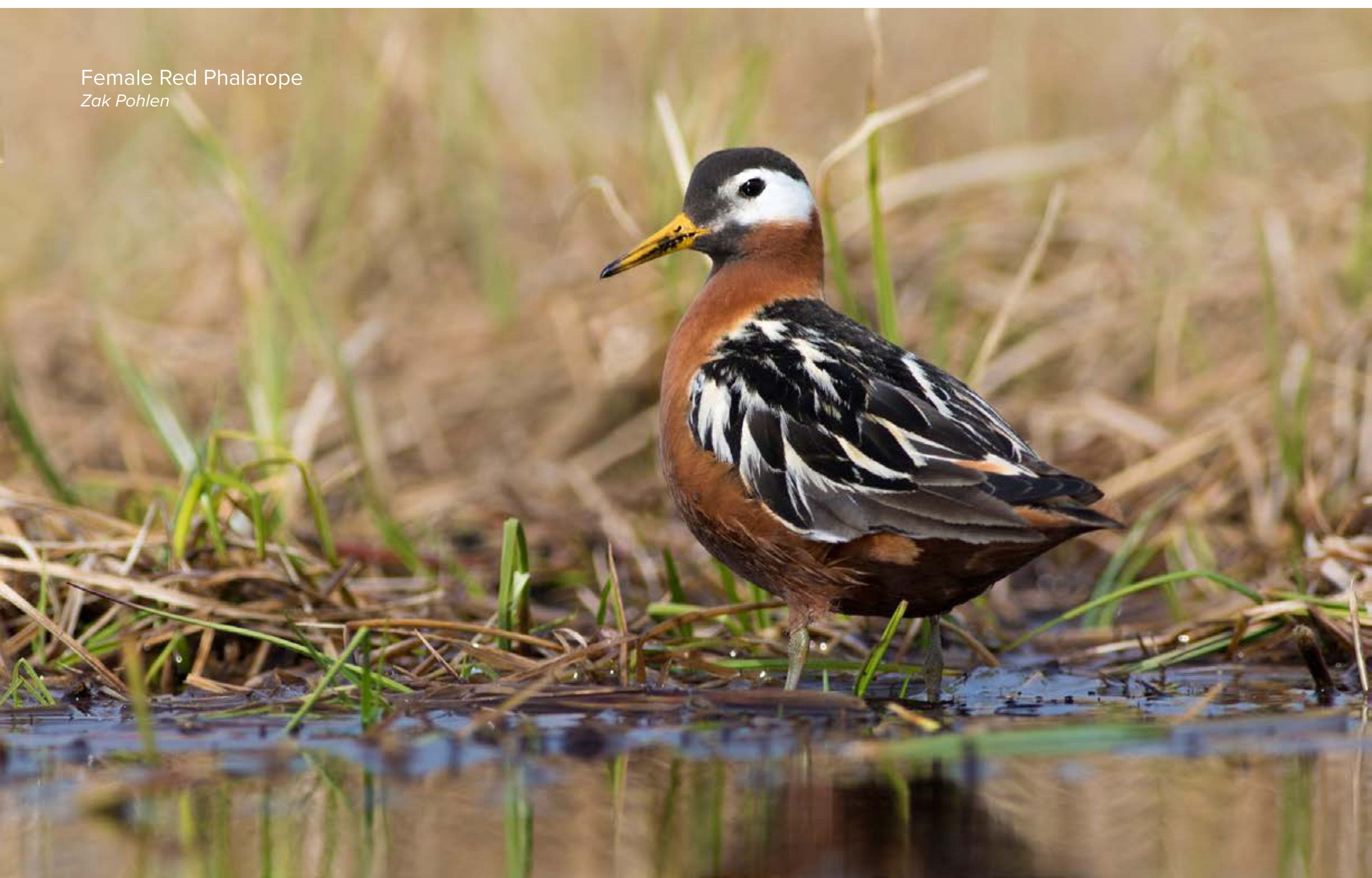
- Identify and determine the magnitude of factors limiting shorebird populations during breeding and nonbreeding periods of the annual cycle.
- Determine migratory timing, routes, and site use of shorebirds.
- Assess the effects of climate change on shorebird demography.
- Conduct breeding ecology studies on species occupying alpine, boreal, or other rare or difficult-to-access habitats.
- Obtain better estimates of illegal and legal harvest levels for Alaska-breeding shorebirds within Alaska and when outside Alaska.
- Identify effects associated with energy production, mining, disturbance, and other anthropogenic activities on shorebirds.
- Identify and delineate potentially distinct populations of shorebirds breeding in Alaska.
- Develop habitat-based models to predict the

abundance and distribution of shorebirds, and assess the adaptability of shorebirds to habitat changes.

Population Inventory and Monitoring

Recent evidence suggests many shorebird species throughout the world are declining (Stroud *et al.* 2006; Bart *et al.* 2007; Andres *et al.* 2012b; Clemens *et al*. 2016; Pearce-Higgins *et al.* 2017; Studds *et al*. 2017). One shorebird species that historically occurred in Alaska, the Eskimo Curlew, is now likely extinct, and 17 other species have populations that have been identified as priority species (Table 4). Twelve others are considered stewardship species in Alaska because ≥50% of their population occurs within the state (Table 4). But despite the heightened conservation status of many shorebird populations, accurate information regarding the distribution and abundance of shorebirds is often woefully lacking (but see Appendix 5). Shorebirds often occur cryptically or at low densities across their breeding ranges, making systematic breeding surveys costly to conduct and difficult to analyze. And although many shorebird species predictably concentrate at certain periods of their annual cycles, accurately determining population sizes from huge flocks spread across vast ranges presents great logistical and analytical challenges. Given Alaska's huge size and the cost and difficulty associated with accessing representative habitats, the aforementioned problems relating to determining shorebird population sizes are all magnified in Alaska.

Most contemporary efforts to monitor shorebirds in Alaska have focused on breeding birds, and two principal protocols have been implemented. The first protocol, called Arctic PRISM, is a component of the Program for Regional and International Shorebird Monitoring (PRISM; Skagen *et al*. 2004; Bart *et al*. 2005) developed for Arctic species and habitats. Arctic PRISM relies on a double-sampling approach developed and tested in low tundra habitats within the Arctic and subarctic regions of Alaska between 1994 and 2000 (Bart and Earnst 2002). This protocol involves habitat regression analysis techniques, and rapid and intensively surveyed plots that are used in combination to correct density estimates. This pro-



Female Red Phalarope
Zak Pohlen

Semipalmated Plover
Zak Pohlen

tocol has been used to estimate population sizes of shorebird species breeding in the Arctic National Wildlife Refuge (Brown *et al.* 2007), the Teshekpuk Lake Special Area (Andres *et al.* 2012b), the Arctic Coastal Plain (Bart *et al.* 2013), smaller areas in western Alaska (McCaffery *et al.* 2012), and the Yukon Delta National Wildlife Refuge (R. Lanctot, unpubl. data). Species presence information has also been used to describe the distribution of shorebirds across the Arctic Coastal Plain (Johnson *et al.* 2007; Saalfeld *et al.* 2013b) and the Yukon-Kuskokwim Delta (R. Lanctot, unpubl. data). Although portions of Arctic Alaska have not been surveyed, efforts are needed to repeat these surveys so trends of shorebird populations can be estimated for the first time. A second protocol that relies on variable circular plots and distance estimation to survey shorebirds has been used in montane tundra regions within Alaska since 1987 (C. Handel and R. Gill, pers. comm.). This protocol was first tested on Bristle-thighed Curlews on the Seward Peninsula and in the Nulato Hills region within the Yukon-Kuskokwim Delta, and has provided useful information on shorebird distribution and abundance in various park regions within Alaska (Tibbitts *et al.* 2006; Ruthrauff *et al.* 2007; Ruthrauff and Tibbitts 2009). Another standard approach involves measuring the distance of birds from transect lines to estimate avian densities, an approach used on the Pribilof and St. Matthew Islands (Ruthrauff *et al.* 2012) and the central Alaska Peninsula (D. Ruthrauff, pers. comm.). A program for surveying shorebirds in boreal forests is being developed, with initial work focused on the efficacy of incorporating shorebird surveys within existing landbird monitoring programs. The abundance and distribution of shorebirds in Alaska's boreal region constitutes a major knowledge gap.

Under the broader umbrella of PRISM, the Alaska Shorebird Group recommends implementing rigorously designed protocols for monitoring the status and trends of shorebird populations in Alaska. Where and when such efforts are implemented varies by species due to differences in life-history traits, habitat use, and factors that influence detection rates and the accuracy and precision of counts. For species with dispersed breeding populations that are logistically or financially unrealistic to survey, consideration should be given towards monitoring programs that occur outside of Alaska during the nonbreeding season. Monitoring efforts on the breeding grounds should focus on priority species with small or declining populations, or in regions or habitats where accurate and precise trend information may be more readily derived.

Population Inventory and Monitoring Objectives

- Inventory alpine, boreal, and other poorly studied shorebird species.
- Conduct long-term population monitoring efforts (e.g., PRISM).
- Evaluate the efficacy of existing programs (e.g., the Alaska Landbird Monitoring Survey [ALMS], Breeding Bird Survey [BBS] program) to monitor shorebird populations.
- Assess the utility of new technologies (e.g., Automated Recording Units, aerial drones, eBird) to determine shorebird presence and abundance.

Habitat Management and Protection

The actions most likely to buffer shorebirds against conservation threats are to protect, restore, and maintain as much shorebird habitat as possible. As both the human population and global demand for resources (e.g., minerals, oil) and habitable land increase, so too does the need to identify and protect key sites and habitats for shorebirds. In addition, climate-driven habitat change is altering terrestrial, estuarine, and aquatic habitats important to shorebirds in Alaska. The effects of these changes, as well as those associated with habitat-specific food webs, are poorly understood. Thus, the development of bird-habitat models that predict bird abundance and distribution is necessary. Such predictive information will assist managers in protecting critical areas and assessing the effects of proposed developments throughout Alaska. The effect of habitat loss or change on shorebirds has been limited primarily to the assessment of oil and gas exploration and other development projects, local land-use decisions, and spills within the Arctic Coastal Plain (Troy 1988; TERA 1993). Many of these studies have been short in duration, focused on specific sites, and have rarely followed individual birds over several years to determine the potential long-term effects of disturbance on survival and productivity. We encourage long-term studies over appropriate spatial scales to better understand potential effects of these large-scale processes.

Habitat Management and Protection Objectives

- Apply abundance and distribution information to identify key shorebird habitats and sites.
- Support land acquisitions, easements, restoration efforts, and conservation designations (e.g., the Western Hemisphere Shorebird Reserve Network, East Asian–Australasian Shorebird Reserve Network, Ramsar Convention on Wetlands, and Important Bird Areas Programs) for key shorebird sites.
- Minimize loss and degradation of critical shorebird habitats by participating in natural resource planning and management.
- Model the potential effects of climate change on shorebird habitats and identify future potential regions of habitat refugia.

Environmental Education and Public Outreach

The Alaska Shorebird Group seeks to inform elected officials, government agencies, industries, non-government organizations, and private citizens about shorebirds and the importance of their breeding, nonbreeding, and migratory habitats. We seek to increase opportunities to view, enjoy, and learn about shorebirds that occur in Alaska, support opportunities for the active engagement of diverse audiences in shorebird conservation programs, and increase international and national collaboration among shorebird conservation efforts. Creating awareness about the complex and remarkable natural history of shorebirds may be one of the greatest contributions the Alaska Shorebird Group can make towards the conservation of shorebirds. Strategic implementation of education and outreach programs is critical to facilitate acceptance of conservation recommendations by key stakeholders. Various tools are available to increase awareness about shorebird-related issues, including the International Migratory Bird Day (http://www.birdday.org/), Shorebird Sister Schools (https://www.fws.gov/sssp/), festivals at important shorebird sites (http://shorebirdsfestivals.com/, http://kachemashorebird.org/), and site-specific public presentations. Such programs encourage public participation in the conservation of shorebirds and their habitats by connecting people to their local birds and to other people and cultures throughout Alaska's flyways.

Environmental Education and Public Outreach Objectives

- Raise the profile of shorebirds through public presentations, media outreach, support of shorebird festivals, and collaboration with education programs.
- Develop shorebird-related outreach and media materials.
- Host workshops and outreach events to engage the diverse communities of Alaska in shorebird conservation.
- Encourage the synthesis and reporting of results of Alaskan shorebird studies to scientific and general audiences.
- Promote shorebird education to youth via the Shorebird Sister Schools Program.
- Identify and support ways to involve citizen scientists in shorebird monitoring programs.
- Incorporate principles of good governance in research and outreach efforts.

International Collaborations

Migratory shorebirds actually spend relatively little time in Alaska; most species spend more than nine months of their annual cycle outside Alaska. Shorebirds highlight connections between the hemispheres as they undergo their annual migrations from breeding to nonbreeding grounds along international flyways. Shorebirds breeding in Alaska migrate over a vast region of the globe, including at least 40 different countries (Appendix 2). Nearly all of Alaska's shorebird species migrate beyond the United States during the nonbreeding season, with only a few species remaining in Alaska during the winter months. Of the 45 breeding species that migrate internationally, about 70% use the North American flyways *en route* to Mexico, the Caribbean, and South America, while 30% use either the Central Pacific or East Asia–Australasia flyways to reach East Asia, Australasia, and Oceania (Gill *et al.* 1994; Page and Gill 1994).

Because shorebirds experience different population threats depending on where they breed, stage, and winter, migratory bird conservation can only be achieved by integrating management, research, and conservation efforts throughout a species' annual cycle. To do this, Alaskans must join national and international colleagues to facilitate the protection and conservation of these incredible migrants. Alaska provides crucial breeding habitat for millions of migratory shorebirds at the terminus of their north-south migrations, and efforts within Alaska can guide range-wide conservation and research programs. Efforts to promote shorebird conservation actions outside of Alaska will be challenging, but this should not preclude the Alaska Shorebird Group from working beyond our borders when opportunities occur.

International Collaboration Objectives

- Foster and participate in cooperative research and monitoring efforts throughout species' ranges (e.g., Arctic Shorebird Demographics Network, PRISM, Migratory Shorebird Project, and Arctic Birds Breeding Conditions Survey).
- Participate in partnerships to conserve migratory shorebirds and their habitats in the circumpolar Arctic (e.g., the Arctic Council's Conservation of Arctic Flora and Fauna working group and initiatives therein), North America (e.g., landscape conservation cooperatives, joint ventures, flyway councils), Western Hemisphere (e.g., Western Hemisphere Shorebird Reserve Network, Western Hemisphere Shorebird Group), Asia (e.g., East Asian-Australasian Flyway Partnership), and other partnerships as they arise.
- Coordinate and participate in international, national, and other regional shorebird conservation planning efforts (e.g., Pacific Americas Shorebird Conservation Strategy, Atlantic Flyway Shorebird Initiative; see other groups listed in Appendix 4).

Implementation, Coordination, and Evaluation of the Plan

For the Alaska Shorebird Conservation Plan to be effective, the plan must be implemented collectively and collaboratively by interested parties working in all parts of Alaska. The Alaska Shorebird Group will be responsible for evaluating whether the goals, objectives, and actions outlined in this plan are being addressed, a process that will occur during preparation of the group's annual project summaries and at the annual meetings (https://www.fws.gov/alaska/mbsp/mbm/shorebirds/working_group.htm). At the national level, representatives of the Alaska Shorebird Group will contribute information as requested to the U.S.

Shorebird Council and participate in relevant regional or national conferences/meetings. The Alaska Shorebird Group will also assume primary responsibility for updating the objectives and actions detailed in Part I and Part II of the conservation plan, and will modify species population estimates, trends, conservation priority scores, percent occurrences within Alaska, and threats (Tables 1, 3, and 4) as new information becomes available. All sections of the plan are intended to be "living" online documents that will be updated as necessary by members of the Alaska Shorebird Group (see https://www.fws.gov/alaska/mbsp/mbm/shorebirds/plans.htm for updates). For more information, contact Rick Lanctot, Alaska Shorebird Coordinator, Migratory Bird Management, U.S. Fish and Wildlife Service, Richard_Lanctot@fws.gov, (907) 786-3609.

SHOREBIRD SPECIES CONSERVATION PRIORITIES IN ALASKA

Prioritization Process

The magnitude of shorebird population declines around the world has led to the development of a prioritization process to ensure that species at higher risk are given the attention needed to avoid further declines. The most recent prioritization list was published by the U.S. Shorebird Conservation Plan Partnership in 2016 (USSCPP 2016) with input from international shorebird experts. The recent effort built upon previous assessment efforts by the U.S. Shorebird Conservation Plan Partnership (2004), the U.S. Fish and Wildlife Service's Birds of Conservation Concern (2008), the North American Bird Conservation Initiative's Watch List (latest version NABCI 2016), and Audubon Alaska's WatchList (latest version Warnock 2017). The goal of the process was to provide a clearly organized method for categorizing the various risks that affect the conservation status of each species in a format that can be easily updated as additional information becomes available. The system has been modified in collaboration with Partners in Flight (PIF) to ensure that it is as compatible as possible with the PIF plan while still reflecting the unique biology of shorebirds.

A subset of variables used in the national and regional prioritization processes—population size and trend—are presented in Table 1. The remaining variable scores (breeding and nonbreeding threats, breeding and nonbreeding distribution, and climate change

Sanderlings
Lucas DeCicco

Outreach and education on Lesser Yellowlegs research project, Anchorage
Dena Strait

vulnerability) used for the prioritization process can be requested by contacting Brad Andres (U.S. Fish and Wildlife Service, National Shorebird Coordinator, brad_andres@fws.gov, (303) 275-2324). Several of these variables, while widely agreed to affect conservation status, are very difficult to estimate. For example, population sizes of highly dispersed nesting species (e.g., Solitary Sandpiper, Upland Sandpiper, and Wandering Tattler) are difficult to determine because of their low densities, their broad distribution, and the lack of species-specific surveys. Because appropriate data are often lacking, the priority scores should be considered estimates of the actual conservation status of each species. Further study is needed for many species with respect to these variables.

The current list of priority species in Alaska (Table 4) has undergone substantial revision since the second version of the Alaska Shorebird Conservation Plan in 2008 (Alaska Shorebird Group 2008). We evaluated conservation priorities at the subspecies or population level based on the approach used by the U.S. Shorebird Conservation Plan Partnership (USSCPP 2016). We relied on the most recent information and our scores generally reflect those presented in USSCPP (2016), with the exception of recent information on population sizes and trends of certain species (see Table 1).

In this framework, Alaska currently supports 17 shorebird populations categorized as either Greatest or High Concern (Table 4), and another 24 populations of Moderate or Least Concern. Shorebird populations designated as Greatest and High conservation concern are considered the highest priority for conservation efforts. In addition to these prioritized species, we created an Alaska-specific conservation category, called the Alaska Stewardship species (Table 4). The 12 species on this list include shorebirds for which ≥50% of the population occurs in the state during some phase of the annual cycle. This category was created to address Alaska's regional importance for these shorebird taxa, and to promote research, monitoring, and conservation efforts related to these species. All of Alaska's shorebirds of conservation concern exhibit unique life histories that necessitate a thoughtful consideration of species-specific conservation actions. With this in mind, species accounts providing details on the conservation status of each of these 29 populations are found in Appendix 8.

Table 4. Conservation status of shorebird species of conservation concern that regularly occur in Alaska

Species[1]	Conservation Status[2]
Bristle-thighed Curlew	Greatest
Bar-tailed Godwit (*baueri*)	Greatest
Red Knot (*roselaari*)	Greatest
Black Oystercatcher	High
American Golden-Plover	High
Pacific Golden-Plover (North America breeding)	High
Whimbrel (*hudsonicus*, AK/SW Yukon Territory breeding)	High
Hudsonian Godwit (AK breeding)	High
Marbled Godwit (*beringiae*)	High
Black Turnstone	High
Dunlin (*arcticola*)	High
Rock Sandpiper (*ptilocnemis*)	High
Buff-breasted Sandpiper	High
Pectoral Sandpiper	High
Semipalmated Sandpiper (AK breeding)	High
Short-billed Dowitcher (*caurinus*)	High
Lesser Yellowlegs	High
Black-bellied Plover (North America breeding)	Stewardship
Ruddy Turnstone (*interpres*, AK breeding)	Stewardship
Surfbird	Stewardship
Sharp-tailed Sandpiper (Global juvenile cohort)	Stewardship
Dunlin (*pacifica*)	Stewardship
Rock Sandpiper (*couesi*)	Stewardship
Rock Sandpiper (*tschuktschorum*)	Stewardship
Western Sandpiper	Stewardship
Long-billed Dowitcher	Stewardship
Solitary Sandpiper (*cinnamomea*)	Stewardship
Wandering Tattler	Stewardship
Red-necked Phalarope (North America breeding)	Stewardship

[1]Refers to the global population unless noted otherwise for subspecies or population segments. Taxonomy follows AOU 7th edition (1998) and supplements through Chesser *et al*. (2017). See population definitions in Table 1.

[2]Categories of conservation concern (USSCPP 2016) include: Greatest Concern = a shorebird taxon that meets the Watch List 2016 criteria for the Red List, High Concern = a shorebird taxon that meets the Watch List 2016 criteria for the Yellow List, AK Stewardship = Alaska Shorebird Group's stewardship species that have ≥50% of their population occurring in Alaska and are rated as Moderate or Least Conservation Concern. Species ranked as Moderate or Least Conservation Concern with <50% occurrence do not appear in the table.

Lesser Yellowlegs
Zak Pohlen

Part II: Alaska's Bird Conservation Regions

THE ALASKA ENVIRONMENT

Alaska encompasses more than 1.5 million km^2, representing an area one-fifth the size of the contiguous United States. The region spans more than 20 degrees of latitude and 58 degrees of longitude, and is bordered by almost 55,000 km of shoreline. The Yukon River, the third longest river in the United States, flows through 3,000 km of Alaska and drains a watershed encompassing over half of the state. Broad, shallow rivers and associated valleys are dominant features of Alaska's interior landscape, but equally prominent are numerous mountain ranges that crisscross the state. For example, 9 of the 16 tallest peaks in North America occur within the Wrangell–St. Elias Mountains bordering the northern Gulf of Alaska. The continent's highest peak at 6,252 meters, Denali (formerly Mount McKinley), is part of the Alaska Range that arcs across Southcentral Alaska to the base of the Alaska Peninsula. The periphery of the mostly mountainous interior of the state is a mixture of expansive coastal wetlands and riverine deltas, the extent of which exceeds that of all such habitat in the contiguous United States Permafrost occurs throughout most of the state and is continuous north of the Arctic Circle. Finally, Alaska has over 40 active volcanoes, mostly along the Alaska Peninsula and Aleutian Islands, and more than 100,000 glaciers, which cover 5% of its land area.

Alaska's climate varies markedly by region. The maritime influence of the Gulf of Alaska brings warm winters, cool summers, heavy precipitation, and persistent wind to most of southeastern Alaska. In contrast, Interior Alaska has warm summers, very cold winters, little wind, and light precipitation. Cool summers, cold winters, moderate winds, and light precipitation are typical of western and northwestern Alaska. Periods of over two months of continuous darkness in winter and continuous sunlight in summer characterize northern Alaska.

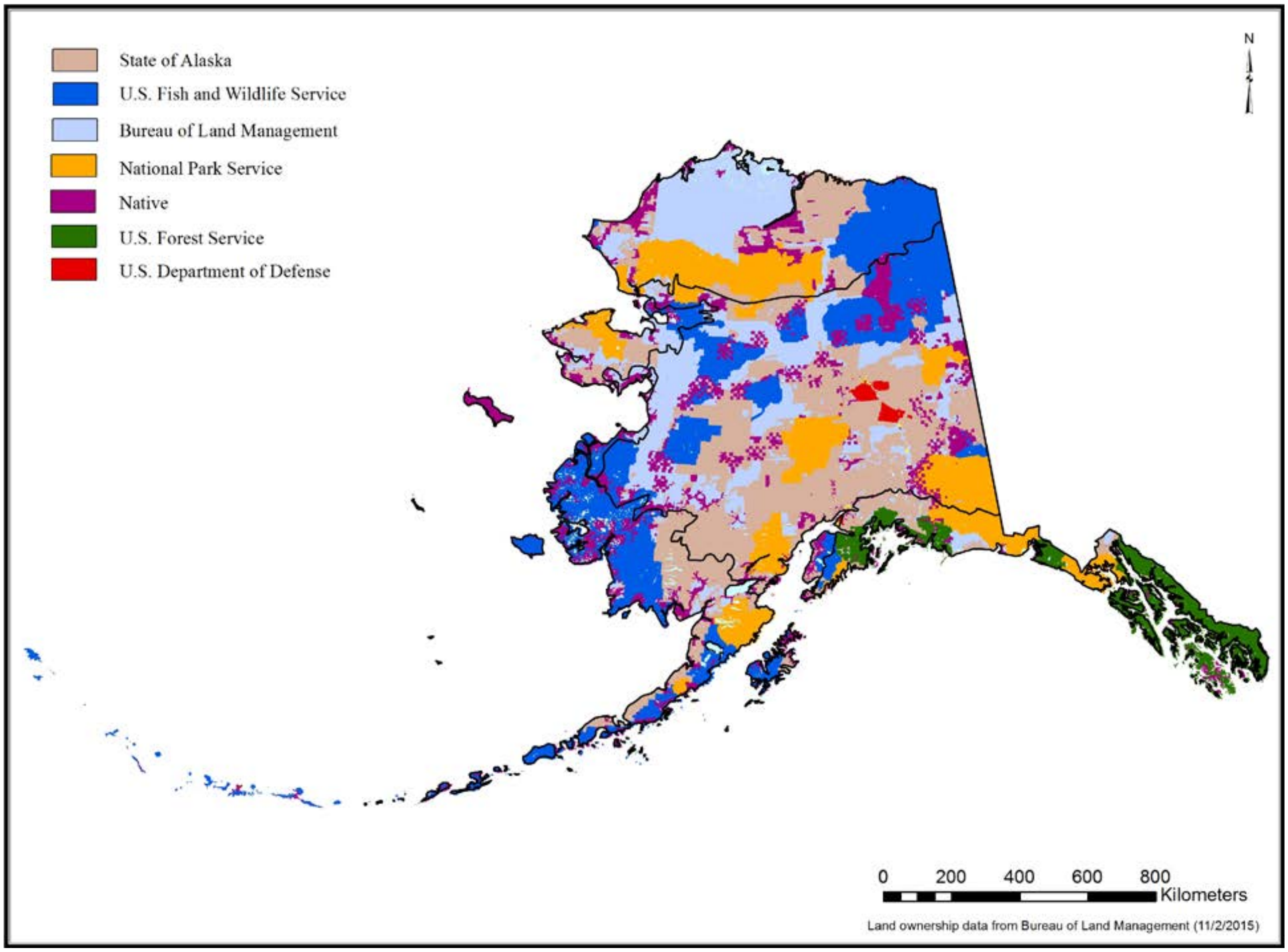


Figure 2. Distribution of land governed by the major state, federal, and Alaska Native organizations within Bird Conservation Regions of Alaska. See land area totals in Table 5.

Table 5. Area of land managed within each Bird Conservation Region by seven primary groups or agencies (see Figures 2 and 3.). Percentages refer to precent of total across these seven groups within a BCR, and a blank cell indicates that the group does not manage land in that particular BCR.

Landowner	BCR1		BCR2		BCR3		BCR4		BCR5		All BCRs	
	km²	%	km²	%	km²	%	km²	%	km²	%	km²	%
State of Alaska	72	1	66,740	24	59,293	20	258,766	36	21,683	16	406,555	28
U.S. Fish and Wildlife Service	5,574	48	100,537	37	54,450	18	129,329	18	3,352	2	293,243	20
Bureau of Land Management	<1	<1	23,491	9	97,886	32	151,498	21	6,586	5	279,461	19
National Park Service	-	-	25,985	9	62,346	21	85,381	12	30,360	22	204,073	14
Alaska Native	5,875	51	44,628	16	24,856	8	87,646	12	5,571	4	168,575	12
U.S. Forest Service	-	-	3	<1	-	-	105	<1	67,102	49	67,209	5
U.S. Department of Defense	65	1	99	<1	29	<1	7,644	1	127	<1	7,964	1

The diversity of physiographic features has shaped an equally diverse assemblage of landcover types (Bailey *et al.* 1994) but, as is typical of northern ecoregions, biotic communities are generally of low species richness. For example, only 128 species of trees and shrubs are known from Alaska (Viereck and Little 1972). Vegetation across Alaska ranges from that found in temperate rainforests of Southeast to that of high Arctic tundra in the north.

Two-thirds of Alaska is publicly owned (Duffy *et al.* 1999; Table 5, Figure 2). Of the nation's conservation lands, the two largest national forests, nine of the ten largest national parks and preserves, and 83% of all national wildlife refuge lands occur in Alaska. In northern Alaska the Bureau of Land Management administers the 96,000 km^2 National Petroleum Reserve–Alaska. In Southeast Alaska, Glacier Bay and Wrangell–St. Elias National Parks in the United States, and adjacent Kluane National Park and Tatshenshini-Alsek Wilderness Provincial Park in Canada, form the largest contiguous protected wilderness on the globe.

The human population of Alaska has more than doubled from 302,583 people in 1970 to 737,080 people in 2017, yet the state remains one of the least populated areas of North America with an average density of slightly more than one person per square mile. Nonetheless, a few major population centers exist, including Anchorage, where 40% of all Alaskans resided as of 2017. Outlying areas near Anchorage, including the Matanuska-Susitna Borough, support another 14% of the state's population. Indigenous people constitute about 15% of the state's population (Alaska Department of Labor and Workforce Development, Research and Analysis Section 2018).

Oil and gas development is the major revenue-producing industry in Alaska and is concentrated in Cook Inlet and on the Arctic Coastal Plain. In 2014, the State of Alaska received $2.5 billion in royalties from oil extracted from its lands. Alaska is one of the nation's leading oil producers, accounting for approximately 7% of United States domestic production. While these numbers have declined in recent years, the oil and gas industry remains prominent in Alaska: four

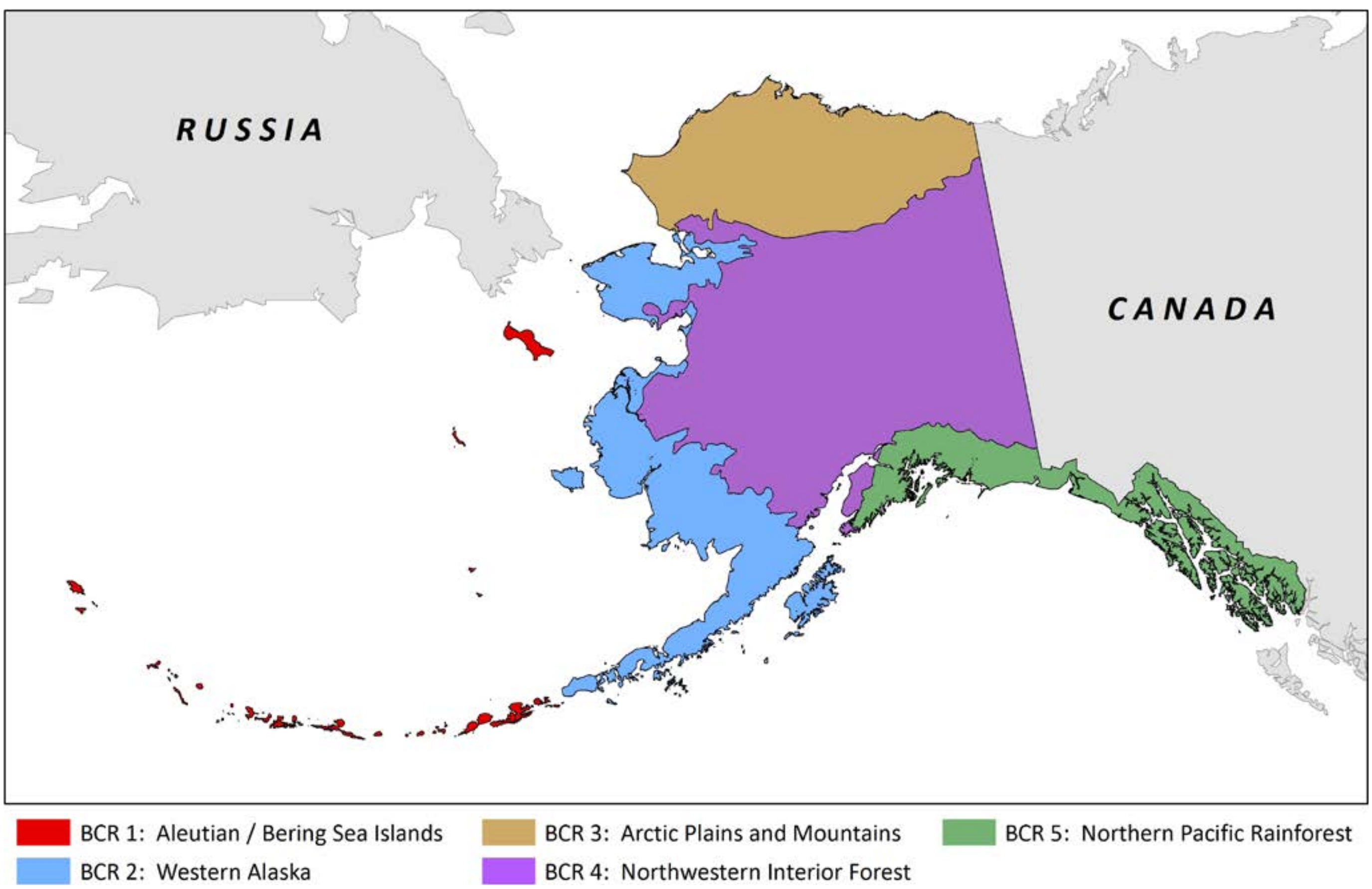


Figure 3. Bird Conservation Regions in Alaska.

of the ten largest oilfields in North America are located entirely within Bird Conservation Region 3 (see below) on Alaska's North Slope, including Prudhoe Bay, the continent's largest. Development is expanding within the National Petroleum Reserve–Alaska, and lease sales are planned for the 1002 area of the Arctic National Wildlife Refuge. Shorebirds are especially vulnerable to oil spills, and as such oil development and its supporting infrastructure are potential threats to the conservation of shorebirds in Alaska.

Alaska's current growth industry is tourism; 2.1 million people visited Alaska in the summer of 2015, and visitors spent an estimated $1.9 billion in the state (State of Alaska 2016). More than 78% of this tourism is based in Southcentral and Southeast Alaska. With increases in tourism in Alaska, recreational disturbance in coastal habitats is becoming a major concern for shorebird conservation. Ecotourism in general, and bird-watching tours in particular, are also increasing in popularity throughout Alaska. Shorebird festivals have become important to the regional economies of Cordova, Homer, and Wrangell.

ALASKA'S BIRD CONSERVATION REGIONS

State, provincial, federal, and nongovernmental organizations from Canada, Mexico, and the United States met in Puebla, Mexico, in November 1998 to adopt an ecological framework that would facilitate coordinated conservation planning, implementation, and evaluation of major bird conservation initiatives. The scheme adopted by the group was based on the Commission for Environmental Cooperation's hierarchical framework of nested ecological units. From this exercise, five Bird Conservation Regions (BCRs, Figure 3) were designated within Alaska (https://www.birdscanada.org/research/gislab/index.jsp?targetpg=bcr&targetpg=bcr). These roughly follow the biogeographic regions previously defined for the state by Kessel and Gibson (1978). Shorebird occurrence varies spatially and temporally across each BCR (Table 2).

Part II of the Alaska Shorebird Conservation Plan contains a more focused shorebird conservation plan for each of the five BCRs. Each BCR plan includes a description of the primary ecoregions within the area (see Appendix 6 for the "Ecoregions of Alaska" map; descriptions of ecoregions are provided in Gallant *et al.* [1995] and Nowacki *et al.* [2001]); a list of the priority shorebird species that breed, migrate, or winter within the area; a description of the important shorebird conservation areas; and a list of the important conservation issues and action items. Finally, the BCR plans end with a section that evaluates the progress of conservation in each BCR since the last revision of the plan.

Alpine Tundra Near Nome
Samantha Franks

BCR 1: ALEUTIAN/BERING SEA ISLANDS

Figure 4. Aleutian/Bering Sea Islands Bird Conservation Region 1. Lands included in BCR 1 are in red on the inset and outlined in black on the map.

Rock Sandpiper chick
St. Matthew Island
Rachel Richardson

Priority Species

Table 6. Priority shorebird species that commonly breed, stage during migration, or winter in the Aleutian/Bering Sea Islands Bird Conservation Region 1.

Breeding	Migration	Winter
Black Oystercatcher	Black-bellied Plover	Black Oystercatcher
Dunlin (unknown if *arcticola* or *pacifica* subspecies)	Pacific Golden-Plover	Rock Sandpiper (*couesi*)
Rock Sandpiper (*ptilocnemis*)	Ruddy Turnstone	
Rock Sandpiper (*couesi*)	Sharp-tailed Sandpiper	
Western Sandpiper	Rock Sandpiper (*ptilocnemis*)	
Long-billed Dowitcher	Western Sandpiper	
Wandering Tattler	Wandering Tattler	

See Tables 1, 2, and 4 for conservation priority status and relative seasonal importance.

The relatively small (18,000 km^2) BCR 1 is one of the most seismically and volcanically active regions in the world. This BCR includes two ecoregions, the Aleutian Islands and the Bering Sea Islands (Nowacki *et al.* 2001, Appendix 6). The Aleutian Islands consist of hundreds of volcanic summits of a submarine ridge created by the subduction of the Pacific plate by the North American plate. These islands extend westward from the Alaskan mainland for 1,770 km, terminating at the Kamchatka Peninsula in Russia (Figure 4). The Bering Sea Islands (i.e., Pribilofs, St. Matthew, Hall, St. Lawrence, and Little Diomede) are also volcanic mounts, and are situated in the relatively shallow Bering Sea. Nearly all (97%) of this region is included within the Alaska Maritime National Wildlife Refuge (AMNWR; Table 5).

This region experiences a maritime climate; rain, fog, and persistent winds are the defining climatic features. Permafrost and winter sea ice are both important physical processes of the Bering Sea Islands, but these conditions are not prevalent in the Aleutian Islands. Elevations range from sea level to over 1,900 m, with the higher volcanoes glaciated. Most of the region is treeless, and vegetation at higher elevations consists of dwarf shrub communities, mainly willow (*Salix* spp.) and crowberry (*Empetrum nigrum*). Meadows and marshes of herbs, sedges, and grasses are plentiful and ericaceous bogs occur on several islands.

The breeding diversity and absolute number of individual shorebirds is relatively low in this region. Black Oystercatchers are the most notable breeding shore-

Bull Seal Point, St. Matthew Island
Rachel Richardson

bird in the Aleutian Islands, while Ruddy Turnstones, Rock Sandpipers, Dunlin (subspecies unknown), Western Sandpipers, Long-billed Dowitchers, and Red Phalaropes breed on St. Lawrence Island (Fay and Cade 1959). Semipalmated Plovers, Least Sandpipers, and Red-necked Phalaropes also breed in this region in small numbers. Numerous Old World species are regular migrants or visitants, and some of these also regularly breed in the region in small numbers (e.g., Common Ringed Plover, Wood Sandpiper; Gibson and Byrd 2007). Notably, three races of Rock Sandpiper (*ptilocnemis, couesi, tschuktschorum*) occur in BCR 1.

Important Shorebird Areas

Unlike the other BCRs in Alaska, BCR 1 contains no large embayments or river deltas. Consequently, the region does not support large numbers of shorebirds during migration. The region does, however, provide important breeding and nonbreeding habitat for shorebirds. The Bering Sea Islands are home to the *ptilocnemis* race of Rock Sandpiper, an endemic race which breeds only on the Pribilof, St. Matthew, and Hall Islands. A large proportion of the *couesi* race of Rock Sandpiper breeds and winters in the Aleutian Islands (Gill *et al.* 2002a). Similarly, the Aleutian Islands support many hundred breeding pairs of Black Oystercatchers (Gibson and Byrd 2007; Tessler *et al.* 2014), constituting approximately 10% of the breeding population (Tessler *et al.* 2007).

Primary Conservation Objectives

The distribution and seasonal occurrence of shorebirds in parts of the region are relatively well documented (e.g., Friedmann 1932; Fay and Cade 1959; Murie 1959; Gibson and Byrd 2007), but many of these observations are anecdotal and few concern the nonbreeding season. Foremost, a formal assessment of the status of the region's shorebirds is needed. Future work in BCR 1 should also address the following:

ACTIONS

- ❑ Implement breeding and nonbreeding population monitoring programs, with a focus on Black Oystercatchers and *ptilocnemis* and *couesi* subspecies of Rock Sandpipers.
- ❑ Assess the importance of the Aleutian Islands in supporting trans-Pacific migrants.

Juvenile Black-bellied Plover
Ted Swem

Priority Conservation Issues and Actions

Pollution

The islands throughout BCR 1 are extremely susceptible to pollution. Both point source and atmosphere-borne contaminants have been identified in the region (Anthony *et al.* 1999; Rocque and Winker 2004), but the biggest threat to shorebirds likely derives from marine transport. The Aleutian Islands straddle major shipping routes between Asia and North America, along which over 10,000 transits of the Aleutian Islands occur annually by container ships, freighters, and fishing vessels (Aleutian and Bering Sea Islands LCC 2018. Furthermore, the coming of an ice-free northwest passage in the near future will likely lead to an increase in shipping traffic across the region. The region's notoriously bad weather heightens the risk of shipwrecks and groundings, a fact emphasized by the grounding of the M/V *Selendang Ayu* off Unalaska Island in December 2004. This wreck spilled over 300,000 gallons of heavy bulk fuel oil and 66,000 tons of soybeans when it foundered and sank in heavy seas (Ritchie and Gill 2008). Since 1988, over 80,000 barrels of diesel oil have been spilled in the Aleutian region alone (State of Alaska 2008). Once ashore, marine pollution is concentrated along coastlines, making shorebirds especially vulnerable to physical contamination and displacement.

Effective planning can help minimize the effects of marine-derived pollution, but given that most of the islands in BCR 1 are remote and unpopulated, spill response measures are unlikely to be effective. Even when a vessel has the relatively good fortune to encounter problems near an inhabited island, as in the case of M/V *Selendang Ayu* off Dutch Harbor, extreme weather events often preclude effective containment and mitigation measures. Nonetheless, federal and state agencies have implemented extensive spill response measures that integrate the realities of prior incidents and region-specific logistics (e.g., Aleutian Islands Emergency Towing System). Risk assessments (e.g., Renner and Kuletz 2015) highlight the vulnerability of shoreline habitats to spills and can help guide site and species prioritization processes in the Bird Conservation Region.

ACTIONS

- ❑ Identify sites where large concentrations of Rock Sandpipers and Black Oystercatchers occur in the region.
- ❑ Ensure that shorebird conservation concerns are addressed in shipping accident preparedness plans.

Invasive and Problematic Species, Pathogens, and Genes

Perhaps the single biggest threat to bird species in this region is the introduction of non-native mammals (e.g., rats [*Rattus* sp.], mice [*Mus musculus*, *Peromyscus maniculatus*], foxes [both arctic *Vulpes lagopus* and red foxes *V. vulpes*], reindeer [*Rangifer tarandus*]). Ship-borne rats and mice have been accidentally introduced to many islands in the Aleutian archipelago, and foxes were purposefully introduced to foster the fur trade. The AMNWR has been actively involved in fox eradication efforts in the Aleutian Islands since the 1950s. To date, more than 40 islands have been successfully cleared of non-native foxes, and the response of the birds has been dramatic. For instance, the Aleutian subspecies of the Cackling Goose (*Branta hutchinsii leucopareia*), once threatened with extinction, has made a dramatic population recovery and has reestablished nesting populations on several islands from which foxes were removed (Byrd 1998). The Cackling Goose was removed from the list of threatened species under the Endangered Species Act in 2001, and eradication of foxes on the Aleutian breeding grounds played a vital role in this subspecies' recovery.

The eradication of rats and mice in the region is a more daunting task than fox removal. Due to their small size and high fecundity, total eradication of these problematic species is extremely difficult. Despite the inherent difficulties, efforts to remove these invasive predators has seen success (e.g., Hawadax Island, (https://www.fws.gov/refuge/alaska_maritime/what_we_do/partnership/rat_island.html). Preventative measures, however, are the most effective methods of dealing with rats and mice in the region. For instance, the AMNWR and the tribal governments on the Pribilof Islands have implemented anti-rat measures around harbor facilities at these locations. The threat from introduced species is greatest for seabirds that nest in high-density colonies. Nonetheless, shorebirds in this region are also extremely vulnerable to nest predators and respond positively to restoration efforts (Byrd *et al.* 1997; Croll *et al.* 2016).

A less obvious result of the introduction of non-native species to the region is the conversion and degradation of habitat due to trampling and over-grazing by animals. Reindeer, cattle, and horses have been introduced to islands in BCR 1, and these large herbivores can produce marked changes to fragile native habitats. For instance, reindeer were introduced to St. Matthew Island in 1944 and over-grazed the island to the extent that the herd suffered a spectacular population crash when a severe weather event coincided with a depletion of food resources (Klein 1968). Fragile, lichen-dominated upland tundra suffered serious impacts across the island, and a recent comparison of these areas to pristine tundra on adjacent Hall Island demonstrated that recovery has not yet occurred (M. Romano, pers. comm.). While reindeer no longer occur on St. Matthew Island, they are still present on the Pribilof Islands, where they have been an important food resource for island inhabitants since their introduction in 1911 (Scheffer 1951).

Native vegetation on these islands has been subjected to conversion and degradation (Scheffer 1951), but the extent to which habitat conversion adversely affects shorebirds (primarily Rock Sandpipers) breeding at these sites is unknown. Immediate threats posed by reindeer are obvious (e.g., nest trampling, egg consumption; Wright 1979), but threats due to habitat conversion are more difficult to assess given the lack of knowledge of conditions prior to reindeer introductions. Habitat conversion may adversely affect nest concealment, potentially increasing nest predation. Alternatively, a change in vegetation cover may precipitate a change in the invertebrate community, potentially eliminating the preferred prey items of shorebirds and shorebird chicks during the breeding period.

Black Oystercatchers
Matt Prinzing

ACTIONS

- ❑ Participate with key groups and agencies (e.g., AMNWR, Pribilof Island tribal governments) to plan and implement programs to eradicate introduced mammals.
- ❑ Develop and implement studies to assess the response (i.e., recolonization, breeding success, site fidelity) of Black Oystercatchers and Rock Sandpipers following eradication of introduced mammals.
- ❑ Assess impacts of reindeer grazing by comparing Rock Sandpiper habitat use at pristine (Hall Island), recovering (St. Matthew Island), and impacted (Pribilof Islands) sites. Compare habitat-specific measures of reproductive success (e.g., hatching success, fledging success) across these sites.
- ❑ Provide information to local governments and management agencies on potential impacts of habitat alteration to shorebird species; promote the removal or regulation of populations of introduced grazers.

Emerging Conservation Issues

As discussed in Part I, a potential threat to shorebirds in BCR 1 concerns the alteration of broad-scale climatological patterns, specifically predicted changes in the position, frequency, and seasonality of storm tracks in the Northern Hemisphere. Such impacts would pertain primarily to shorebirds from other regions migrating through BCR 1. Some climate models predict regional reductions in the number of weaker cyclones and a poleward shift of the storm track in the North Pacific (Graham and Diaz 2001; Brayshaw 2005; Bengtsson *et al.* 2006; Yin 2005), and others indicate a likely increase in frequency and intensity of high-latitude cyclones, particularly in the North Pacific (McCabe *et al.* 2001). Many shorebirds that pass through BCR 1 exploit predictable weather patterns to enable successful annual migrations (e.g., Pacific Golden-Plover [Johnson *et al.* 2012], Bar-tailed Godwit [Gill *et al.* 2014], Sharp-tailed Sandpiper [Handel and Gill 2010]). The effect of projected changes in frequency, intensity, and tracking of storms in the North Pacific on the migration strategy of these birds is unknown but may be significant.

Evaluation of Conservation Progress

The Bering Sea region supports millions of breeding seabirds, which deservedly receive a great deal of attention from researchers and conservationists. Thus, research and conservation efforts dedicated to shorebirds in BCR 1 typically occur in conjunction with the study of seabirds. For instance, efforts to eradicate invasive rats and foxes for the sake of seabirds have directly benefitted Black Oystercatchers and Rock Sandpipers at sites in the region (e.g., Croll *et al.* 2016), and recent surveys across the entire breeding range of *ptilocnemis* Rock Sandpipers (Ruthrauff *et al.* 2012) were made possible only due to the support and preexisting infrastructure of the AMNWR.

Thus, although shorebirds have not garnered much dedicated research attention in BCR 1, shorebird species in general have benefitted from conservation planning efforts dedicated to seabirds in the region. In addition, the human population of the region is small, and access to most sites is possible only by boat, helping to minimize potential impacts to shorebirds and their habitats in the region. And because BCR 1's shorebirds breed on islands and generally occur in low densities, they may be less vulnerable to impacts that potentially affect aggregations of birds occurring across contiguous ranges.

BCR 1 does, however, provide critical breeding habitats for Black Oystercatchers and *ptilocnemis* Rock Sandpipers, two species of high conservation concern that should continue to serve as focal study species in the region. And because BCR 1's breeding shorebirds often congregate in large numbers outside of the region during migration or at their nonbreeding destinations, we encourage future studies that determine the connectivity of the BCR to other sites during the annual cycle (e.g., Ruthrauff 2014; Tessler *et al.* 2014). Such efforts have largely been lacking to date. Given the logistical difficulties associated with the region and the state and federal obligations that often prioritize seabird monitoring efforts in the region, future work in BCR 1 must accommodate and leverage these challenges to succeed.

St. Paul Island
James Johnson

BCR 2: WESTERN ALASKA

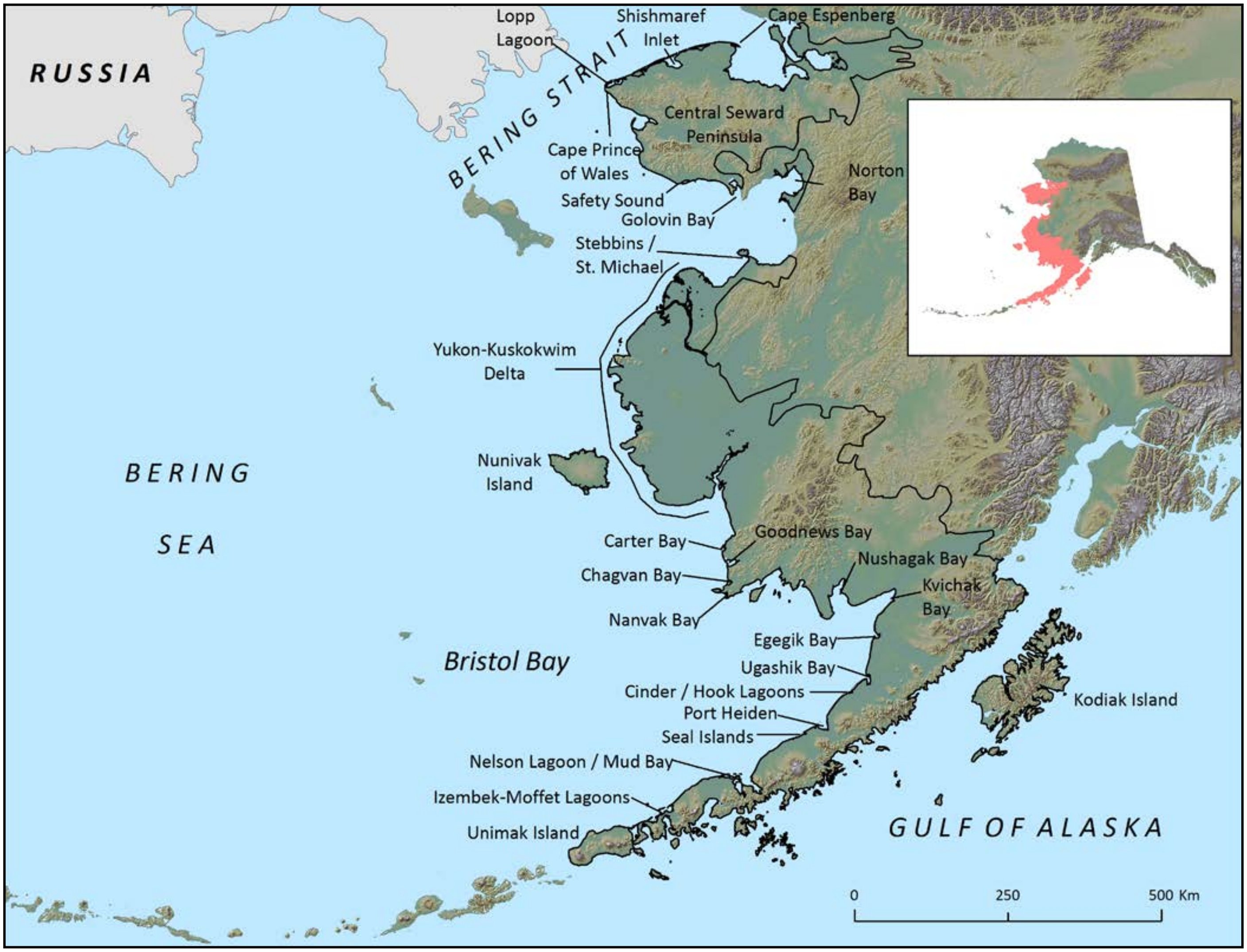


Figure 5. Western Alaska Bird Conservation Region 2. Lands included in BCR 2 are in red on the inset and outlined in black on the map.

This large, 293,000-km^2 BCR consists primarily of the coastal plain and mountains of western and southwestern mainland Alaska, as well as three of Alaska's largest islands: Kodiak, Nunivak, and Unimak. BCR 2 spans over 12 degrees of latitude from Unimak Island at the end of the Alaska Peninsula to just above the Arctic Circle near Cape Espenberg (Figure 5). Ecoregions within this BCR include Kodiak Island, Alaska Peninsula, Bristol Bay Lowlands, Ahklun Mountains, Yukon-Kuskokwim Delta, Kotzebue Sound Lowlands, and Seward Peninsula (Appendix 6, Nowacki *et al.* 2001). Over half of BCR 2 is included within federal land conservation units, including national parks, preserves, monuments, and wildlife refuges (Table 5, Figure 2). In fact, the seven national wildlife refuges within BCR 2 account for one-third of the entire landmass protected by the National Wildlife Refuge system. BCR 2 also includes three national park units, several Alaska state conservation units, and the Bristol Bay critical habitat areas.

Expansive intertidal habitat associated with the numerous river deltas characterizes this BCR. Mountains exceeding 1,000 m elevation occur on the Seward Peninsula, in the Kilbuck-Ahklun Mountains, and on the Alaska Peninsula and Unimak Island.

Alpine tundra and fell fields dominate the summits and ridges of these mountainous areas. Lowlands are particularly rich in wetlands, including marshes, ponds, lakes, and meandering rivers, and wet and mesic graminoid herbaceous habitats dominate these sites. Tall shrub communities are found along rivers and streams and on well-drained slopes, while low shrub communities occupy uplands. Forests of spruce and hardwoods penetrate the region on the eastern edge and approach the coast along major rivers. Permafrost is continuous on the northern Seward Peninsula and around Kotzebue Sound but is discontinuous to absent for most of the BCR. A cool maritime climate prevails throughout much of this region, with moderate seasonal temperatures, abundant annual precipitation, frequent wind, and persistent fog or overcast conditions. In the northern latitudes, sea ice spans the Bering Sea in the winter, creating persistent cold and windy conditions.

Priority Species

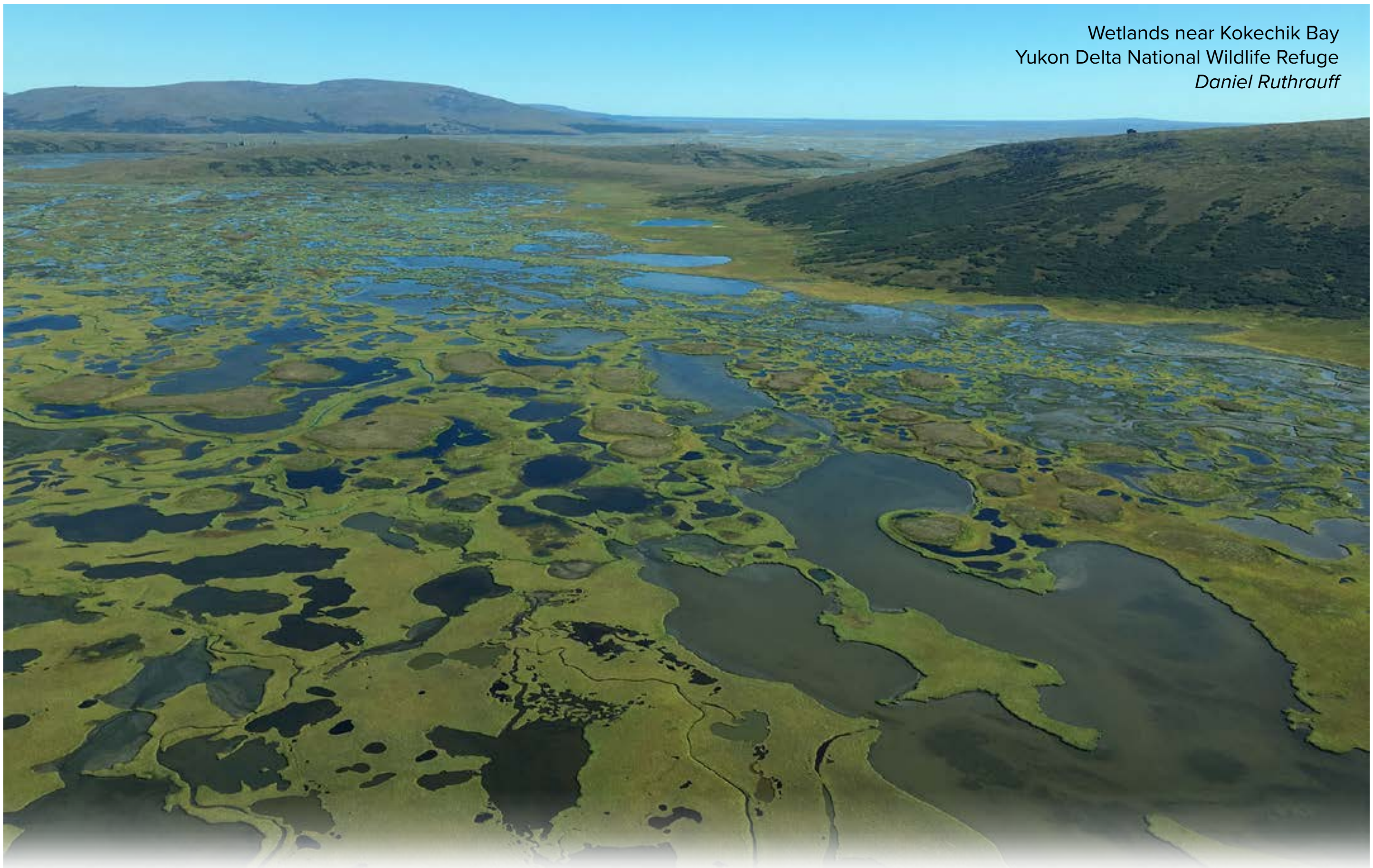
Table 7. Priority shorebird species that commonly breed, stage during migration, or winter in Western Alaska Bird Conservation Region 2.

Breeding	Migration	Winter
Black Oystercatcher	Bristle-thighed Curlew	Black Oystercatcher
American Golden-Plover	Whimbrel	
Pacific Golden-Plover	Bar-tailed Godwit	
Bristle-thighed Curlew	Hudsonian Godwit	
Whimbrel	Marbled Godwit	
Bar-tailed Godwit	Black Turnstone	
Hudsonian Godwit	Red Knot	
Marbled Godwit	Sharp-tailed Sandpiper	
Black Turnstone	Dunlin (*arcticola, pacifica*)	
Red Knot	Rock Sandpiper (*ptilocnemis*)	
Dunlin (*pacifica*)	Rock Sandpiper (*tschuktschorum*)	
Rock Sandpiper (*tschuktschorum*)	Pectoral Sandpiper	
Semipalmated Sandpiper	Semipalmated Sandpiper	
Western Sandpiper	Western Sandpiper	
Red-necked Phalarope	Long-billed Dowitcher	

See Tables 1, 2, and 4 for conservation priority status and relative seasonal importance.

BCR 2 hosts 36 of 41 shorebird populations that commonly occur in the state (Table 2). Though many areas of western Alaska have not been adequately surveyed, this BCR supports high densities of breeding shorebirds and provides critical stopover and staging habitat for migrating shorebirds in both spring and fall.

BCR 2 supports a unique breeding shorebird component that is largely restricted to Beringia, including Bristle-thighed Curlew, Bar-tailed Godwit (*baueri* subspecies), Marbled Godwit (*beringiae subspecies*), Black Turnstone, Western Sandpiper, Rock Sandpiper (*tschuktschorum subspecies*), and Dunlin (*pacifica* subspecies) (Gill and Jorgensen 1979; Warnock and Gill 1996; McCaffery and Gill 2001; Gill *et al.* 2002a). The BCR also supports the majority of the global breeding population of four species: Bristle-thighed Curlew (>50%; Marks *et al.* 2002; B. McCaffery, pers. comm.), Black Turnstone (>90%; Handel and Gill 1992), Western Sandpiper (>50%; Franks *et al.* 2014), and Marbled Godwit (100%, Gibson and Kessel 1989). Other priority species or subspecies that nest in high numbers within BCR 2 include Black Oystercatcher, American Golden-Plover, Pacific Golden-Plover, Whimbrel, Hudsonian Godwit, Red Knot, and Semipalmated Sandpiper. The rocky shores of


Wetlands near Kokechik Bay
Yukon Delta National Wildlife Refuge
Daniel Ruthrauff

the Kodiak Archipelago provide year-round habitat for the Black Oystercatcher (Corcoran 2016).

Intertidal habitats and coastal meadows in BCR 2 support millions of shorebirds during migration (Gill and Jorgensen 1979; Gill and Handel 1981, 1990; Gill *et al.* 1981), including species of conservation concern such as Red Knots, Bristle-thighed Curlews, Hudsonian Godwits, and Marbled Godwits. The majority of two populations of Rock Sandpiper (*C. p. tschuktschorum* and *C. p. ptilocnemis)* stage in western Alaska in late summer and fall to molt and prepare for migration (Gill *et al.* 2002a). Intertidal habitats throughout western Alaska provide the primary molting and staging for the entire *C. a. pacifica* and an unknown portion of the *C. a. arcticola* populations of Dunlin between August and October (Gill and Handel 1981, 1990; Warnock and Gill 1996; Gill *et al.* 2013; Warnock *et al.* 2013). Birds from the western population of Whimbrels stage in coastal Alaska from Kotzebue Sound to Alaska Peninsula (Handel and Dau 1988).

Important Shorebird Areas

BCR 2 contains numerous areas identified by international, federal, state, and nongovernmental organizations as important to shorebirds, including three sites currently recognized within the Western Hemisphere Shorebird Reserve Network program: Kvichak and Nushagak Bays (both regional reserves) and the Yukon-Kuskokwim Delta, a hemispheric reserve (Appendix 6). Additionally, the Yukon Delta National Wildlife Refuge has been designated as an East Asian-Australasian Flyway Network Site for migratory waterbirds. Five State of Alaska Critical Habitat Areas (Port Moller, Port Heiden, Cinder River, Pilot Point, and Egegik) and one State Game Refuge (Izembek Lagoon) are located on the Alaska Peninsula (Alaska Department of Fish and Game 2016), and the National Audubon Society's Important Bird Areas (IBA) program identifies 16 IBAs within BCR 2 as important to shorebirds. Together these sites annually support millions of individuals of many shorebird species (Appendices 3 and 5).

The central coast of the Yukon-Kuskokwim Delta is particularly rich in tidal marshes and brackish wetlands (Boggs *et al.* 2016) that support exceptionally high densities of breeding shorebirds (McCaffery *et al*. 2012; R. Lanctot, unpubl. data), including Black Turnstone, Dunlin, Semipalmated Sandpiper, Western Sandpiper, and Red-necked Phalarope. In addition to the region's importance to breeding shorebirds, this area is the most important autumn staging site for shorebirds in the Pacific Flyway (Gill and Handel 1990), supporting over a million birds during fall migration, with daily peaks approaching 300,000 individuals (Gill and Handel 1990). Although small sandpipers (Western Sandpipers, Dunlin, and Rock Sandpipers) numerically dominate the shorebird communities during fall, over 60,000 Bar-tailed Godwits occur at one time on the Yukon-Kuskokwim Delta during the peak of fall staging (Gill and McCaffery 1999). In addition, most breeding adult and hatching-year Bristle-thighed Curlews stage on the Yukon-Kuskokwim Delta each fall (Handel and Dau 1988). Notably, the majority of the annual juvenile cohort of Sharp-tailed Sandpipers uses coastal habitats in this region during the postbreeding period (Handel and Gill 2010), and Aropuk Lake is an important inland staging area during fall migration for one of the largest concentrations of Hudsonian Godwits in North America (McCaffery and Conklin 2004; McCaffery *et al.* 2005). During spring migration, regionally significant numbers of Red Knots, Pectoral Sandpipers, and Long-billed Dowitchers also occur on the Yukon-Kuskokwim Delta (Gill and Handel 1990; R. Gill and B. McCaffery, unpubl. data).

The Alaska Peninsula provides important breeding habitat for Dunlin (*pacifica* subspecies), Least Sandpipers (McCaffery *et al.* 2012), and an entire breeding population of Marbled Godwit (*beringiae* subspecies) (Gibson and Kessel 1989). The lagoons, estuaries, intertidal habitats, and coastal meadows of Bristol Bay and the Alaska Peninsula are used by large numbers of shorebirds during spring and fall migration (Gill and Jorgenson 1979; Gill and Handel 1981; Gill and Sarvis 1999; Gill and Tibbitts 1999). Greater numbers of shorebirds use these estuaries during fall. Bar-tailed Godwits, Dunlin, Western and Rock sandpipers, Red and Red-necked phalaropes, and Short-billed Dowitchers occur in high numbers across these sites (Gill and Handel 1981; MacDonald 2000; MacDonald and Wachtel 1999; Appendix 6). The entire world population of Marbled Godwit (*beringiae* subspecies) stages at sites on the Alaska Peninsula, principally at Ugashik Bay and Cinder-Hook Lagoons. The south side of the Alaska Peninsula and the Kodiak Archipelago are both dominated by rocky shores. Although little is known about shorebird occurrence along this remote coastline, the Kodiak Archipelago supports about one-third of the Black Oystercatcher population (Corcoran 2016) and also provides important winter habitat for Dunlin and Rock Sandpipers.

The Seward Peninsula shares many of its common breeding species (Dunlin, Western and Semipalmated sandpipers, Red-necked Phalarope, Bar-tailed Godwit, Whimbrel, and Pacific and American Golden-Plovers) with other areas of the BCR. Notably, however, the *roselaari* subspecies of Red Knot breeds in high densities in montane regions of the Seward Peninsula (J. Johnson, pers. comm.), and approximately 40% of the global breeding population of the Bristle-thighed Curlew occurs on the central Seward Peninsula (Marks *et al.* 2002). Coastal habitats from Cape Espenberg to eastern Norton Sound encompass several important postbreeding sites for Dunlin, Western Sandpiper, and Semipalmated Sandpiper (Gill and Handel 1981; Mizel and Taylor 2014; Taylor *et al.* 2016), and Red-necked Phalaropes stage at bays and lagoons on the southern coast of the Seward Peninsula.

Primary Conservation Objectives

Anthropogenic activities have had a relatively minor impact across the landscape of western Alaska owing to the region's low human population density, minimal road network, and widely dispersed and generally small settlements, which occur primarily along coastlines and rivers (State of Alaska 2013). In addition, the proportion of land under some form of protection in BCR 2 is high compared with other regions in Alaska. Degradation and loss of shorebird habitat in BCR 2 are most likely to increase because of changes in climate-related processes, and not due to local human development. Thus, sustaining ecosystem functions crucial to shorebirds within the region is an overarching conservation objective, as ecosystems important to shorebirds outside the region are likely to change more rapidly.

Further, given BCR 2's importance as a breeding and migratory staging site for millions of shorebirds from around the globe, actions that effectively conserve shorebirds in this region must reach beyond the BCR's borders. The greatest immediate threats to most shorebird populations in BCR 2 likely occur outside the region, necessitating strong regional, national, and international partnerships. In addition to many of the objectives outlined in the Conservation Strategy for Alaska in Part 1, additional primary conservation objectives for BCR 2 include the following:

- Identify and determine the magnitude of factors limiting shorebird population sizes during breeding and nonbreeding periods of the annual cycle. This information is particularly needed for priority species such as Bristle-thighed Curlew, Hudsonian Godwit, Marbled Godwit, Bar-tailed Godwit, Black Turnstone, and Red Knot.
- Model the potential effects of climate change on shorebird habitats, specifically addressing changes related to coastal erosion, permafrost loss, wetland drying, and expansion of trees and shrubs.
- Develop and maintain national and international partnerships to foster habitat protection in regions to which BCR 2 shorebirds migrate.
- Obtain better estimates of shorebird subsistence harvest within BCR 2 and determine the exposure of shorebirds from BCR 2 to hunting in regions where they migrate.

Priority Conservation Issues and Actions

Climate Change and Severe Weather
Climate change and the resulting alteration of natural habitats and broad-scale changes in climatological patterns are among the most significant potential threats to shorebirds in BCR 2. Habitat loss and alteration due to climate-mediated increases in coastal flooding and erosion (Jones *et al.* 2009; Terenzi *et al.* 2014), permafrost degradation (Jorgenson *et al.* 2001), wetland drying (Riordan *et al.* 2006), and tree and shrub expansion (Tape *et al.* 2006) are the most relevant potential drivers of habitat change in BCR 2. In addition to expected changes in habitat, there may be temporal decoupling of important stages of birds' annual cycles from the resources that currently support them at those times, resulting in decreased survival and productivity (Meltofte *et al.* 2007; McKinnon *et al.* 2012). Additionally, sites in BCR 2 serve

Semipalmated Plover chick
Zak Pohlen

as the departure location for many shorebird species embarking on long-distance migrations, and these species rely on predictable weather patterns to successfully complete their annual migrations. The effect of projected changes in the frequency, intensity, and track of storms in the North Pacific on shorebirds in the tribe *Numeniini* (curlews and godwits) is of particular concern because these species consistently exploit reliable winds to complete their migrations (Gill *et al*. 2014; Pearce-Higgins *et al.* 2017). More frequent extreme weather events could negatively affect shorebirds during the breeding season and migration. Finally, coastal sites in BCR 2 support millions of migrating shorebirds each year, and most of these species rely on benthic invertebrates to fuel their migrations (Handel and Gill 1990). Ocean acidification is predicted to severely alter marine communities (Orr *et al.* 2005), and benthic ecosystems are no exception (e.g., Hale *et al.* 2011). Many of these climate change-related impacts may already be occurring, but are not adequately monitored.

Galbraith *et al.* (2014) ranked shorebird species based on their vulnerability to climate change. Species considered especially vulnerable to the risk of climate-induced change in BCR 2 include Black Oystercatcher, Bristle-thighed Curlew, Bar-tailed and Marbled godwits, Black Turnstone, and Red Knot. These species would be extremely vulnerable to predicted changes in terrestrial habitats, sea level, storm frequency, and storm intensity. While the magnitude of the potential impacts of global climate change on shorebirds and their habitats in BCR 2 is great, the opportunities for implementing shorebird conservation efforts that will ameliorate, slow, or reverse the effects of global climate change and its impact on shorebirds are extremely limited. Perhaps the most important, if still limited, conservation actions to buffer shorebirds against the impacts of climate change will be to protect as much current and future shorebird habitat as possible. Accordingly, identifying and protecting geographic areas within Alaska with relatively stable and favorable climates (climate refugia) for priority or climate-sensitive species may be an important conservation strategy. In this context, BCR 2 may be a particularly important region for Alaska birds, as future shifts in the region's climate envelope are expected to be more moderate than the larger shifts projected in northern and Interior Alaska (SNAP and EWHALE Lab 2012).

ACTIONS

- ❑ Support development of dynamic models of habitat change across the landscape relative to major ecosystem drivers (e.g., permafrost, hydrology, soil nutrients, fire, saltwater intrusion, coastal erosion and deposition) and climatic factors.
- ❑ Identify and target for protection areas that are likely to provide critical refugia for tundra- and boreal-associated species.

Pollution

Oil and fuel spills and the release of mining wastes have the potential to degrade habitats and poison shorebirds and aquatic fauna in the region. Commercial fishing and processing are major economic activities in Alaska. Within BCR 2, the Bristol Bay sockeye salmon fishery and the Bering Sea crab and pollock fisheries are among the largest fisheries in the world and Kodiak hosts one of the largest fishing ports in the world (https://www.st.nmfs.noaa.gov/Assets/commercial/fus/fus12/FUS_2012_factsheet.pdf). Such a high volume of marine vessel traffic (fishing boats as well as support vessels such as fuel barges) translates into a high risk of chronic and catastrophic fuel spills related to vessel groundings and sinkings, activities that put intertidal habitats at risk.

In addition to pollution associated with marine spills, the rising demand for gold, copper, and other metals has fueled multinational interests in extracting mineral resources present along the eastern border of BCR 2 (see Energy Production and Mining for BCR 4). Proposed large-scale mines in this region risk the loss of fuel containments, tailings, and other toxic material, such as mercury and arsenic. Such spills have the potential to contaminate important riparian and estuarine habitats that support high densities of shorebirds, as well as the bays and estuaries into which the watersheds drain.

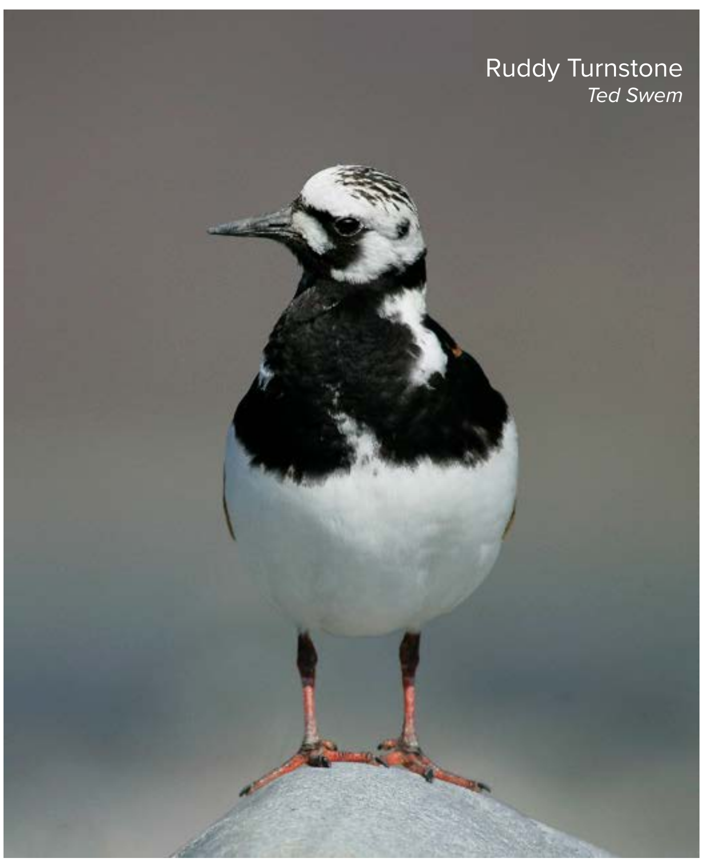
Mercury pollution is of particular relevance to BCR 2, because some areas within the region, such as the Kuskokwim River, have naturally high levels of mercury (Matz *et al.* 2017). In addition, distant industrialized areas, particularly in East Asia, deposit mercury via atmospheric or aquatic pathways (Landers *et al.* 2008; AMAP 2011). Taken together, even small increases in mercury could increase mercury exposures to toxic levels (Evers *et al.* 2005; Edmonds *et al.* 2010). For example, the Red Devil Mine, an abandoned cinnabar mine which operated from 1933–1971, has left a legacy of contamination of mercury, arsenic, and antimony still seen in the fish and aquatic insects of the middle Kuskokwim River (Matz *et al.* 2017). Although previous studies of mercury exposure in Alaska have not detected adverse effects in shorebirds, differences in exposure related to site, habitat, age, and sex (Perkins *et al.* 2016) indicate the susceptibility of shorebirds to mercury exposure and may warrant further investigation.

Coastal habitats in the north Pacific Ocean and the southern Bering Sea, which remain ice-free year-round, are particularly vulnerable to fuel spills associated with shipping traffic and fishing vessels. Shipping traffic through the Bering Sea is projected to increase with continued warming of the Arctic Ocean. New routes such as the Northwest and Northeast passages are projected to account for 5% of global trade volume by 2050 (Arctic Council 2009). Increased shipping traffic, along with expanded exploration and development for offshore petroleum reserves in the Bering and Chukchi Seas, will increase risk of fuel spills in the region (Corbett *et al.* 2010).

ACTIONS

- ❑ Ensure shorebird conservation concerns are addressed in environmental response plans for oil spills and loss of containment for toxic materials associated with resource development and transportation.
- ❑ Monitor levels and potential effects of mercury, plastics, and other contaminants for high-risk species.
- ❑ Minimize loss and degradation of critical shorebird habitats by participating in natural resource planning and management. Promote mitigation measures to limit negative impacts on important shorebird habitats, and provide guidance on how best to incorporate habitat restoration into post-mining reclamation plans.


Juvenile Black-bellied Plover
Zak Pohlen


Ruddy Turnstone
Ted Swem

Biological Resource Use

Subsistence harvest of migratory birds is more prevalent in BCR 2 than other areas of the state. Subsistence bird harvest surveys (including shorebirds) have been conducted on the Yukon-Kuskokwim Delta since the mid-1980s and in Bristol Bay since the mid-1990s (Wentworth 2007a, 2007b). Assessments by the Alaska Migratory Bird Co-Management Council's (AMBCC) Harvest Assessment Program and the Community Subsistence Information System indicated that the Yukon-Kuskokwim Delta region accounted for a large proportion of the shorebird harvest in Alaska in general and BCR 2 in particular (CSIS 2017; L. Naves, unpubl. data). Of note, the Alaska-wide estimated harvest of godwits was 1,115 birds/year, with 98% of this total derived from the south coast of the Yukon-Kuskokwim Delta region (L. Naves, unpubl. data). Due to known seasonal distribution patterns of godwits in this region, most of this harvest was likely Bar-tailed Godwit. The Alaska-wide estimated harvest of Whimbrel/Curlew was about 150 birds/year, with 68% of this harvest occurring in the Yukon-Kuskokwim Delta region (L. Naves, unpubl. data).

A better understanding of shorebird harvest levels, harvest composition, and population trends is needed to assess harvest sustainability in BCR 2 (e.g., Watts *et al.* 2015). In addition, a better understanding of the importance of shorebirds as food for and cultural resources of subsistence users is needed to develop conservation measures appropriate for this user group. Finally, potential threats to Alaska-breeding shorebirds due to harvest outside of Alaska needs to be quantified and addressed in conservation policy and actions.

ACTIONS

- ❑ Improve subsistence harvest estimates for shorebirds in BCR 2 and make harvest data and estimates available to the public.
- ❑ Work with national and international partners to quantify levels of shorebird harvest outside of Alaska, ensure sustainable harvest, and develop management strategies that account for harvest throughout the annual cycle.
- ❑ Develop quantitative population models, identify factors involved in population decreases, and use improved information on population size and trend to determine sustainable harvest levels for large shorebirds.
- ❑ Document local and traditional knowledge about shorebirds in western Alaska to devise culturally appropriate shorebird conservation messages and harvest regulations that are meaningful for subsistence communities.
- ❑ Work with the AMBCC and other partners to engage subsistence users in shorebird conservation efforts.

Emerging Conservation Issues

Overall, BCR 2 is sparsely populated, with only approximately 0.15 people/km^2 (2016 population estimates; www.live.laborstats.alaska.gov/pop/). Despite the low population density, the rate of human population growth in some communities is relatively high. Four census areas that overlap BCR 2 had among the highest growth rates in the state (Alaska Department of Labor and Workforce Development 2016). As populations increase, potential negative effects associated with residential and commercial development, transportation and service corridors, biological resource use, invasive and problematic species, and human intrusion and disturbance will increase as well. Individually, these threats may not warrant current concern, but the cumulative impact of future threats associated with increasing human populations in the region should be recognized.

Offshore oil and gas development in waters adjacent to BCR 2 could affect shorebirds in the region through point-source pollution and disturbance. In 2017, the Secretary of Interior was directed to develop a new National Outer Continental Shelf Oil and Gas Leasing Program two years ahead of schedule. However, offshore oil and gas development in Alaska remains logistically difficult and, while exploration may accelerate, it seems unlikely that these reserves would be developed in the near term.

ACTIONS

- ❑ Identify important shorebird habitats vulnerable to activities related to human population growth and advocate for protection of such sites.
- ❑ Document extent of all-terrain/off-road vehicle (ATV/ORV) use and trails in conservation areas and work with local communities to minimize impacts to shorebirds.

Evaluation of Conservation Progress

Considerable recent progress has been made in BCR 2 that addresses many knowledge gaps outlined in Version II of the Alaska Shorebird Conservation Plan. Perhaps foremost, this includes efforts to inventory shorebirds and update population estimates. Researchers conducted inventories of breeding shorebirds in lowland tundra habitats of the Alaska Peninsula (Savage *et al. 2018*) and montane habitats of southwestern Alaska (Amundson *et al.* 2018). In 2015–2016, theProgram for Regional and International Shorebird Monitoring (PRISM) breeding shorebird surveys were conducted across lowland habitats of the Yukon Delta National Wildlife Refuge, surveys that will generate refuge-wide population estimates and provide information to update continental estimates (R. Lanctot unpubl. data). These surveys augment initial work on the Refuge summarized by McCaffery *et al.* (2012). Work was conducted on the Yukon Delta National Wildlife Refuge to estimate the population sizes of Bristle-thighed Curlews (K. Sowl, unpubl. data) and Black Turnstones (A. Taylor, unpubl. data). Nearshore surveys of marine birds yielded an estimate for the postbreeding population of Black Oystercatchers on Kodiak Island (Corcoran *et al.* 2016).

Numerous studies in the BCR also addressed the topics of migration, migratory behavior, and migratory connectivity. These studies included evaluations of Black Oystercatchers (Johnson *et al.* 2010b), Pacific Golden-Plovers (Johnson *et al.* 2011b), Bar-tailed Godwits (Gill *et al.* 2009; McCaffery *et al.* 2010), Black Turnstones (M. Bishop, unpubl. data), Red Knots (Bishop *et al.* 2016; J. Johnson, unpubl. data), Sharp-tailed Sandpipers (Handel and Gill 2010; Lindström *et al.* 2011), and Dunlin (Gill *et al.* 2013; Warnock *et al.* 2013). Mizel and Taylor (2014) and Taylor *et al.* (2016) examined postbreeding aggregations and staging behavior of multiple species on the Seward Peninsula. A study of a growing wintering population of Bristle-thighed Curlews on Oahu included an investigation of this population's demographic composition, local movements, and breeding ground connections (Tibbitts *et al.* 2016).

A handful of recent studies have also assessed the effects of climate change on shorebirds in western Alaska. The U.S. Geological Survey's Changing Arctic Ecosystems initiative addressed how climate-driven habitat change is impacting the distribution, abundance, and community structure of breeding birds on the Seward Peninsula (McNew *et al.* 2013; Thompson *et al.* 2016). The Western Alaska Landscape Conservation Cooperative funded a project to develop a predictive model of landcover changes on the Yukon-Kuskokwim Delta in response to sea-level rise and increases in storm frequency and permafrost thaw, and assessed the vulnerability of waterfowl and shorebird habitats to these changes (https://westernalaskalcc.org/projects/SitePages/yk.aspx; Project WA2016-46). Ely *et al.* (2018) investigated the relationship between spring arrival dates and local environmental conditions for 12 species of shorebirds breeding on the central Yukon-Kuskokwim Delta using data from 1977–2008.

In 2017, the Alaska Department of Fish and Game initiated an effort to assess the magnitude of subsistence harvest on shorebirds as well as the importance of shorebirds as food and cultural resources for Alaska's subsistence communities. This study analyzed existing harvest data and documented local and traditional knowledge about shorebird ecology (Naves and Keating 2018). Naves and Keating (2018) also produced communication and outreach materials in English and Yup'ik on the ecology, subsistence importance, and conservation of shorebirds. Shorebird conservation perspectives were also represented in resource planning efforts across the region (e.g., Donlin Gold Project, Pebble Mine, proposed land exchanges on the Izembek National Wildlife Refuge). Finally, international outreach efforts resulted in the designation of the Yukon Delta National Wildlife Refuge as a site in the East Asian-Australasian Flyway Network, the first site to join the network from the United States. In sum, significant progress has recently been made across this large region to better understand and promote shorebirds via research, monitoring, and education and outreach.

Black Turnstones
Lucas DeCicco

BCR 3: ARCTIC PLAINS AND MOUNTAINS

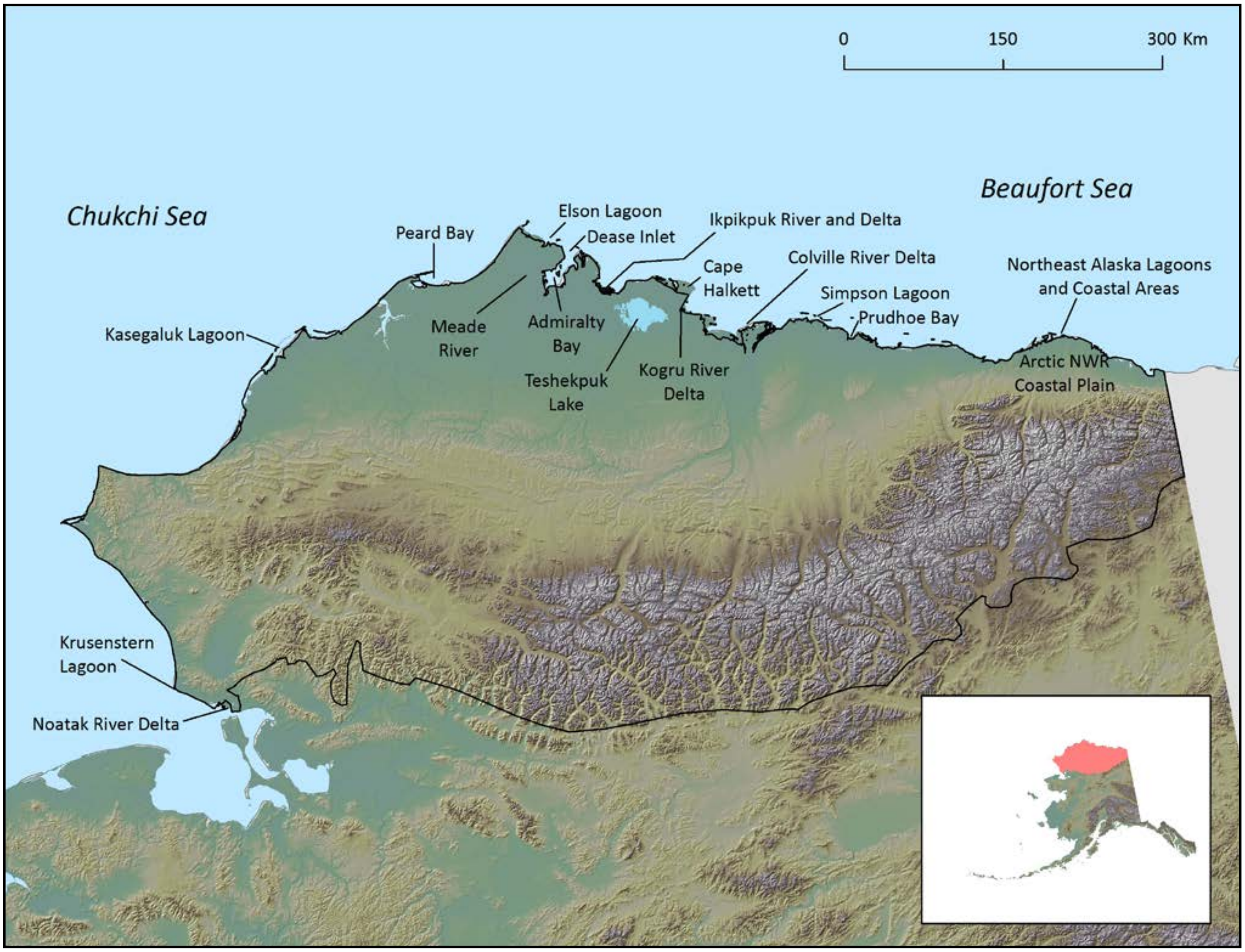


Figure 6. Arctic Plains and Mountains Bird Conservation Region 3. Lands included in BCR 3 are in red on the inset and outlined in black on the map.

The 240,000-km^2 Arctic Plains and Mountains BCR includes low-lying coastal tundra, drier uplands of the Arctic Foothills of the Brooks Range, and montane areas of the Brooks Range (Figure 6). Ecoregions include Beaufort Coastal Plain, Brooks Foothills, and Brooks Range (Appendix 6). The region extends from the Alaska-Canada border at Demarcation Point westward and southward to the mouth of the Noatak River. Seventy percent of this BCR is federally managed within the Arctic National Wildlife Refuge (NWR), the National Petroleum Reserve–Alaska (NPR–A), and the Arctic Network of National Parks (Table 5, Figure 2).

Most of the region is underlain with thick, continuous permafrost, and much of the coastal plain landscape is dominated by surface water during the brief Arctic summer, especially in northern areas of NPR–A in the central region of the coastal plain. Freezing and thawing action over millennia has formed a patterned mosaic of polygonal ridges and ponds. Many rivers, the most notable being the Colville and Canning Rivers, traverse the plain from south to north, flowing into the Arctic Ocean. This region has 67 days when the sun is below the horizon in the winter and 84 days when the sun does not set in the summer. Ice covers the ocean much of the year, but the Arctic sea ice extent is rapidly declining; the 10 years with the lowest extents of sea ice on record have all occurred within the last 10 years (Petty *et al.* 2018).

Priority Species

Table 8. Priority shorebird species that commonly breed or stage during migration in Arctic Plains and Mountains Bird Conservation Region 3.

Breeding	Migration
Black-bellied Plover	Black-bellied Plover
American Golden-Plover	American Golden-Plover
Whimbrel	Ruddy Turnstone
Bar-tailed Godwit	Red Knot
Ruddy Turnstone	Sharp-tailed Sandpiper
Black Turnstone	Dunlin (*arcticola*)
Red Knot	Pectoral Sandpiper
Surfbird	Semipalmated Sandpiper
Dunlin (*arcticola*)	Western Sandpiper
Dunlin (*pacifica*)	Long-billed Dowitcher
Buff-breasted Sandpiper	Red-necked Phalarope
Pectoral Sandpiper	
Semipalmated Sandpiper	
Western Sandpiper	
Long-billed Dowitcher	
Wandering Tattler	
Lesser Yellowlegs	
Red-necked Phalarope	

See Tables 1, 2, and 4 for conservation priority status and relative seasonal importance.

The large amount of surface water on the coastal plain supports an abundant and diverse avifauna, predominately shorebirds and waterfowl. At least 29 species of shorebirds breed in BCR 3; the most common being American Golden-Plover, Semipalmated Sandpiper, Pectoral Sandpiper, Dunlin, Long-billed Dowitcher, and Red-necked and Red phalaropes (Johnson *et al.* 2007). Four and one-half million shorebirds are estimated to breed in the NPR–A alone, and 6.3 million are thought to breed across the Beaufort Coastal Plain (Bart *et al.* 2013). An estimated 230,000 shorebirds breed within the 1002 Area of the Arctic NWR (Brown *et al.* 2007) and >573,000 breed within the Teshekpuk Lake Special Area of the NPR–A (Andres *et al.* 2012a). Compared to other regions of the world, the NPR–A has some of the highest densities of shorebirds in the Arctic (Bart *et al.* 2013). Within Alaska, the NPR–A densities may be second only to coastal areas of the Yukon Delta NWR (R. Lanctot, unpubl. data).

Analyses based on surveys for shorebirds at 767 plots between 1998 and 2008 indicated habitat suitability increased at lower elevations where large areas of wetlands predominate (i.e., typically near the coast and river deltas) and decreased within upland habitats across the Beaufort Coastal Plain (Saalfeld *et al.* 2013b). The most suitable habitat was present in the NPR–A, followed by coastal areas within the Arctic NWR, and coastal areas between the Canning River and Prudhoe Bay.

Distributions of individual shorebird species vary within BCR 3. In general, the highest numbers and the greatest diversity occur west of the Colville River at sites near the coast, although certain sites east of the Colville River (e.g., Prudhoe Bay, Canning River Delta) also have relatively high species richness (Brown *et al.* 2007; Johnson *et al.* 2007). Relatively uncommon habitats in BCR 3 (e.g., dry, montane regions of the Brooks Range; riparian strips; gravel coastlines) support low breeding densities of species with restricted distributions like Red Knots, Wandering Tattlers, Surfbirds, and Semipalmated Plovers (Tibbitts *et al.* 2006; Johnson *et al.* 2007).

The river deltas and coastal lagoons of BCR 3 are used extensively by hundreds of thousands of post-breeding shorebirds from July through September to build energy reserves necessary for migration to wintering areas (Taylor *et al.* 2010, 2011; Brown *et al.* 2012). Shorebird numbers vary significantly between years and among river deltas (Taylor *et al.* 2010; Brown *et al.* 2012), and there is a high level of spatial connectivity among coastal staging areas by postbreeding shorebirds (Taylor *et al.* 2011).

Important Shorebird Areas

Prebreeding

There is little information concerning the existence of concentration sites used during the pre-breeding season. The fact that tundra habitats become free of snow and ice before the Arctic Ocean coastline suggest that coastal areas may be unavailable, and thus unimportant, to pre-breeding shorebirds. In contrast, offshore open-water areas within the Arctic Ocean may serve as foraging locations for both Red and Red-necked phalaropes prior to coming to shore to breed (Gudmundsson *et al.* 2002). Pectoral Sandpipers, and perhaps other polygamous species, travel over vast regions of the Arctic to access mates (Lanctot *et al.* 2016; Kempenaers and Valcu 2017).

Breeding

Bart *et al.* (2013) determined that 72% of all shorebird detections during surveys conducted across the Arctic Coastal Plain between 1998 and 2004 occurred in the NPR–A, 23% in the area between the Colville River and the Arctic NWR, and the remaining 5% in the Arctic NWR. Shorebird densities were four times higher in the NPR–A as in the Arctic NWR (Bart *et al.* 2013).

Brown *et al.* (2007) estimated 26 shorebirds/km^2 occurred within the 1002 Area of the Arctic NWR, while Andres *et al.* (2012) reported 126 shorebirds/km^2 in the Teshekpuk Lake Special Area of the NPR–A. Liebezeit *et al.* (2011) reported 49 and 51 shorebird nests/km^2 at Prudhoe Bay and a site southeast of Teshekpuk Lake, respectively. Saalfeld and Lanctot (2015) found total shorebird nest densities to range from 52–183/km^2 between 2003 and 2012 in Utqiaġvik (formerly Barrow). These high densities may have been an artifact of a fox removal program at the site designed to help Steller's Eiders (*Polysticta stelleri*); density changes were driven mostly by Red Phalarope and Pectoral Sandpiper, which individually exceeded 45 nests/km^2 in some years (Saalfeld and Lanctot 2015). High densities of breeding shorebirds also occur in other areas of the NPR–A (see Appendix 5); prominent sites include areas surrounding Admiralty Bay, the Kogru River, the Ikpikpuk River and delta, and areas to the north and west of Teshekpuk Lake (Liebezeit and Zach 2010; Liebezeit *et al.* 2011; Andres *et al.* 2012a; Bart *et al.* 2012b).

The Colville River Delta is the largest river delta in BCR 3 and supports 20 species of breeding shorebirds. Important concentrations of Stilt Sandpipers and American Golden-Plovers breed here, as well as several priority species such as Whimbrels, Bar-tailed Godwits, and Buff-breasted Sandpipers (https://www.audubon.org/important-bird-areas/colville-river-delta). The Canning River Delta also supports relatively high densities of breeding shorebirds (75 shorebirds/km^2 within wetland areas, Brown *et al.* 2007). The most abundant breeding species on the Canning River includes Semipalmated Sandpipers, Pectoral Sandpipers, Red-necked Phalaropes, and Red Phalaropes (Brown *et al.* 2007). The elevated areas along the Sagavanirktok River have some of the highest densities of breeding Buff-breasted Sandpipers known on the Arctic Coastal Plain (Lanctot and Weatherhead 1997).

The breeding ranges of some shorebird species extend into BCR 3 from the west (e.g., Bar-tailed Godwit, Western Sandpiper) and shorebird species regularly breeding in the Canadian Arctic extend from the east (e.g., Sanderling, Baird's and White-rumped sandpipers). The *arcticola* subspecies of Dunlin breeds in BCR 3 and winters in Asia (Gill *et al.* 2013; Miller *et al.* 2015). A list of broad-scale surveys conducted in BCR 3 is listed in Appendix 5.

Postbreeding

Kasegaluk Lagoon is one of the longest lagoon–barrier island systems in the world and is used by at least 19 species of shorebirds during fall migration. Density

2018 Shorebird Crew, 4th of July Parade
Utqiaġvik
Samantha Gale

estimates extrapolated across Kasegaluk Lagoon yield peak single-day counts between 4,000 and 55,000 individuals, including mostly juvenile Semipalmated and Western sandpipers, Dunlin, and Red Phalaropes (Johnson *et al.* 1993; Taylor *et al.* 2010).

Peard Bay is a large, relatively deep bay, located on the north Chukchi Sea coast west of Utqiaġvik. Density estimates extrapolated across the bay translate into peak single-day counts of between 14,000 and 21,000 individuals (Gill *et al.* 1985; Taylor *et al.* 2010). Red Phalaropes constitute the majority of postbreeding shorebirds in this location. Other species present in substantial numbers included Semipalmated, Western, and Pectoral sandpipers, and Dunlin.

Elson Lagoon is another large, mostly closed lagoon that is heavily used by postbreeding shorebirds. Density estimates extrapolated across the lagoon yield peak single-day counts of between 74,000 and 246,000 individual shorebirds (Taylor *et al.* 2010). Farther to the east, Taylor *et al.* (2010) reported shorebirds along the Smith Bay to Cape Halkett region of the Beaufort Sea coastline but no population estimates are available.

The Colville River Delta hosts an estimated 41,000 individuals of 18 species during fall migration, including large numbers of American Golden-Plovers, Dunlin, and Stilt Sandpipers (Andres 1994). More contemporary surveys estimated a peak single-day count of 17,000 Dunlin on the Colville River Delta in 2006 (A. Taylor, unpubl. data).

The shorelines and barrier islands of the Arctic NWR also support large numbers of staging shorebirds, where ≥112,000 individuals have been observed during a single survey (A. Taylor, unpubl. data). A 5-year study conducted at 13 major river deltas on the coast of the Arctic NWR found that shorebird density varied significantly between years and among river deltas (Taylor *et al.* 2010; Brown *et al.* 2012). In order of abundance, Semipalmated Sandpipers, Red-necked Phalaropes, Black-bellied Plovers, Dunlin, Stilt Sandpipers, and Pectoral Sandpipers are the most common species staging in this area (Brown *et al.* 2012). Radio telemetry studies indicate the Canning River may serve as a southward migration corridor for Semipalmated Sandpipers leaving the Beaufort Coastal Plain (Taylor *et al.* 2011).

Audubon Alaska (2014) recognized two inland sites (Colville River Delta and Teshekpuk Lake Area), four marine sites (Beaufort Sea Nearshore, Barrow Canyon, Smith Bay, and Chukchi Sea Nearshore), and one coastal site (Kasegaluk Lagoon) as Important Bird Areas (see also Appendix 3).

Primary Conservation Objectives
To assess potential effects of climate change and current and future development in this area on shorebirds, information is needed on shorebird habitat use and demography, long-term monitoring of environmental phenology (e.g., snow melt, hydrology), predator abundance, alternative prey sources, and other relevant ecological factors. A summary of the cumulative effects of these changes is needed to identify actions that could mitigate effects from many of the threats to shorebirds. For effective conservation, collaboration with key stakeholders is essential to ensure that development and climate-mediated habitat change do not adversely affect shorebird populations. In addition, very little is known about shorebird occurrence in the foothills and mountain regions of the BCR. Immediate action is needed to address the conservation objectives listed below:

- Identify and determine the magnitude of factors limiting shorebird population sizes during breeding and nonbreeding periods of the annual cycle.
- Identify the immediate and cumulative effects of existing and future oil and gas development, disturbance, and other anthropogenic activities on shorebirds.
- Assess the effects of, and adaptations to, climate change on shorebird demography, and estimate how shorebirds may fare under future projected climate change scenarios.
- Monitor species composition and abundance of shorebirds along the Arctic Coastal Plain, with an emphasis on high-density areas or areas proposed for development.
- Determine the migratory timing, routes, and site use of shorebirds between and during prebreeding, breeding, and postbreeding stages.
- Inventory and study the distribution, abundance, and breeding ecology of species residing in upland, alpine, and other poorly studied areas.
- Develop habitat-based models to predict the abundance and distribution of shorebirds, especially to guide proposed development planning efforts.

Priority Conservation Issues and Actions

Energy Production and Mining
Abundant oil and gas resources occur throughout the Beaufort Coastal Plain region of BCR 3. Upwards of 90% of Alaska's unrestricted revenue comes from oil and gas revenues (AOGA 2016), much of which comes from BCR 3. Additional oil and gas exploration and development will depend on future legislative actions, as well as a favorable economic climate (i.e., high oil and gas prices). Fluctuations in resource prices (e.g., 40-year-lows in 2015 for oil) have profound effects on the feasibility of (and industry commitment to) exploration, development, and production of petroleum resources within BCR 3. These issues aside, we present some of the important existing or prospective energy production/mineral resource issues that potentially affect shorebirds and their habitats in the BCR.

Development associated with oil production has occurred in BCR 3 since the mid-1970s. The Prudhoe Bay-Kuparuk complex encompasses about 2,000 km^2 along the central Beaufort Sea coast. Expansion is most prominent within the Colville River Delta, eastern NPR–A, and in state and federal offshore waters of the Beaufort and Chukchi Seas. Currently, almost 7,000 km^2 have been leased to oil companies in the NPR–A, and additional lease sales are likely. There are ~11,160 km^2 of active leases managed by the Bureau of Ocean Energy Management in the Beaufort and Chukchi Seas. The State of Alaska has leased ~3,450 km^2 onshore and ~540 km^2 offshore, some of which has been developed for oil extraction and some of which is currently being explored for oil potential.

The primary negative effects of oil development include displacement of breeding birds due to loss and fragmentation of habitat and possible reduced nest success associated with disturbance and predation (see Invasive and Problematic Species, Pathogens, and Genes below; Troy and Carpenter 1990). Additional effects may include alteration of habitat due to changes in drainage patterns, roadside dust, thermokarst (i.e., melting of permafrost), physical and noise disturbance, industrial pollution, and collisions with human structures (NRC 2003). The area affected indirectly by roadside flooding, dust, and thermokarst can greatly exceed the development footprint (NRC 2003). Studies have showed that the development of infrastructure has displaced nesting shorebirds

(TERA 1993a), affected passerine nest survival but not shorebird nest survival (Liebezeit *et al.* 2009), and had no effect on the survival of artificial or real nests (Bentzen *et al.* 2017). These studies demonstrate that nesting success varies naturally in time and space, and that disentangling effects of human disturbance is difficult with short-term or spatially-restricted studies. The exception to this might be oil spills that occur in areas of high shorebird concentrations, such as postbreeding staging areas, where large numbers of birds might be affected in a short time. Understanding long-term chronic effects on shorebird populations requires long-term, spatially expansive research and must be viewed cumulatively.

ACTIONS

- ❑ Identify concentration areas, migration corridors, and other critical habitats for shorebirds and inform land managers of potential conflicts with energy production and mining projects.
- ❑ Assess the direct and indirect effects (local and cumulative) of oil and gas development and mining on shorebird breeding ecology, and determine which species are most vulnerable.
- ❑ Develop models to assess the potential effects of riverine and marine oil spills of various sizes, locations, and time periods on shorebirds.
- ❑ Contribute biological expertise to environmental assessments/ impact statements for planning new developments. Develop and promote mitigation measures to limit negative effects on shorebirds and their habitats, and provide guidance on how best to incorporate habitat restoration into post-development reclamation plans.
- ❑ Collaborate with stakeholders to promote industry environmental compliance.

Transportation and Service Corridors

A 70-mile-long electric transmission line has been proposed by the North Slope Borough to provide Atqasuk with electricity produced from Utqiaġvik's local natural gas supply. This transmission line could create nesting and perching platforms for Common Ravens (Coates *et al.* 2014) and other avian predators, potentially increasing predation on shorebirds nesting nearby and increasing the predator population overall (see Invasive and Problematic Species, Pathogens, and Genes below).

Transportation of cargo and tourists through the Northwest Passage is becoming increasingly common as sea ice extent diminishes each year. To address safety concerns associated with vessel accidents, the U.S. Coast Guard is considering building a deepwater port at Utqiaġvik, and other safety and support infrastructure will likely be needed. Expansion of oil and gas developments into the Beaufort and Chukchi Seas requires more support vessels in the air and sea. Collectively these activities raise the risks of contamination of shorelines and nearshore waters used by shorebirds.

ACTIONS

- ❑ Advise on best practices for locating and marking proposed transmission lines, transportation lanes, and ports to minimize negative effects on shorebirds.

Invasive and Problematic Species, Pathogens, and Genes

Changes in predator distribution and abundance have become major concerns in BCR 3 with the establishment of permanent villages and construction of oil and gas development facilities. Predators may benefit from these developments by gaining access to food, principally through supplemental food resources found at landfills (Weiser and Powell 2010, 2011). This food may be particularly important to ensure predators can survive the winter. The negative effects of landfills can be reduced by proper fencing, incineration, and daily covering of garbage to reduce attraction of predators to landfills (Saalfeld *et al.* 2013a). Lehner (2012) determined that the average contribution of anthropogenic foods to the diet of arctic fox at Prudhoe Bay was more than 50%, and the northward expansion of red foxes into the oil fields at Prudhoe Bay may be due to their greater reliance on this food during the winter (Stickney *et al.* 2014; Savory *et al.* 2014).

Village and oil and gas field infrastructure also provides denning and nesting structures otherwise not available for arctic foxes and Common Ravens (Day 1998; Liebezeit and Zack 2008). Burgess *et al.* (1993) reported a higher density of fox dens in the Prudhoe Bay region compared to surrounding areas outside of the oilfields, although no pre-development data exist to address the alternative explanation that the fox population was always higher. Common Ravens were relatively uncommon on the Beaufort Coastal Plain before human development, but between 2004 and 2007, 89 nests were in the Kuparuk and Prudhoe Bay oil fields (Powell and Backensto 2009). Common Ravens have also been reported nesting at the Alpine oilfield (Johnson *et al.* 2003). As their numbers have increased, Common Ravens likely have become important predators of tundra-nesting birds, but no direct measurement of their impact is available (Day 1998). Backensto (2010) found Common Ravens at the Prudhoe Bay and Kuparuk oil fields were generalist predators and scavengers, with small mammal and bird remains found commonly in pellets. In 34 waterfowl, passerine, and shorebird nest predation events filmed with video cameras, predators included arctic fox, all three jaeger species, and Glaucous Gulls, but not ravens (Liebezeit and Zack 2008; Bentzen *et al.* 2017). Thus, despite their increased occurrence in BCR 3, ravens may not be important predators of shorebird nests, although more study is needed.

Estimating the potential effects of apparently higher predator populations in developed areas on breeding shorebirds is difficult because shorebird nest success may be affected by many ecological factors besides predators and infrastructure, such as alternative prey for predators (e.g., lemmings), timing of snow melt, weather, and invertebrate food (Liebezeit *et al.* 2009). An arctic fox removal program conducted in Utqiaġvik between 2005 and 2015, however, determined that shorebird nest survival increased with increasing levels of fox removal effort (R. Lanctot and S. Saalfeld, unpubl. data). Similarly, nest densities, nest survival, and return rates of shorebirds were greater inside a fenced landfill than outside (Saalfeld *et al.* 2013a), likely because the fence was keeping arctic fox out of the landfill. Because predation is a potentially critical factor in Arctic-breeding shorebird productivity, efforts to minimize the food/denning/nesting subsidy of potential shorebird predators is necessary with any new developments.

Finally, seasonal movements of migratory shorebirds may lead to the exposure and spread of a variety of parasites, virulent diseases, and antibiotic resistance genes (Reed *et al.* 2003; Smith and Ramey 2014; Hernández and González-Acuña 2016). Evidence suggests that shorebirds may serve as vectors for diseases such as avian influenza (de Araujo *et al.* 2014) and avian malaria (Ganser 2017).

ACTIONS

- ❑ Assess the effect of predators in natural and human-altered settings on shorebird demography and population size.
- ❑ Monitor distribution and abundance of avian and mammalian predators in relation to village and industrial expansion, and encourage efforts to reduce the availability of human food and artificial den and nest sites near developments.
- ❑ Develop and determine how shorebirds respond to methods (e.g., nest protection devices) to reduce predation. Provide biological expertise to reduce predation in proposed developments.
- ❑ Document the prevalence and effect of common diseases and pathogens in shorebirds and study the role of shorebirds as potential disease vectors.

Climate Change and Severe Weather
Both direct and indirect effects of climate change, driven primarily by increases in temperature, changes in amounts and timing of precipitation, and the duration of ice in the marine environment, are likely to have significant effects in BCR 3 (Rehfisch and Crick 2003; Meltofte *et al.* 2007; Taylor *et al.* 2018). Ecological niche models suggest that climatically suitable breeding conditions for shorebirds will decrease in Beringia (Wauchope *et al.* 2016). Species will likely need to adapt to new climatic conditions at current locations or move north and east to projected refugia in the Eurasian and Canadian Arctic islands to

avoid population declines (Wauchope *et al.* 2016).

The loss and shift in phenology of sea ice in the marine areas of BCR 3 is well documented (Markus *et al.* 2009), with November ice extent declining 5% annually since 1979 (http://nsidc.org/arcticseaicenews/). Maximum sea ice extent in March has been measured via satellite since 1979, and hit its lowest extent in 2017, followed by 2018. These drastic changes may affect marine birds such as Red and Red-necked phalaropes that feed on prey near upwellings (Kuletz *et al.* 2015), although how loss of sea ice will affect invertebrate prey and the survival of phalaropes is unknown.

Global sea levels are predicted to rise on the order of one-half meter over the 21st century (Church *et al.* 2013), resulting in loss of coastal habitats important to shorebirds, particularly low-lying intertidal areas, estuaries, and river deltas. The decrease of sea ice is also increasing the frequency and severity of storms, causing severe coastal erosion and inundation of salt water into freshwater systems (Mars and Houseknecht 2007; Tape *et al.* 2013). The major river deltas fed by glacial streams are likely to change as meltwater levels increase and then decrease as warming temperatures cause glaciers to melt faster and ultimately recede (Churchwell *et al.* 2016). This will affect sediment coarseness, which will likely negatively impact freshwater benthic macroinvertebrates that specialize in finer silts. Thus, ocean- and glacier-driven changes in the river deltas are likely to affect both the composition and total productivity of macroinvertebrates (Rehfisch and Crick 2003; Churchwell *et al.* 2016). It remains unknown how such changes will impact postbreeding shorebirds that stage at these sites during migration.

Terrestrial habitats are rapidly changing in the Arctic due to climate change (e.g., Myers-Smith *et al.* 2011). The occurrence and rate of such change is strongly influenced by the depth of the active layer and the resilience of the underlying permafrost (Hinzman *et al.* 2005). Ice wedge degradation and resulting development of thermokarst ponds has increased the proportion of the landscape covered with surface water (Jorgenson *et al.* 2006). At the same time, surface water is being redistributed from flooded low-centered polygonal tundra centers and low-lying basins to linear troughs surrounding high-centered polygons. These troughs degrade over time, leading to a draining of thaw lakes and a decline in the number of lakes (Smith *et al.* 2005; Smol and Douglas 2007; Liljedahl *et al.* 2016). Similarly, the hilly terrain of the Arctic Foothills is prone to thaw slumps and gully formation, and the formation or drainage of thermokarst lakes. All these changes will affect the suitability of BCR 3 to shorebirds, either by altering the physical habitat conditions needed for nesting (Cunningham *et al.* 2016) or the temporal and spatial distribution of invertebrates used for food. These changes may benefit some species and hurt others (Thompson *et al.* 2016).

Changes in the amount of snow or the timing of snowmelt may also affect shorebirds. More snow during winter may enhance lemming survival (via reduced predation and greater insulation). This may in turn enhance shorebird nest survival by providing an alternative prey source during the summer months to predators. Over the last 60 years, there has been a consistent trend toward earlier snowmelt at Utqiaġvik, with snowmelt date advancing by about 10 days (Hinzman *et al.* 2005; Saalfeld and Lanctot 2017). Earlier summers, combined with warmer temperatures, are also changing dominant tundra vegetation types, with decreases in plant species that prefer wet and moist conditions, and increases in tall shrubs (Tape *et al.* 2006; Elmendorf *et al.* 2012; Villarreal *et al.* 2012). These changes are likely to negatively affect shorebird species that are dependent on wetlands (e.g., Long-billed Dowitcher, Red Phalarope; Cunningham *et al.* 2016), but may promote shrub-tolerant species (Thompson *et al.* 2016). The distribution and abundance of predators (see Invasive and Problematic Species, Pathogens, and Genes) and parasites may also change in response to altered habitat and climatic conditions (Ganser 2017).

Earlier summers and more variable seasonal weather may also decouple the apparent synchrony between shorebird hatch and the emergence of invertebrates, potentially leading to reduced growth and survival of young (Schekkerman *et al.* 2003; Pearce-Higgins and Yalden 2004; McKinnon *et al.* 2012; Senner *et al.* 2016; Saalfeld *et al.,* in review), and ultimately long-term population declines (e.g., van Gils *et al.* 2016). Alternatively, warmer temperatures may provide thermogenic relief to growing offspring (McKinnon *et al.* 2013), although the availability of invertebrates may be limiting later in the breeding season due to variable seasonal weather (Saalfeld *et al.,* in review). Opportunistic species and those that typically nest later in the breeding season appear to be more resilient to earlier phenologies (Saalfeld and Lanctot 2017).

In general, the extent and severity of effects from climate change, either positive or negative, are likely to be species-specific and dependent on many variables that can change annually. Collectively, however, long-term changes in climate are likely to have negative effects on shorebirds.

ACTIONS

- ❑ Participate in long-term, multi-disciplinary, collaborative projects to examine the impact of melting sea ice and warming sea temperatures on marine invertebrate communities and shorebird movement/foraging patterns.
- ❑ Conduct long-term studies to assess and model how storm intensity and severity, sea-level rise, saltwater intrusion, changes in salt water chemistry, and changes in glacier melt affects the quality (e.g., invertebrate abundance and diversity) of littoral habitats and their use by shorebirds.
- ❑ Collect long-term demographic data to model potential effects on shorebird populations from changing environmental (e.g., snow depth, snowmelt, temperature) and ecological conditions (e.g., predators, alternative prey, timing of invertebrate emergence).
- ❑ Evaluate factors that convey resilience to shorebird species with respect to climate change, including timing of arrival and nesting phenology (i.e., "mismatch"), habitat use, foraging patterns, and flexibility of migratory behaviors.
- ❑ Identify areas or habitats in need of protection in Arctic Alaska that may serve as areas of high diversity or refugia due to climate change.

Pollution

Mercury, persistent organic pollutants, radioactivity, plastics, and other contaminants emitted into the environment from both natural and anthropogenic sources can be transported long distances through atmospheric and oceanic pathways to the Arctic, where they pose threats to the health of both wildlife and humans (Li and Macdonald 2005; AMAP/UNEP 2013). Recent studies suggest that climate change will significantly alter contaminant pathways and mobility, increasing contaminants in the Arctic environment (Macdonald *et al.* 2005; AMAP 2011). Within BCR 3, sequestered persistent pollutants may be liberated from thawing permafrost, resulting in an increase in the methylation of mercury (Matz *et al.* 2011b). Shorebirds will be exposed to these new pollution sources at breeding sites, and may also accumulate environmental contaminants elsewhere during their annual cycle.

A recent study of mercury contamination in eight shorebird species breeding and staging in BCR 3 found low blood mercury concentrations in post-breeding staging shorebirds, but higher blood mercury concentrations in some breeding shorebirds (specifically at Utqiaġvik, Perkins *et al.* 2016). Differences in blood mercury exposure levels among species were attributed to sampling location, habitat association, and the age and sex of individuals. A larger study conducted at nine sites distributed across Alaska and Arctic Canada confirmed that blood and feather mercury concentrations varied by year, location, species, and individual (Stenhouse *et al.* 2014). Mean blood mercury concentrations were generally below levels considered detrimental to avian health; only 2 birds (0.2%) had levels associated with toxic effects, while 83 birds (7.6%) had levels believed to potentially cause physiological constraints and impact reproductive behavior. Further, most shorebirds sampled at Utqiaġvik had particularly high levels of mercury in blood samples, suggesting a local source of exposure (Perkins *et al.* 2016). These results and others (Hargreaves *et al.* 2010, 2011) indicate that Arctic-breeding shorebirds are exposed to potentially detrimental levels of mercury.

A study of contaminants in shorebird eggs from 16 species in Alaska (10 species in BCR 3) detected low levels of most inorganic and organic contaminants (Saalfeld *et al.* 2016). Higher inorganic contaminant concentrations were found in eggs of Pectoral and

Semipalmated Sandpipers, and higher organic contaminant concentrations were found in eggs of American Golden-Plover, Black-bellied Plover, and Semipalmated Sandpiper. The relatively low concentrations of contaminants found in this study, however, suggest that Alaskan breeding environments are relatively free of most contaminants. The prevalence of other contaminants, however, such as substituted diphenylamine antioxidants and benzotriazole UV stabilizers that are used as additives to plastics, rubbers, fuels, lubricants, paints, coatings, and adhesives, have been not investigated in shorebirds (Lu *et al.* in press).

Most Industries and communities in BCR 3 rely on seagoing or river vessels to deliver diesel oil and gasoline for electrical generation and heating. Marine traffic through the Northwest Passage is expected to increase with decreases in sea ice. Such activities require storage and transfer facilities along the coast, and current facilities vary in quality and maintenance. A recent multi-year federal initiative to upgrade and consolidate village bulk fuel facilities should lower the risk of leaks or spills at remote villages. However, spills from delivery barges and accidents at fuel depots may lead to chronic oiling of birds and the contamination of prey resources at stopover sites.

ACTIONS

- ❑ Continue to monitor levels of contaminants in shorebirds and conduct studies to determine which species are most susceptible to bioaccumulation.
- ❑ Determine where in the annual cycle shorebirds in BCR 3 are accumulating contaminants, and investigate how contaminants affect shorebirds.
- ❑ Determine how shorebirds breeding at Utqiaġvik are exposed to mercury, and whether higher levels of mercury are affecting their productivity and survival.

Emerging Conservation Issues

The North Slope Borough's population grew about 2.7% between 2008 and 2015 (https://www.census.gov/quickfacts/fact/table/northslopeboroughalaska/PST045218). The footprint of some communities is expected to double in size by 2050 (USDOI BLM 2012), especially if oil and gas development expands in the region (Thomas *et al.* 2009). This will likely lead to an increase in the filling of wetlands, general loss of natural habitat, expansion of landfills, and an increase in other human activities, such as off-road vehicle use, that may negatively affect shorebirds.

Several villages along the Arctic Coast have explored the use of wind turbines that are "hybridized" to existing diesel generators. To the extent that wind power diminishes the need for diesel fuel, the risk of oil spills would be reduced. Wind turbines themselves pose a risk to migrating shorebirds, however, because migrating flocks may collide with towers and blades (Smallwood 2013; Zimmerling *et al*. 2013). Given that coastal sites in BCR 3 experience consistent winds, the use of wind turbines in the region is likely to grow, especially in villages away from oil and gas supply lines. If properly sited to minimize bird strikes, such efforts should be encouraged as they will reduce the likelihood of pollution related to a reliance on fossil fuels.

The development of hard rock and coal resources has been proposed in the southern portions of NPR–A; such activities are currently prohibited and would require congressional legislation to change. Mining directly modifies only a small amount of surface area but can indirectly affect a much larger area through introduction of fuels, heavy metals, and acids into the environment. Contaminated sites may have broad footprints due to the persistence of contaminants in the environment or effects far from the point source. Developments in the interior of NPR–A would have less impact on shorebirds than coastal developments due to the lower diversity and abundance of birds, but some Interior species would potentially be affected (Johnson *et al.* 2007; Bart *et al.* 2013; Saalfeld *et al.* 2013b). Currently few studies have evaluated the effects of mining on shorebirds.

ACTIONS

- ❑ Quantify local and cumulative effects of community expansion on shorebirds and identify useful mitigation measures.

Evaluation of Conservation Progress

A tremendous amount of research focused on shorebirds has been conducted within BCR 3 since the last version of the shorebird plan was completed in 2008. This includes work on the basic natural history of shorebirds, population monitoring efforts, studies to estimate demographic rates, and assessments of factors that potentially limit shorebird populations. This work was done by many organizations, primarily in the Arctic Coastal Plain of BCR 3, although some studies were conducted in the foothills and Brooks Range, and the far western region of the BCR.

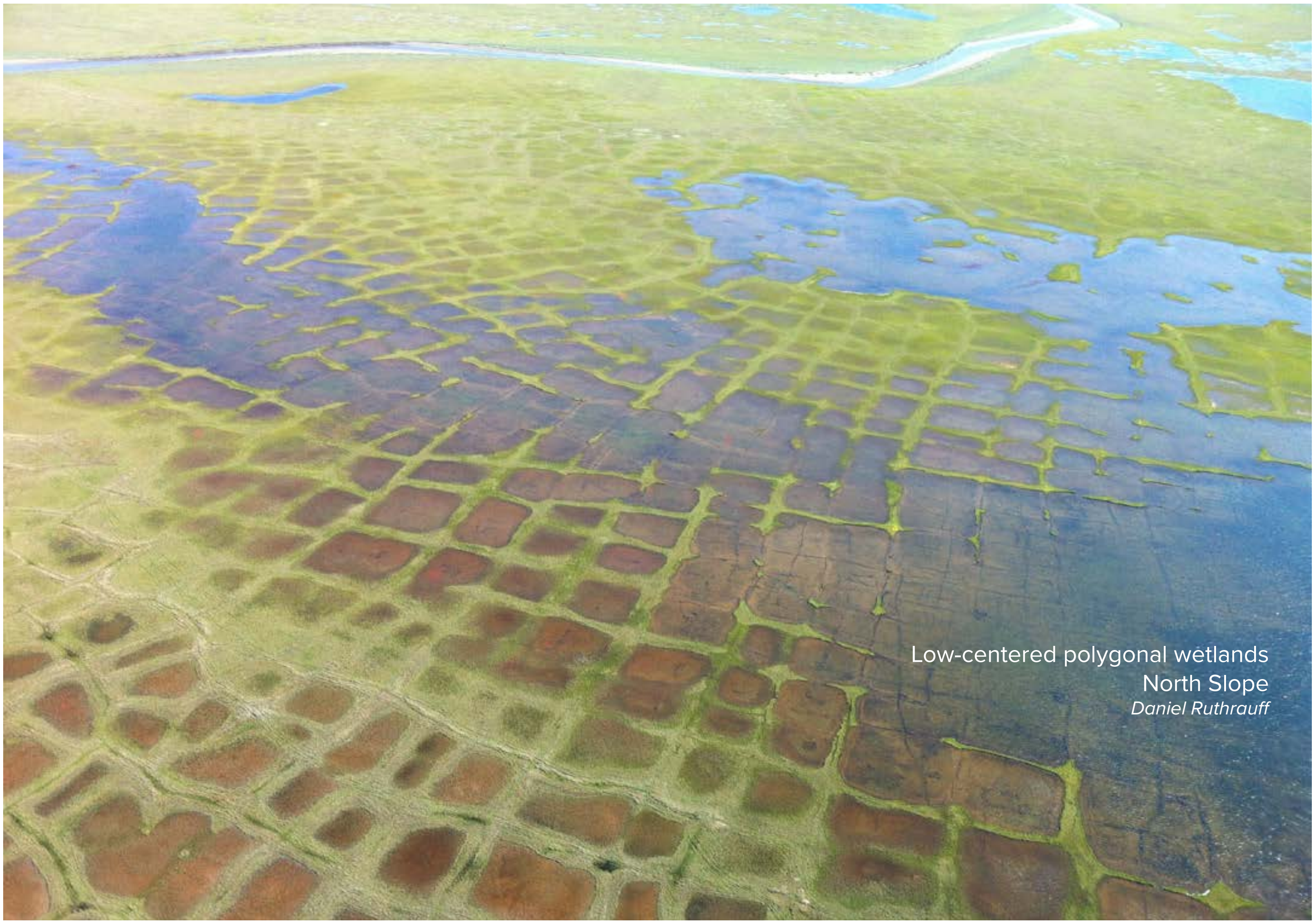
Monitoring studies conducted between 1998 and 2008 included work on breeding shorebirds across the Arctic Coastal Plain (Andres *et al.* 2012a; Bart *et al.* 2012b, 2013; Smith *et al.* 2012; Saalfeld *et al.* 2013b), montane regions of national parks (Tibbitts *et al.* 2006), and postbreeding shorebirds using river deltas and lagoons of the Chukchi and Beaufort sea coasts (Brown *et al.* 2012; Taylor *et al.* 2010, 2011; Churchwell *et al.* 2016, 2017). This research documented important areas throughout the Arctic Coastal Plain (Sullender and Smith 2016), facilitating the planning of oil and gas leasing within the NPR–A and the Arctic NWR in ways to minimize effects on shorebirds.

There was a continued emphasis on conducting intensive breeding ecology studies at sites throughout the Arctic Coastal Plain. These sites, along with others in Russia and Canada, collaborated to form the Arctic Shorebird Demographics Network (https://www.manomet.org/publication/arctic-shorebird-demographics-network-asdn/). This partnership investigated how environmental conditions on the breeding grounds affect demographic traits (e.g., adult survival, nest survival; see Weiser *et al.* 2018a, b, c). This partnership also contributed to spatial-temporal studies of shorebirds focused on mercury pollution (Stenhouse *et al.* 2014, Perkins *et al.* 2016), avian malaria (Ganser 2017), incubation patterns (Bulla *et al.* 2017), gut microbiota (Grond *et al.* 2018), trophic mismatch (Kwon *et al.,* in review), and effects of factors during the nonbreeding season on breeding productivity (Boldenow 2018). Additional side projects are on-going.

A variety of natural history studies of shorebirds were also conducted at many of these sites. Examples include studies on settlement strategies of shorebirds (Saalfeld and Lanctot 2015), replacement of nests (Naves *et al.* 2008; Gates *et al.* 2013), reuse of nests (Herzog *et al.* 2018), arrival date estimation using stable isotopes (Doll *et al.* 2015), adult and chick survival of Dunlin (Hill 2012), habitat selection of nesting shorebirds (Cunningham *et al.* 2013), contaminant loads in eggs (Saalfeld *et al.* 2016), and genetic studies of American Golden-Plovers (Yezerinac *et al.* 2013) and Dunlin (Miller *et al.* 2015).

There were also a number of studies assessing how human developments influence shorebirds. A multi-site study assessed the influence of human development and predators on nest survival of tundra birds (Liebezeit *et al.* 2009). Other studies used cameras to document the predators of shorebird nests (Bentzen *et al.* 2017), and still others monitored predators themselves to see how their movements were affected by anthropogenic food sources near human developments (Powell and Backensto 2009; Lehner 2012; Savory *et al.* 2014; Elmhagen *et al.* 2017). Saalfeld *et al.* (2013a) evaluated the effects of a new landfill at Utqiaġvik on shorebird nest survival, and others investigated how landfills may provide supplemental food


Dunlin
Daniel Ruthrauff



Low-centered polygonal wetlands
North Slope
Daniel Ruthrauff

to potential predators of shorebirds and their nests (Weiser and Powell 2010, 2011). Several field programs focused on understanding the effects of climate change on nesting shorebirds, including changes in species composition and abundance (Taylor *et al.* 2018), shorebird arrival and nest initiation patterns in response to earlier spring phenology (Liebezeit *et al.* 2014; Saalfeld and Lanctot 2017; Ward *et al.* 2016; D. Ruthrauff, unpubl. data), and assessments of potential mismatches between the timing of arthropod emergence and shorebird hatch (Kwon *et al.,* in review; Saalfeld *et al.,* in review, D. Ruthrauff, unpubl. data).

Finally, the reduction in size of tracking devices facilitated numerous studies to document the movement of shorebirds both locally and throughout their annual cycle. This research assessed the migratory connectivity of Semipalmated Sandpipers (Brown *et al.* 2017), Pectoral Sandpipers (Kempenaers and Valcu 2017), Buff-breasted Sandpipers (Lanctot *et al.* 2016), and include considerable ongoing research on many other species. Such studies will aid in identifying priority conservation areas and sites at which to focus future studies.

Stilt Sandpiper
Zak Pohlen

BCR 4: NORTHWESTERN INTERIOR FOREST

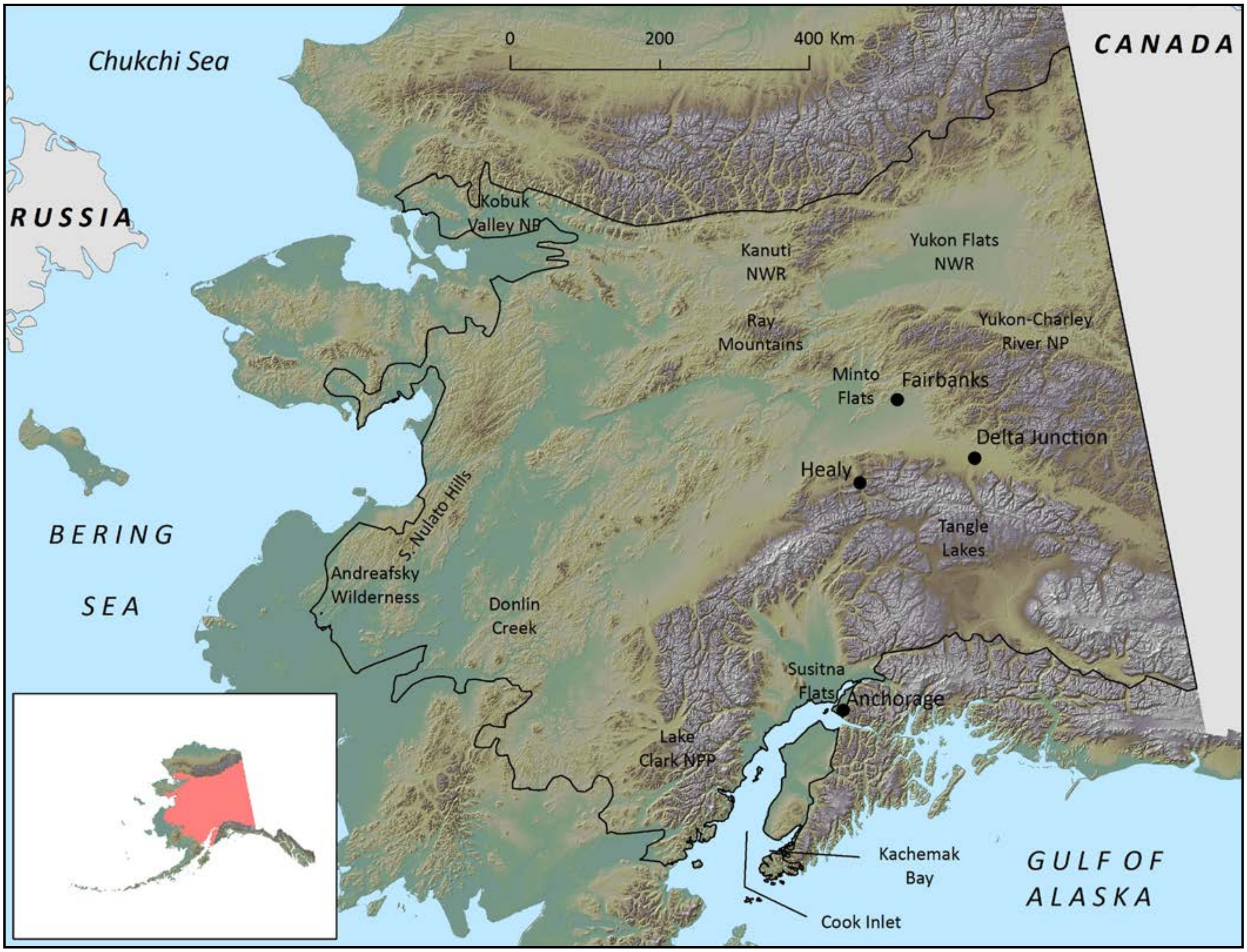


Figure 7. Northwestern Interior Forest Bird Conservation Region 4. Lands included in BCR 4 are in red on the inset and outlined in black on the map.

This largest of Alaska's BCRs is an extensive, 733,000-km^2 patchwork of mainly 21 diverse ecoregions (Appendix 6) located in Central Alaska (Figure 7). Critical habitats for boreal shorebirds occur throughout much of this BCR and are contained mostly within extensive state- and federally-managed lands (Figure 2). Cold winters and warm summers characterize the continental climate of most of the BCR, with Cook Inlet being under a more moderating maritime influence. Much of the Interior BCR is a mosaic of vegetation communities, dominated by boreal forest, including needleleaf, deciduous, and mixed forests. Tall shrub communities occur along rivers, drainages, and near tree line. Bogs, consisting of low shrubs and shrub-graminoid communities, are common in the lowlands. Alpine dwarf shrub communities are common throughout mountainous regions, while highest elevations are generally devoid of vegetation. The Cook Inlet region is characterized by vast expanses of intertidal habitats.

Priority Species

This BCR supports eight taxa of "greatest" or "high" conservation concern and sizeable portions of Alaska populations of nine additional stewardship species (Table 9). The wet or moist lowlands support multiple species of migrating and breeding shorebirds, including Least, Spotted, and Solitary sandpipers; Lesser Yellowlegs; Short-billed Dowitchers; and Wilson's Snipe (Gabrielson and Lincoln 1959; Kessel 1979; Gibson 2011). American Golden-Plovers, Wandering Tattlers, Whimbrels, and Surfbirds are found in tundra habitats (the tattlers often associated with riparian areas) in the Interior's foothills and mountainous ecoregions (Senner and McCaffery 1997; Gill *et al.* 2002b; Johnson and Connors 2010; Harwood 2016). The taiga-tundra transition zone hosts patchily distributed breeding Hudsonian Godwits and Upland Sandpipers (Gibson 2011; Walker *et al.* 2011; Harwood 2016). Cook Inlet is the primary wintering site for the nominate form of Rock Sandpiper (*C. p. ptilocnemis*) (Ruthrauff *et al.* 2013), as well as a major spring stopover site for Western Sandpipers and Dunlin (Gill and Tibbitts 1999). Significant numbers of Hudsonian Godwits and Short-billed and Long-billed dowitchers also use upper Cook Inlet during migration (Gill and Tibbitts 1999). Scattered annual observations of dozens to hundreds of north-bound Semipalmated and Pectoral sandpipers and Long-billed Dowitchers in places like Delta Junction, Fairbanks, and Kanuti National Wildlife Refuge (NWR) (J. Mason, D. Gibson, C. Harwood, pers. comms.) suggest Interior Alaska may support many thousands of shorebirds migrating within the Central Americas Flyway in the spring.

Important Shorebird Areas

The interior boreal forest and alpine biomes that constitute most of BCR 4 generally do not support the richness, diversity, or densities of breeding shorebirds found in the more productive coastal habitats to the south, west, and north. Nonetheless, the area does have several important shorebird areas. The southern Nulato Hills (including the Andreafsky Wilderness) support an estimated 60% of the world's breeding population of Bristle-thighed Curlews (Marks *et al.* 2002), with at least half of the curlews in the Nulato Hills occurring in BCR 4 (B. McCaffery, pers. comm.; C. Handel, unpubl. data). During spring migration, Kachemak Bay's rich tidal mudflats historically supported up to 200,000 shorebirds, including substantial numbers of Western Sandpipers and more than 10% of the world's population of Surfbirds. As such, Kachemak Bay was designated as a site of international importance in the Western Hemisphere Shorebird Reserve Network (WHSRN) in 1995. Although long-term monitoring has suggested a decline in shorebirds using Kachemak Bay in more recent years, prompting a reassessment of that designation (Matz *et al.* 2011a), the importance of the site to possibly recovering populations remains, resulting two years ago in an expansion of the WHSRN site to include all

Table 9. Priority shorebird species that commonly breed, stage during migration, or winter in Northwestern Interior Forest Bird Conservation Region 4.

Breeding	Migration	Winter
American Golden-Plover	Black-bellied Plover	Rock Sandpiper (*ptilocnemis*)
Bristle-thighed Curlew	American Golden-Plover	Rock Sandpiper (*tschuktschorum*)
Whimbrel	Whimbrel	
Hudsonian Godwit	Hudsonian Godwit	
Surfbird	Dunlin (*pacifica*)	
Short-billed Dowitcher	Pectoral Sandpiper	
Solitary Sandpiper	Western Sandpiper	
Wandering Tattler	Short-billed Dowitcher	
Lesser Yellowlegs	Long-billed Dowitcher	
Red-necked Phalarope	Lesser Yellowlegs	

See Tables 1, 2, and 4 for conservation priority status and relative seasonal importance.

of Kachemak Bay Critical Habitat Area as well some city parcels in Beluga Slough (G. Matz, pers. comm). The vast expanses of intertidal habitats in Cook Inlet are critical to migrating and even wintering shorebirds (see previous section). Within the Inlet, Susitna Flats' inland muskeg (i.e., Beluga River study site) hosts Alaska's largest population of breeding Hudsonian Godwits documented to date (Walker *et al.* 2011).

Primary Conservation Objectives

There is relatively little information about the occurrence and distribution of most shorebirds in BCR 4. The combination of a vast region, limited access, and widely dispersed species and individuals makes it difficult to obtain even basic information. With few exceptions, the breeding distributions and habitat associations of most boreal-nesting shorebirds in Alaska are poorly documented. While a substantial amount of work has been done to inventory shorebirds in some alpine and upland areas within BCR 4 (e.g., Nulato Hills; Lake Clark, Kobuk Valley, and Yukon-Charley Rivers National Parks and Preserves; Swanson and Nigro 2003; Tibbitts *et al.* 2006; Ruthrauff *et al.* 2007; C. Handel, unpubl. data; Appendix 5), very few such inventories exist for lowland-breeding shorebirds. Another critical piece of data needed for effective conservation is accurate population estimates of boreal-nesting shorebirds. For some species, such estimates are best derived on the nonbreeding grounds. On the breeding grounds, however, the best tool presently available for monitoring some of these species is the North American Breeding Bird Survey (BBS), despite the program's limited coverage in Alaska. The Alaska Landbird Monitoring Survey (ALMS, https://www.usgs.gov/centers/asc/science/alaska-landbird-monitoring-survey), a recent off-road complement to the BBS, shows promise for inventorying, describing habitat associations for, and ultimately monitoring a few boreal shorebird species. Like the BBS, however, ALMS surveys generally do not occur during the peak period for detecting shorebirds. Very little monitoring has been done even in the aforementioned, well-inventoried uplands and alpine sites. Growing concern for species facing possible threats outside the boreal breeding grounds (e.g., hunting of Lesser Yellowlegs) has prompted recent research into tracking of birds throughout their annual cycle.

ACTIONS

- ❑ Design, assess, and implement approaches (e.g., BBS, ALMS, breeding bird atlas, eBird) to inventory (and possibly eventually monitor) boreal shorebirds and identify or refine their habitat associations.
- ❑ Develop habitat-based models to predict the abundance and distribution of lowland-, upland-, and alpine-breeding boreal shorebirds.
- ❑ Apply abundance and distribution information to identify key boreal shorebird habitats and sites hosting priority species of conservation concern. This is particularly important for patchily distributed breeders like Whimbrels and Hudsonian Godwits.
- ❑ Determine migratory timing, routes, and site use of priority boreal-breeding shorebirds, especially for species facing possible threats (e.g., harvest, land-use changes) outside the breeding grounds.
- ❑ Raise the profile of boreal-breeding shorebirds, especially for species of conservation concern, through public presentations (including to the ornithological community), media outreach (e.g., Facebook), etc.
- ❑ Continue to foster and participate in cooperative research and monitoring throughout the Western Hemisphere such as the Pacific Shorebird Migration Project (Whimbrel, Hudsonian Godwit) and recent Lesser Yellowlegs tracking.
- ❑ Identify and delineate potentially distinct populations of shorebirds (e.g., Upland Sandpipers) breeding in Interior Alaska.

Priority Conservation Issues and Action

Energy Production and Mining

Abundant petroleum and mineral resources occur widely throughout the Northwestern Interior Forest. The potential for considerable active and prospective mining for coal/coal-bed methane, precious metals, and rare earth elements exists widely throughout the BCR. Although depressed economic climates can greatly stifle resource development that might threaten shorebirds and their habitats in the BCR, the demonstrated profitability of these petroleum and mineral markets ensures continuous economic interest for exploiting these resources when economics are favorable. Notwithstanding the vagaries of markets during the life of this plan, we present some of the important existing or prospective petroleum or mineral resource issues that potentially affect shorebirds and their habitats in the BCR. Because Cook Inlet hosts the BCR's highest seasonal concentrations of shorebirds, arguably the greatest threats from resource development occur in this subregion. Near-term threats to other subregions tend to be more local, with less chance for pronounced negative population effects.

Nearly all of Cook Inlet is open to oil lease sales by either state or federal agencies, and most of the current energy production in BCR 4 is concentrated in this region. Currently there are 16 platforms situated within Cook Inlet, along with large storage and sub-seabed transfer facilities and a refinery. Additionally, millions of barrels of jet fuel are transported each year across the intertidal zone between the Port of Anchorage and the Anchorage International Airport via a new subsurface pipeline. Offshore production has occurred in this region since the late 1960s, and aging production and transportation infrastructure poses an increased risk for spills (Port of Alaska 2017). Additionally, facilities must withstand relatively frequent seismic events in this earthquake-prone region. Spills or persistent discharge from drilling platforms, transfer facilities, and pipelines are potentially harmful to the marine, estuarine, tidal, and intertidal environments. Powerful currents and ice floes that choke much of Cook Inlet in winter would hamper containment and cleanup efforts from a spill in this region. Significant numbers of wintering Rock Sandpipers (Ruthrauff *et al.* 2013), migrating Western Sandpipers and Dunlin, and breeding and migrating Solitary sandpipers, Greater and Lesser yellowlegs, Hudsonian Godwits, and Short-billed Dowitchers use the Cook Inlet region (Gill and Tibbitts 1999).

Natural gas resources also exist widely in more inland state lands. Sizeable leases already exist for the Susitna and Nenana (includes Minto Flats State Game Refuge) basins, with exploration licenses issued for the Healy, Tolsona, and North Nenana basins, and proposed for the Houston-Willow Basin (ADNRDOG 2017). Finally, an Alaska Native regional corporation has conducted recent seismic work within the Yukon Flats NWR to explore for oil and gas. Breeding shorebirds potentially affected by these developments include Semipalmated Plovers; Spotted, Solitary, and Least sandpipers; Lesser Yellowlegs; Whimbrels; and Wilson's Snipe.

Placer mining for gold makes up much of the region's small-scale mining activity. This technique affects entire watersheds by degrading riparian habitats, accumulating silt in downstream water bodies, and destroying permafrost in adjacent areas through heavy equipment use. Physical modification of the watershed may result in displacement of breeding and foraging shorebirds, including Semipalmated Plovers, Spotted Sandpipers, and Wandering Tattlers, although some riparian corridors heavily disturbed by placer mining support some of the highest reported nesting densities of tattlers (Gill *et al.* 2002b).

In addition to small-scale placer mines, large industrialized mines present a larger footprint and an increased risk of habitat loss and pollution to a larger area. Industrialized mines use extraction techniques that expose large areas to potentially catastrophic results. For example, cyanide is often used to leach microscopic amounts of gold out of hard rock and can diffuse into the adjacent groundwater. Contaminated sites may have broader effects on shorebirds and important habitats due to the persistence of contaminants in the environment or effects far from the point source. Currently there are three active large industrial mines in BCR 4 (Usibelli Coal, Pogo, and Fort Knox) and four proposed large mine projects (Chuitna, Donlin Creek, Livengood, and Pebble; ADNRMLW 2017). Exploration occurred during 2010–2013 for leases in the proposed MAN Alaska mining area, which would include some 2,200 km^2 located in the Tangle Lakes region at the east end of the Denali Highway. Exploration for rare earth elements has occurred recently in the northern Ray Mountains. Development associated with the MAN project and Ray Mountains would likely affect breeding habitats for American Golden-Plovers, Upland Sandpipers, and Whimbrels. The Chuitna Coal Project, with permitting activities suspended in April 2017, lies just 12 miles west of Alaska's largest documented breeding concentration of Hudsonian Godwits at Beluga River.

Renewable energy projects are limited in BCR 4, with only three relatively modest wind farms to date. These include Eva Creek in Healy, Fire Island in Anchorage, and Delta Wind in Delta Junction (REAP 2016). Turbines at Eva Creek could pose a minor threat to alpine breeding shorebirds or ridge-favoring migrants, while Fire Island, just west of Anchorage, could possibly intercept offshore migrants. Currently, wind power is an arguably negligible threat to Alaska's shorebird populations. Nevertheless, more widespread deployment of turbines at sites in the future may elevate this threat.

ACTIONS

- ❑ Identify effects (including pollution) of energy production or mining in BCR 4 on breeding (especially interior montane and foothills), passage migrant (primarily through Cook Inlet), and wintering (mainly Rock Sandpiper) shorebird populations, and evaluate options for mitigation, such as oil spill response plans.
- ❑ Minimize loss and degradation of shorebird habitats in BCR 4 by participating in natural resource planning and management that addresses issues such as oil and gas leasing in western Cook Inlet, residential sprawl in eastern Cook Inlet, large mines in Interior Alaska, and development associated with transportation corridors such as Ambler Road.
- ❑ Conduct breeding ecology studies of priority boreal shorebirds in areas typically targeted for mining (interior subalpine) and oil and gas development (interior basins).

Transportation and Service Corridors
BCR 4 hosts most of the state's existing highways, roads, railbelt, and >50% of the Trans-Alaska Pipeline System. While the actual footprint of this infrastructure is relatively limited, its impacts are far-reaching. These corridors bisect shorebird habitats in alpine, upland, and lowland habitats; encourage increased human access and development in previously isolated habitats; facilitate the spread of invasive plants and pathogens that alter habitats; and increase the likelihood of introducing pollutants (e.g., chemical and fuel spills) via vehicle traffic.

While largely unrealized to date because of considerable logistical and financial constraints, the state's "Road to Resources" program (ADOTPF 2011) has the potential to dramatically increase the footprint of corridors, as well as their associated impacts to shorebirds and their habitats, in the BCR. Recently the most actively pursued major projects have been roads to the Ambler Mining District and West Susitna region. Construction began in 2013 to extend the Elliot Highway to Tanana.

Several major gasline projects have also been proposed for the region. These include 700- to 800-mile-long buried pipelines carrying liquefied natural gas (LNG) from Prudhoe Bay to either Nikiski (Cook Inlet) or Big Lake (north of Anchorage), or LNG trucked from Cook Inlet to Fairbanks. The Donlin Creek gold mining project has also proposed a 315-mile-long natural gas pipeline running northwest through the Alaska Range from Cook Inlet to power the mine (USACE 2016). Other infrastructure proposed in this project's Environmental Impact Statement includes a 30-mile-long access road from the mine to a port on the Kuskokwim River, as well as considerable barging of diesel fuel, supplies, and cargo on the Kuskokwim River.


Whimbrel
Lucas DeCicco

ACTIONS

- ❑ Given that most development in BCR 4 has occurred or is expected to occur along transportation and service corridors, identify any critical habitats, sites, or populations therein.
- ❑ Assess the efficacy of proposed programs such as the road-based Breeding Bird Survey to monitor boreal shorebird populations and characterize habitat associations. Determine if roadside occupancy patterns are representative of off-road areas.

Biological Resource Use

While subsistence harvest of shorebirds within BCR 4 is suspected to be low, there is considerable sport and illegal subsistence hunting of shorebirds (and boreal-breeding shorebirds in particular) migrating through and wintering in the Caribbean and northern South America (Watts *et al.* 2015; Watts and Turrin 2016). The extent to which Alaska-breeding boreal shorebirds such as Lesser Yellowlegs and American Golden-Plovers are being affected by hunting in these areas is unknown (but see Reed *et al.* 2018).

ACTIONS

- ❑ Determine the migratory timing, routes, and site use of Alaska-breeding boreal shorebirds of conservation concern such as Lesser Yellowlegs and American Golden-Plovers to determine whether they overlap with outside sport hunting and subsistence harvest areas.
- ❑ Obtain or refine estimates of illegal and legal harvest levels for Alaska-breeding boreal shorebirds when outside Alaska, especially for those migrating through or wintering in the Caribbean and northern South America, especially the heavily hunted Lesser Yellowlegs and American Golden-Plovers.

Climate Change and Severe Weather

Broad-scale habitat changes have already been observed in the boreal forest due to climate change and more are predicted to occur. There has been a significant increase in mean winter annual temperature in the North American boreal forests over the last half century (Hinzman *et al.* 2005). Concomitant changes observed with an increase in temperature include: an increase in shrubs across tundra habitats (Silapaswan *et al.* 2001; Stow *et al.* 2004; Tape *et al.* 2006; Walker *et al.* 2006), reduction in size and number of waterbodies in wetland habitats (Klein *et al.* 2005; Riordan 2005; Roach *et al.* 2011), peatland loss (Frolking *et al.* 2011), an increase in plant pathogens and pests (aspen leaf miners, alder blight, spruce budworm, spruce bark beetle, sawflies; Werner *et al.* 2006), and more active wildfire regimes (Kasischke and Turetsky 2006; Kasischke *et al.* 2010; Turetsky *et al.* 2011). Additionally, boreal forest has advanced both elevationally into alpine areas and latitudinally into Arctic uplands and permafrost-affected lowland tundra (Lloyd 2005; Dial *et al.* 2007; but see Wilmking *et al.* 2004).

In this context, the most immediate concern for shorebirds in BCR 4 is the drying of wetland habitats. In a study of drying trends from the 1950s to 2002, Riordan (2005) found a reduction in both the area and number of shallow, closed-basin ponds, albeit with considerable fine-scale heterogeneity (Roach *et al.* 2011), in all regions studied in Alaska's boreal forest region. The regional trend in shrinking ponds may be due to either increased drainage as the region's discontinuous permafrost warms, or due to increased evapotranspiration as a result of warmer and extended growing seasons. Klein *et al.* (2005) documented a similar phenomenon on the Kenai Peninsula with the disappearance of kettle ponds and the invasion of black spruce into wetlands and muskeg. Changes in the overall abundance of wetland habitats will likely affect shorebird prey abundance and distribution. Drying of subarctic tundra and taiga could result in landscape-scale reductions of aquatic and semi-aquatic invertebrate populations. The degree to which the timing of shorebird breeding remains coupled to the life cycles of their prey is also of key importance, as shorebird hatch appears highly synchronized with peak availability of surface-active insects upon which the chicks depend (Holmes 1966; Schekkerman *et al.* 2003).

Additional effects of such habitat changes on shorebirds, particularly breeders, are difficult to predict. Tundra-breeding shorebirds in BCR 4 may be displaced northward or further upward in elevation, and squeezed into more fragmented habitats. The distribution and abundance of predators and parasites may also change in response to altered habitat and climatic conditions.

ACTIONS

- ❑ Support research, including development of dynamic models, on the effects to boreal shorebird habitats and demography relative to changes in major ecosystem drivers (e.g., increased frequency, size, and severity of wildland fires; permafrost loss; wetland drying; elevational and latitudinal shrubification or forestation) posited under future climate scenarios for BCR 4.
- ❑ Support research on the effects of changes to wetlands and permafrost on food availability, including the potential decoupling of chick hatch from the timing of peak availability of insect populations.

Emerging Conservation Issues

We recognize additional (although currently minor) conservation issues for boreal shorebirds and their habitats potentially emerging over the life of this plan. For instance, Alaska's population grew about 9% over the life of the 2008 plan (ADOLWD 2017). Although an estimated 78% of Alaskans in 2016 resided in BCR 4 (primarily in Anchorage, Kenai/Soldotna, and Matanuska-Susitna and Fairbanks North Star Boroughs), the residential, commercial, and industrial footprints therein are arguably small, given the vastness of the entire region. However, over time, incremental human encroachment, especially on important shorebird migration stopover sites and breeding areas, could threaten local shorebird populations, and even species, in the case of migration bottlenecks. Biomass production (i.e., commercial harvest of timber for firewood and wood pellet production), while currently limited in its scope and cost-effectiveness, may become more feasible, especially when traditional heating fuels are expensive and when access to timber is facilitated. Such tree harvest could affect true boreal breeders such as Lesser Yellowlegs and Solitary Sandpipers. Finally, concern is building because of the increasing establishments of invasive plants in the BCR. For example, white sweetclover (*Melilotus alba*) and foxtail barley (*Hordeum jubatum*) have infested dozens of sites and with increasing acreage and latitudinal spread in the Dalton Highway Corridor Management Area (Bureau of Land Management 2013). The waterweed *Elodea* has been found on the Kenai Peninsula, Fairbanks, and Anchorage, where floatplanes may inadvertently serve as transport of *Elodea* to other waterbodies. While the establishment of these and other weeds will undoubtedly affect terrestrial and aquatic shorebird habitats, it is currently unknown how deleterious any such effects will be.

ACTIONS

- ❑ Continue to monitor the timing and use of key migratory stopover sites such as Kachemak Bay that face ever-increasing human population pressures.

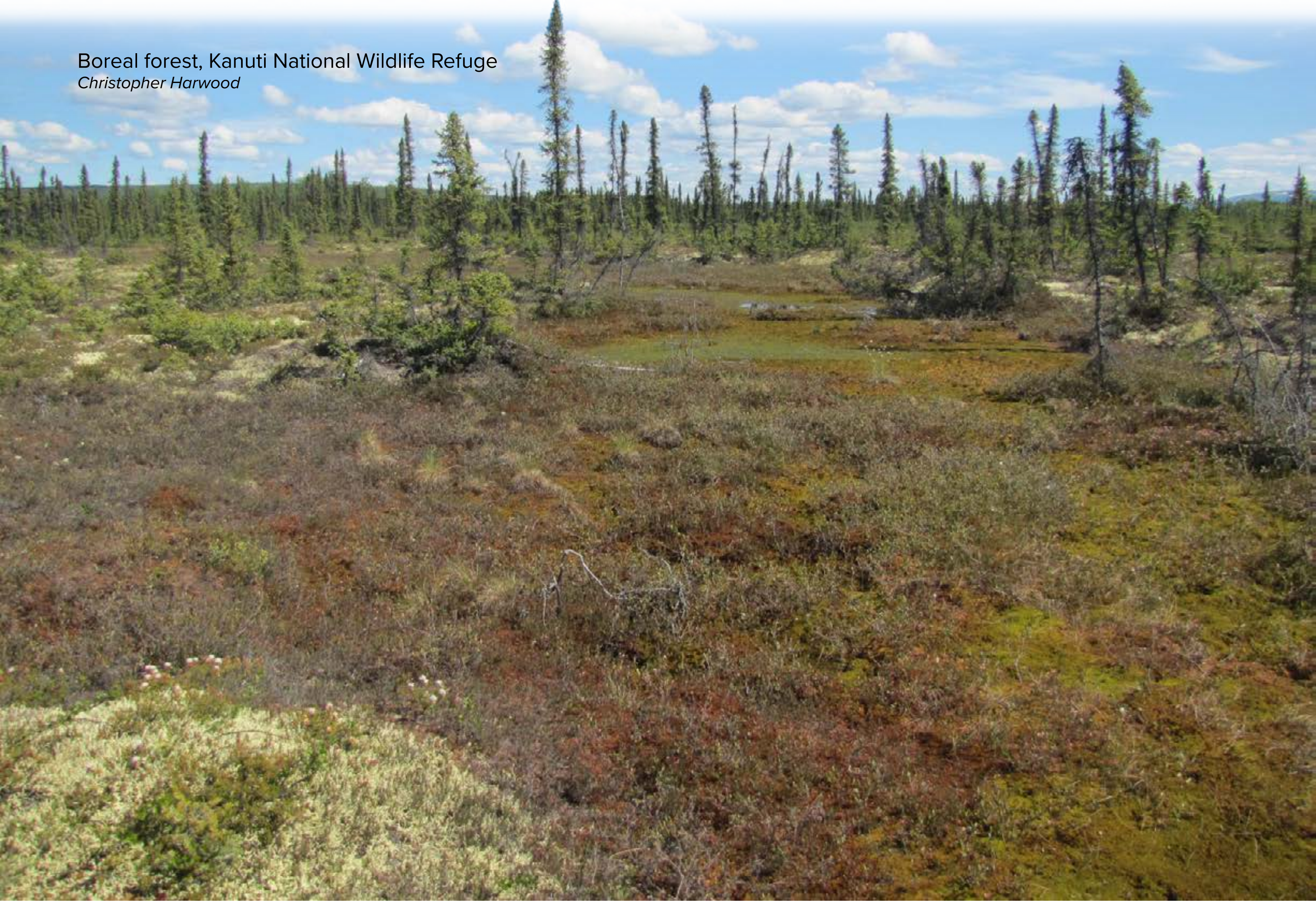
Evaluation of Conservation Progress

Despite numerous challenges to the study and conservation of shorebirds in BCR 4, real progress has occurred in both aspects since the last plan revision. While most work again concentrated at the southern (Cook Inlet, southwestern Alaska Range) and western (Andreafsky Wilderness, eastern Seward Peninsula) margins of the bioregion, there were additional investigations in Interior Alaska proper.

Addressing basic species information gaps, there were multi-year breeding ecology studies for Wandering Tattler (Gill *et al.* 2015), Whimbrel (Neipert *et al.* 2014; Harwood *et al.* 2016), Bristle-thighed Curlew (Jung *et al.* 2016), and Hudsonian Godwit (Senner 2013; Swift 2016). Migration studies centered on Cook Inlet (Matz *et al.* 2011a; Senner 2012, 2014; Ulman 2012), but also touched western BCR 4 (Johnson *et al.* 2010a, 2011a, 2011b, 2012), and finally the Interior (Whimbrels; R. Gill, L. Tibbitts, unpubl. data). The ecology of Rock Sandpipers wintering in Cook Inlet (Ruthrauff 2014) was well investigated. Dedicated shorebird surveys along the Interior road system (Harwood 2016) and on Interior military lands (Martin *et al.* 2016) improved our understanding of the distribution of boreal-breeding shorebirds, complementing the statewide Breeding Bird Survey and Alaska Landbird Monitoring Survey programs, although these latter two initiatives are more optimally timed for detecting passerines.


Wandering Tattler
Robert Gill, Jr.

Several efforts have been made to address objectives or action items noted in the previous version of the Alaska Shorebird Conservation Plan. Ruthrauff's (2014) efforts specifically addressed winter shorebird use of Cook Inlet. Outreach efforts to elevate the profile of boreal shorebirds included the field-based "Birds 'n' Bogs" program (Taylor and Forstner 2013) and multiple public presentations (e.g., C. Harwood, unpubl. data). Efforts to develop habitat-based occurrence models included reliance on strictly historical observations (Gotthardt *et al.* 2013), as well as more recent survey work (Harwood 2016; E. Martin, unpubl. data). Assessing the effects of climate change on boreal shorebirds was largely restricted to Hudsonian Godwits (Senner 2013). Work at areas such as Allen Creek (Jung *et al.* 2016), Turquoise Lake (Gill *et al.* 2015), Kanuti Lake (Harwood 2008; Harwood *et al.* 2016), Susitna Flats (Senner 2013; Swift 2016), "Whimbrel Hill" (Neipert *et al.* 2014), and Stampede Road (Harwood 2016) has illustrated that breeding hotspots do exist within BCR 4 (also see Appendix 5, Figure 11), but only the former three are fully protected within conservation system units. More reconnaissance is needed to identify additional hotspots, especially in multiple-use areas where future development (e.g., mining) or disturbance (military maneuvers) may occur.


Boreal forest, Kanuti National Wildlife Refuge
Christopher Harwood

BCR 5: NORTHERN PACIFIC RAINFOREST

Figure 8. Northern Pacific Rainforest Bird Conservation Region 5. Lands included in BCR 5 are in red on the inset and outlined in black on the map.

BCR 5 extends from the southern extent of the southeastern Alaskan panhandle to the Kenai Peninsula, and is bounded on the landward side by the Coast, St. Elias, Chugach, and Kenai mountain ranges and to the seaward side by the Pacific Ocean and Gulf of Alaska (Figure 8). The narrow mainland and more than 2,000 islands of the region encompass 167,000 km^2. Ecoregions within the BCR include the Alexander Archipelago, Boundary Ranges, Chugach–St. Elias Mountains, and Gulf of Alaska Coast (Nowacki *et al.* 2001). Over 75% of the BCR comprises public lands under the management of the State of Alaska, U.S. Fish and Wildlife Service, U.S. Forest Service, and the National Park Service; the majority of these lands are within the Tongass and Chugach National Forests (Table 5, Figure 2).

The Pacific Ocean and steep coastal mountains strongly influence the climate of the BCR. Warm ocean currents, numerous storms originating from the Gulf of Alaska, and orographic lift produced by the region's coastal mountains produce high levels of precipitation and relatively mild temperatures that in turn shape the region's hydrology and diverse vegetation communities.

The largest system of temperate icefields and glaciers in North America occurs within the coastal mountains of this BCR; ice, snow, and rock cover much of the higher elevations and interior portion of the region. Alpine habitats are prevalent above tree line. Temperate coniferous rainforest communities cover low elevations on the mainland and islands. Deciduous forests, shrublands, and freshwater wetlands are associated primarily with alluvial floodplains of large mainland river systems. Expansive tidal mudflats and estuarine habitats occur on the deltas and outwash plains of large river systems, particularly those that transect the coastal mountains to drain vast regions of the Interior. The region's long and rugged coastline includes extensive exposed and sheltered rocky intertidal shorelines and reefs.

Priority Species

Thirteen shorebird species are known or suspected to breed in the BCR. No breeding species is particularly abundant, but the Black Oystercatcher, Semipalmated Plover, Least Sandpiper, Short-billed Dowitcher (*L. g. caurinus*), Wilson's Snipe, Spotted Sandpiper, and Greater Yellowlegs are among the most common and widespread (Isleib and Kessel 1989; Andres and Browne 2007; Bishop 2007; Johnson *et al.* 2008; Smith 2016). The vast majority of shorebirds that occur in the BCR stop in the region *en route* to western and northern breeding areas. The region supports millions of shorebirds during spring migration, including globally significant numbers of Red Knots (*C. c. roselaari*), Dunlin (*C. a. pacifica*), and Western Sandpipers (Bishop *et al.* 2000). Substantial numbers of Marbled Godwits (*L. f. beringiae*), Black Turnstones, Surfbirds, Short-billed and Long-billed dowitchers, and Red-necked Phalaropes also migrate along the region's coast (Isleib and Kessel 1989; Norton *et al.* 1990; Andres and Browne 1998; Bishop and Green 1999; Warnock *et al.* 2001; Bishop 2007).

The timing, abundance, and distribution of shorebirds in the region during autumn migration are poorly studied (but see Bishop 2007). Substantial numbers of postbreeding and juvenile Least Sandpipers, Pectoral Sandpipers, Western Sandpipers, and Short-billed and Long-billed dowitchers have been observed at large river deltas (Bishop 2007; Johnson *et al.* 2008). The more prolonged autumn migration period (in contrast to spring) makes it difficult to accurately assess the importance of the region to southbound migrants.

Table 10. Priority shorebird species that commonly breed, stage during migration, or winter in Northern Pacific Rainforest Bird Conservation Region 5.

Breeding	Migration	Winter
Black Oystercatcher	Black Oystercatcher	Black Oystercatcher
Short-billed Dowitcher	Black-bellied Plover	Rock Sandpiper (*ptilocnemis*)
Red-necked Phalarope	Marbled Godwit	Rock Sandpiper (*tschuktschorum*)
	Ruddy Turnstone	
	Black Turnstone	
	Red Knot	
	Surfbird	
	Dunlin (*pacifica*)	
	Western Sandpiper	
	Short-billed Dowitcher (*caurinus*)	
	Long-billed Dowitcher	
	Red-necked Phalarope	

See Tables 1, 2, and 4 for conservation priority status and relative seasonal importance.

Important Shorebird Areas

Several areas critical to shorebirds have been identified in the region. Deltas of the Copper and nearby Bering rivers (Controller Bay) comprise vast intertidal mudflats that together form one of the most important shorebird concentration sites in the world (https://www.whsrn.org/copper-river-delta).In spring, as many as five million shorebirds stop there to forage and rest *en route* to breeding grounds (Bishop *et al.* 2000). The area is also critically important to migrating Marbled Godwits, Red Knots, Dunlin, Western Sandpipers, and Short-billed and Long-billed dowitchers (Warnock *et al.* 2001, 2004; Bishop *et al.* 2006, 2016; D. Ruthrauff, pers. comm.; J. Johnson, pers. comm.).

The Stikine River Delta supports as many as three million shorebirds during spring migration (https://www.audubon.org/important-bird-areas/stikine-river-delta) and is part of a network of coastal sites along the Pacific Coast that are critically important stopover sites for shorebirds, particularly Western Sandpipers (Bishop *et al.* 2006). The Stikine's vast mudflats and tidal marshes support well over 300,000 Western Sandpipers (Iverson *et al.* 1996). The tidal mudflats, salt marsh, and barrier islands of Seal Creek-Ahrnklin River estuary and the Yakutat Forelands are important spring stopover sites for Marbled Godwits, Red Knots, Dunlin, Western Sandpipers, and Short-billed and Long-billed dowitchers (Andres and Browne 1998, 2007).

Middleton Island, in the Gulf of Alaska, supports the largest concentration of breeding Black Oystercatchers in Alaska (Gill *et al.* 2004). Black Turnstones, Rock Sandpipers (*C. p. tschuktschorum*), Least Sandpipers, and Western Sandpipers are common autumn migrants on the island (DeCicco *et al.* 2017).

Eastern Prince William Sound supports a large proportion of Southcentral Alaska's breeding population of Black Oystercatchers (Tessler *et al.* 2007). In the 1990s, Pacific herring spawn areas on northern Montague Island in Prince William Sound attracted more than 70% of the world's Surfbirds (P. Martin in Senner and McCaffery 1997) and thousands of Black Turnstones (Norton *et al.* 1990; Bishop and Green 1999) in spring. Since then, herring spawn at Montague Island has declined and shorebird use has decreased substantially (M. Bishop, unpubl. data).

Glacier Bay, in southeastern Alaska, supports many breeding Black Oystercatchers, and Geike Inlet, in lower Glacier Bay, is an important autumn staging site for the species (van Vliet 2005). Black Oystercatchers, Black Turnstones, Rock Sandpipers (*C. p. tschuktschorum*), and Surfbirds occur on shorelines year-round throughout the region.

The Mendenhall Wetlands State Game Refuge, in southeastern Alaska, is widely acknowledged to be a key migratory shorebird stopover location in the region, supporting Black-bellied Plovers, Ruddy Turnstones (*A. i. interpres*), Surfbirds, Dunlin, Rock Sandpipers (*C. p. tschuktschorum*), Least Sandpipers, Pectoral Sandpipers, Western Sandpipers, and Short-billed Dowitchers (Armstrong *et al.* 2004; Smith 2016).

Primary Conservation Objectives

Most shorebirds that occur in the region are restricted to a few sites and predominately during spring migration. Therefore, conservation objectives and efforts should focus on the protection and management of important shorebird habitats at these locations.

- Monitor shorebird populations at key spring stopover sites (e.g., Copper River Delta, Controller Bay, Yakutat Forelands, Mendenhall Wetlands, and Stikine River Delta).
- Determine habitat use of shorebirds, particularly Black Turnstones, Surfbirds, and Red Knots, at key spring stopover sites (e.g., Copper/Bering River Deltas, Yakutat Forelands, Stikine River Delta).
- Identify important wintering areas and stopover sites in Southeast Alaska and Prince William Sound.
- Continue to monitor impacts of recreational activities on shorebirds, particularly Black Oystercatchers.
- Assess the nonbreeding distribution of Black Oystercatchers, identify areas of high concentrations, and determine migratory connectivity between breeding and wintering areas.
- Support conservation designations (e.g., the Western Hemisphere Shorebird Reserve Network (WHSRN), Important Bird Areas Program) for key shorebird sites (e.g., Controller

Bay, Yakutat Forelands, Stikine River Delta).

- Continue to promote conservation efforts for the Copper River Delta WHSRN network site with emphasis on international cooperation and public education (e.g., Copper River International Migratory Bird Initiative [CRIMBI], WetlandsLIVE, social media, birding festivals, and citizen science opportunities).
- Increase coordination and collaboration among the U.S. Forest Service, National Park Service, Parks Canada, Environment Canada, and others currently conducting surveys of breeding Black Oystercatchers to ensure comparability of data for determining population status and to estimate local and range-wide trends.

Priority Conservation Issues and Actions

Human Intrusions and Disturbance
Tourism is the largest growing industry in Alaska (State of Alaska 2016), and within BCR 5 it is concentrated in southcentral and southeastern coastal areas. Black Oystercatchers typically nest close to the high tide line and are therefore extremely vulnerable to flooding events (Andres and Faxla 1995; Morse *et al.* 2006; Spiegel 2008). Growing visitation by private boats, sightseeing vessels, water taxis, and cruise ships heightens the probability that oystercatcher nests will be flooded by large wakes, especially when vessel traffic coincides with periods of high tides, contributing to lower nest success and increased chick mortality. Areas where high nesting activity and vessel traffic overlap (e.g., Harriman Fjord in Prince William Sound, Beardslee Islands in Glacier Bay) are of particular concern (Tessler *et al.* 2007).

Recreational activities in coastal Alaska also often coincide with the chick-rearing period of Black Oystercatchers (Morse *et al.* 2006). Gravel beaches where oystercatchers tend to nest and raise chicks are often popular campsites. Thus, onshore recreational activity (camping, off-road vehicle use) can interfere with nesting, parental care, and foraging. Of greater concern are the indirect effects human disturbance can have on oystercatcher productivity through predation, which is a primary cause of oystercatcher nest failures (Morse *et al.* 2006). Increased human activity can attract scavengers including crows and ravens (*Corvus* spp.) and mink (*Neovison vison*), thereby inflating the number of predators in a region.

The Mendenhall Wetlands State Game Refuge is one of the most frequently visited wetlands in southeast Alaska as well as a key shorebird stopover site. The extent of human disturbance at the refuge and shorebirds' response to such disturbances are unknown.

ACTIONS

- ❑ Develop educational materials and suggest ethical guidelines (e.g., American Birding Association's Code of Birding Ethics) for recreationists using beach areas in Kenai Fjords, Prince William Sound, Glacier Bay, and Mendenhall Wetlands State Game Refuge to minimize potential direct and indirect impacts on Black Oystercatchers and other shorebirds.
- ❑ Encourage consideration of potential impacts to migrating or nesting shorebirds during review and permitting of special use permits/activities that may affect intertidal areas.
- ❑ Assess impacts from domestic dogs on foraging and nesting shorebirds with an emphasis on the Mendenhall Wetlands State Game Refuge.

Pollution
The Trans-Alaska oil pipeline crosses six major tributaries of the Copper River. A breach of the pipeline at any one of these sites would pose a severe threat to the Copper River/Bering River Deltas. This pipeline terminates at the Alyeska oil terminal in Valdez, Prince William Sound. Although oil production has been steadily falling, in 2016 the terminal nonetheless handled over 20 tankers per month. These tankers, with holding capacities of up to 1.3 million barrels each, travel through Prince William Sound into the Gulf of Alaska, heightening the risk of an oil spill that could impact the Copper/Bering River Deltas. The magnitude of any spill's impact on shorebirds would vary seasonally and would be most severe during peak spring shorebird migration.

Shorebirds are vulnerable to oil pollution through both oiling of feathers and the transfer of hydrocarbons through the food chain (see Martin 1994). The 1989 *Exxon Valdez* oil spill in Prince William Sound had a major impact on breeding Black Oystercatchers, killing 20% of the population in the spill area outright, and disrupting breeding activity and decreasing chick survival in subsequent years (Andres 1994, 1997). Hydrocarbons in elevated concentrations were also still being found in the annual production of chicks four years after the spill (Andres 1997). In a 2004 study, liver biopsies of oystercatchers nesting in oiled areas of Prince William Sound showed evidence of continued ingestion via trophic uptake (J. Bodkin, pers. comm.).

Furthermore, increased commercial fishing and recreational vessel traffic in the region can cause chronic, low-level exposure to diesel fuel and gas absorbed into porous shorelines. The impact on shorebirds from chronic low-level exposure is unknown, but cumulative detrimental effects have been demonstrated in other shoreline-obligate species (e.g., sea otters, eiders; Peterson 2001). As such, these effects warrant consideration with respect to the region's shorebirds.

Oil pollution may also adversely affect shorebirds by decreasing the availability of important food resources, such as herring spawn. Studies between 1989 and 1995 at Montague Island documented the importance of Pacific herring spawn in the diet of Surfbirds and Black Turnstones (Norton *et al.* 1990; Martin 1994; Bishop and Green 2001). The *Exxon Valdez* oil spill had immediate impacts on herring stocks, and the herring population in Prince William Sound subsequently suffered a spectacular collapse (Carls *et al.* 2002) and has yet to recover (Exxon Valdez Oil Spill Trustee Council 2014). Since then, use of the area by Surfbirds and Black Turnstones has decreased substantially (M. Bishop, unpubl. data).

Black Oystercatcher nesting habitat
Prince William Sound
Melissa Gabrielson

ACTIONS

- ❑ Identify important shorebird habitats that are vulnerable to water-borne pollution (e.g., proximity to marine shipping lanes, patterns of currents and circulation) as well as potential inland point sources (e.g., wastewater discharge, oil pipelines, mines).
- ❑ Ensure that shorebird conservation concerns are addressed in environmental response plans for oil spills and discharge of toxic materials associated with mining activities.
- ❑ Encourage and engage the public (i.e., students, community members) in beach clean-up efforts.

Climate Change and Severe Weather
Global sea levels are predicted to rise up to one-half meter over the 21st century (Church *et al.* 2013), and will be accentuated in areas with high tidal amplitudes (e.g., broad deltas, estuaries). The magnitude of mean sea-level rise in BCR 5, however, is uncertain due to the offsetting effects of sedimentation, isostatic rebound, and tectonic uplift. The frequency and magnitude of storm events are predicted to increase with global climate change (Cohen *et al.* 2014); in conjunction with rising sea levels, these changes could negatively affect shorebirds by inundating intertidal foraging habitats and flooding nest sites (Galbraith *et al.* 2002; Galbraith *et al.* 2014).

The composition and abundance of invertebrate communities could change with increases in ocean temperatures and fresh water inputs due to glacial melt. Furthermore, increased ocean temperatures could increase the likelihood of more frequent harmful algal blooms in coastal Alaska. In other areas, such blooms have been implicated in die-offs of African Black Oystercatchers (*Haematopus moquini*; Hockey and Cooper 1980) and nonbreeding Red Knots (H. Sitters, pers. comm.).

Ocean acidification caused by increasing human-derived carbon dioxide emissions and the reduction in the amount of carbonate ions in the water is expected to reduce the amount of calcium carbonate available to many marine animals to form skeletons and shells (Orr *et al.* 2005; Hale *et al.* 2011). Invertebrates under the most immediate threat include bivalves and zooplankton, which shorebirds rely on to fuel migrations (Senner *et al.* 1989; Handel and Gill 1990).

ACTIONS

- ❑ Model the potential effects of climate change on shorebird habitats, especially changes to intertidal foraging habitats used by migrating shorebirds and the supratidal nesting habitats of Black Oystercatchers.
- ❑ Examine the effect of warming sea temperatures, changes in marine currents, and increased ocean acidification on factors (e.g., prevalence of harmful algal blooms, abundance of marine invertebrates) that may affect shorebirds.

Emerging Conservation Issues
Although a large portion of coal rights for the Bering River coal field was recently retired, the potential remains for onshore oil and gas exploration in nearby Controller Bay. Industrial development of this area, in addition to the related increase of shipping traffic, would heighten the risk of habitat loss or alteration and oil and fuel spills in this important shorebird stopover area.

Other existing and potential developments that could affect shorebird populations include mining and other resource extraction near the headwaters of the Stikine River Delta and on the Yakutat Forelands. The Red Chris, Galore Creek, and Schaft Creek mines have the potential to generate hundreds of millions of tons of acidic tailings and waste rock within the Stikine River watershed, the largest watershed (by volume) in the Tongass National Forest and fourth-largest in Alaska.

The introduction of non-native plants can diminish and degrade intertidal habitats (e.g., Li *et al.* 2009). In Alaska, invasive plants that may affect shorebirds through direct loss or adverse modification of foraging habitat include brass buttons (*Cotula coronopifolia*), reed canarygrass (*Phalaris* spp.), and cordgrass

(*Spartina* spp.). In addition, *Elodea canadensis* is gaining a foothold in many freshwater regions of the state, and can degrade habitats by forming dense, mono-specific mats. The effect of introduced plant species on shorebirds in Alaska is unknown, but similar introductions elsewhere have negatively affected shorebirds (Li *et al.* 2009; MacKinnon *et al.* 2012).

The Mendenhall Wetlands State Game Refuge, located in Juneau, is surrounded by expanding residential and commercial development, is immediately adjacent to the airport, and is downstream from the city and borough's landfill and sewage treatment plant. Wastewater discharge and other associated sources of pollution could result in accumulated levels of contaminants in shorebirds.

ACTIONS

- ❑ Review land use plans and stewardship of public lands to promote management beneficial to shorebirds; provide science support, engage in planning processes, and monitor outcomes of decisions.
- ❑ Continue monitoring areas of high shorebird use within the Mendenhall Wetlands State Game Refuge and assess effects of water quality on shorebirds.
- ❑ Identify and map sites of invasive plant introduction in shorebird habitats.
- ❑ Monitor invasive plants at sites used by shorebirds and advocate for habitat rehabilitation that removes and prevents their expansion.

Roosting Western Sandpipers
Sean Meade

Evaluation of Conservation Progress

Substantial progress has been made in BCR5 that addresses many knowledge gaps outlined in Version II of the Alaska Shorebird Conservation Plan. Studies focused primarily on four species of concern: Black Oystercatcher, Black Turnstone, Red Knot, and Surfbird.

Several survey and monitoring activities were completed throughout the region. Researchers focused on breeding Black Oystercatchers in Sitka Sound (Andres and Christensen 2009), Tracy Arm–Fords Terror Wilderness Area (Baluss 2015), Prince William Sound (Poe *et al.* 2013; Gabrielson 2016), and Middleton Island (Guzetti 2008). Survey efforts also described the distribution, abundance, and habitat characteristics of Black Turnstones and Surfbirds in Prince William Sound during spring migration (Bishop 2011; Bishop and Hsu 2011; Taylor and Bishop 2015), and highlighted the importance of the central Copper River Delta to Red Knots during spring migration (Gabrielson 2015b). As part of the Migratory Shorebird Project (www.migratoryshorebirdproject.org/datamap), citizen scientists assisted with shorebird monitoring at Orca Inlet at the Copper River Delta during spring migration. Shorebird surveys completed during the 2016 spring migration at Yakutat Forelands provided important new information for the region (J. Lopez, USFS-Tongass, unpubl. data).

There has been a sustained emphasis on conducting studies of Black Oystercatchers during the breeding season. Several studies yielded new information on general breeding ecology, diet, vital rates, and population structure (Guzetti 2008; Robinson and Phillips 2013; Coletti *et al.* 2014; Stark *et al.* 2015). Researchers also continued to examine the potential negative consequences of recreation-related disturbance in Prince William Sound (Spiegel 2008; Spiegel *et al.* 2012; Poe *et al.* 2013) and Kenai Fjords National Park (Robinson and Phillips 2013; Stark *et al.* 2015). A long-term breeding study of Semipalmated Plovers on a barrier island on the Copper River Delta (M. Bishop and E. Nol, unpubl. data) is also noteworthy.

Advancements in the miniaturization of tracking devices have increased our understanding of migratory movements of shorebirds in BCR 5. Johnson *et al.* (2010b) described the nonbreeding distribution and migratory connectivity of Black Oystercatchers breeding at Middleton Island, Prince William Sound, and Juneau. Research also underscored the importance of the Copper River and Bering River Deltas to Red Knots during spring migration (Bishop *et al.* 2016; J. Johnson, unpubl. data). Finally, the migratory connectivity of Black Turnstones was documented between breeding sites on the Yukon-Kuskokwim Delta and Southeast Alaska stopover and wintering areas (Taylor and Bishop 2015).

Enjoying Shorebirds
Copper River Delta
Erica Gaeta

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Red-necked Phalarope chick
Zak Pohlen

Appendices

APPENDIX 1. COMMON NAME, SCIENTIFIC NAME, AND STATUS OF SHOREBIRDS IN ALASKA

Common Name[1]	*Scientific Name[1]*
Common/Regular Breeder[2]	
Black Oystercatcher	*Haematopus bachmani*
Black-bellied Plover	*Pluvialis squatarola*
American Golden-Plover	*Pluvialis dominica*
Pacific Golden-Plover	*Pluvialis fulva*
Semipalmated Plover	*Charadrius semipalmatus*
Killdeer	*Charadrius vociferus vociferus*
Upland Sandpiper	*Bartramia longicauda*
Bristle-thighed Curlew	*Numenius tahitiensis*
Whimbrel *hudsonicus*	*Numenius phaeopus hudsonicus*
Bar-tailed Godwit	*Limosa lapponica baueri*
Hudsonian Godwit	*Limosa haemastica*
Marbled Godwit	*Limosa fedoa beringiae*
Ruddy Turnstone *interpres*	*Arenaria interpres interpres*
Ruddy Turnstone *morinella*	*Arenaria interpres morinella*
Black Turnstone	*Arenaria melanocephala*
Red Knot	*Calidris canutus roselaari*
Surfbird	*Calidris virgata*
Stilt Sandpiper	*Calidris himantopus*
Sanderling	*Calidris alba*
Dunlin *pacifica*	*Calidris alpina pacifica*
Dunlin *arcticola*	*Calidris alpina arcticola*
Rock Sandpiper *ptilocnemis*	*Calidris ptilocnemis ptilocnemis*
Rock Sandpiper *couesi*	*Calidris ptilocnemis couesi*
Rock Sandpiper *tschuktschorum*	*Calidris ptilocnemis tschuktschorum*
Baird's Sandpiper	*Calidris bairdii*
Least Sandpiper	*Calidris minutilla*
White-rumped Sandpiper	*Calidris fuscicollis*
Buff-breasted Sandpiper	*Calidris subruficollis*
Pectoral Sandpiper	*Calidris melanotos*
Semipalmated Sandpiper	*Calidris pusilla*
Western Sandpiper	*Calidris mauri*
Short-billed Dowitcher *caurinus*	*Limnodromus griseus caurinus*
Long-billed Dowitcher	*Limnodromus scolopaceus*
Wilson's Snipe	*Gallinago delicata*
Spotted Sandpiper	*Actitis macularius*
Solitary Sandpiper *cinnamomea*	*Tringa solitaria cinnamomea*
Wandering Tattler	*Tringa incana*
Lesser Yellowlegs	*Tringa flavipes*
Greater Yellowlegs	*Tringa melanoleuca*
Red-necked Phalarope	*Phalaropus lobatus*
Red Phalarope	*Phalaropus fulicarius*
Rare/Sporadic Palearctic Breeder[2,3]	
Common Ringed Plover *tundrae*	*Charadrius hiaticula tundrae*
Red-necked Stint	*Calidris ruficollis*
Palearctic Migrant[2,3]	
Lesser Sand-Plover* *stegmanni*	*Charadrius mongolus stegmanni*
Eurasian Dotterel*	*Charadrius morinellus*
Whimbrel *variegatus*	*Numenius phaeopus variegatus*
Black-tailed Godwit *melanuroides*	*Limosa limosa melanuroides*
Ruff*	*Calidris pugnax*
Sharp-tailed Sandpiper	*Calidris acuminata*
Long-toed Stint	*Calidris subminuta*
Jack Snipe	*Lymnocryptes minimus*
Common Snipe* *gallinago*	*Gallinago gallinago gallinago*
Gray-tailed Tattler	*Tringa brevipes*
Wood Sandpiper	*Tringa glareola*

Common Name[1]	*Scientific Name*[1]
Nearctic Extralimital Visitant[2,3]	
American Avocet	*Recurvirostra americana*
Eskimo Curlew[4]	*Numenius borealis*
Long-billed Curlew	*Numenius americanus*
Purple Sandpiper	*Calidris maritima*
Solitary Sandpiper *solitaria*	*Tringa solitaria solitaria*
Willet *inornata*	*Tringa semipalmata inornata*
Wilson's Phalarope*	*Phalaropus tricolor*
Palearctic Extralimital Visitant[2,3]	
Black-winged Stilt *himantopus*	*Himantopus himantopus himantopus*
Eurasian Oystercatcher *osculans*	*Haematopus ostralegus osculans*
Northern Lapwing	*Vanellus vanellus*
European Golden-Plover	*Pluvialis apricaria*
Little Ringed Plover *curonicus*	*Charadrius dubius curonicus*
Little Curlew	*Numenius minutus*
Far Eastern Curlew	*Numenius madagascariensis*
Great Knot	*Calidris tenuirostris*
Broad-billed Sandpiper *sibirica*	*Calidris falcinellus sibirica*
Curlew Sandpiper*	*Calidris ferruginea*
Temminck's Stint	*Calidris temminckii*
Spoon-billed Sandpiper	*Calidris pygmea*
Rock Sandpiper *quarta*	*Calidris ptilocnemis quarta*
Little Stint	*Calidris minuta*
Pin-tailed Snipe	*Gallinago stenura*
Solitary Snipe *japonica*	*Gallinago solitaria japonica*
Terek Sandpiper	*Xenus cinereus*
Common Sandpiper*	*Actitis hypoleucos*
Green Sandpiper	*Tringa ochropus*
Spotted Redshank	*Tringa erythropus*
Common Greenshank	*Tringa nebularia*
Marsh Sandpiper	*Tringa stagnatilis*
Oriental Pratincole	*Glareola maldivarum*

[1]Taxonomy follows AOU 7th edition (1998) and supplements through Chesser ***et al***. (2017). Subspecies follow Gibson and Withrow (2015) and Andres ***et al.*** (2012b). Subspecific inferences for rare migrants and visitants that are not specimen-based rely on expert opinion. *Denotes extralimital visitants or migrants that have, or probably have, bred in Alaska.

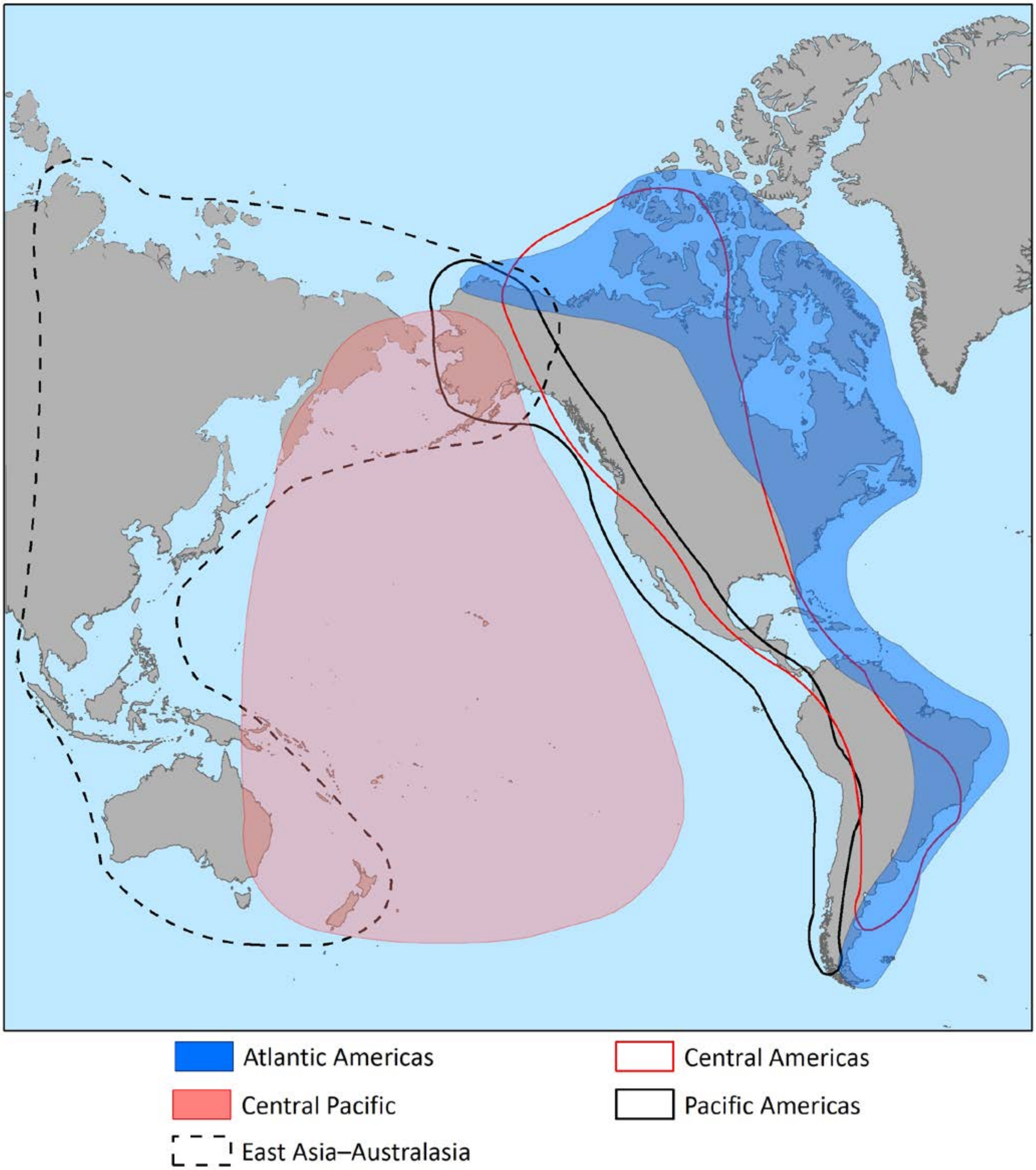
[2]Status follows Gibson and Withrow (2015) and Gibson ***et al.*** (2018). ***Common/Regular Breeder***: those species that breed regularly throughout a portion of Alaska. ***Rare/Sporadic Breeder***: those species that nest peripherally, but regularly, in Alaska. ***Migrant***: those species that occur regularly in Alaska primarily/exclusively as migrants (status Rare) but do not nest regularly and are more regular/numerous than an Extralimital Visitant. ***Extralimital Visitant***: those species that occur in Alaska irregularly (status Casual or Accidental).

[3]Provenance: ***Nearctic***: those species that nest primarily in the Nearctic and are generally New World during annual cycle. ***Palearctic***: those species that nest primarily in the Palearctic and are generally Old World during annual cycle.

[4]Likely extinct (Andres ***et al***. 2012b).

Red Knot on nest
Lucas DeCicco

APPENDIX 2. PRIMARY WINTERING AREAS AND PRIMARY MIGRATORY FLYWAYS OF SHOREBIRD SPECIES COMMONLY OCCURRING IN ALASKA



Migratory bird flyways that include Alaska. Based on Boere and Stroud (2006).

Primary Wintering Area[1]	Species	Primary Migratory Flyway(s)[2]
Pacific North America	Black Oystercatcher	Pacific Americas
	Marbled Godwit (*beringiae*)	Pacific Americas
	Black Turnstone	Pacific Americas
	Rock Sandpiper	Pacific Americas
The Americas	Black-bellied Plover	Pacific Americas & Central Americas
	Semipalmated Plover	Pacific Americas & Central Americas
	Killdeer	Central Americas
	Whimbrel	Pacific Americas & Atlantic Americas
	Ruddy Turnstone (*interpres*)	Central Pacific & Pacific Americas
	Red Knot (*roselaari*)	Pacific Americas
	Surfbird	Pacific Americas
	Stilt Sandpiper	Central Americas
	Sanderling	Pacific Americas
	Dunlin (*pacifica*)	Pacific Americas
	Least Sandpiper	Central Americas
	Semipalmated Sandpiper	Atlantic, Central, & Pacific Americas
	Western Sandpiper	Pacific Americas
	Short-billed Dowitcher (*caurinus*)	Pacific Americas
	Long-billed Dowitcher	Central, Pacific, & Atlantic Americas[3]
	Wilson's Snipe	Central Americas
	Spotted Sandpiper	Central Americas
	Solitary Sandpiper	Central Americas
	Lesser Yellowlegs	Central Americas & Atlantic Americas
	Greater Yellowlegs	Atlantic Americas
	Red-necked Phalarope	Pacific Americas & Central Pacific
	Red Phalarope	Pacific Americas & Central Pacific
South America	American Golden-Plover	Central Americas & Atlantic Americas[4]
	Upland Sandpiper	Central Americas
	Hudsonian Godwit	Central Americas & Atlantic Americas[4]
	Baird's Sandpiper	Central Americas
	White-rumped Sandpiper	Central Americas
	Buff-breasted Sandpiper	Central Americas
	Pectoral Sandpiper	Central Americas

Primary Wintering Area[1]	**Species**	**Primary Migratory Flyway(s)[2]**
Oceania/East Asia–Australasia	Pacific Golden-Plover	Central Pacific
	Bristle-thighed Curlew	Central Pacific
	Bar-tailed Godwit (*baueri*)	East Asia–Australasia & Central Pacific[5]
	Sharp-tailed Sandpiper	East Asia–Australasia
	Dunlin (*arcticola*)	East Asia–Australasia
	Wandering Tattler	Central Pacific

[1]Primary wintering area: the geographic location where each species spends the relatively stationary period of the annual cycle (Dec–Feb). Pacific North America encompasses sites north of and including California; The Americas includes sites in North, Central, or South America; South America includes sites only in South America; Oceania/East Asia–Australasia includes sites outlined by the East Asia–Australasia Flyway (see Figure 9). Information on wintering area and flyway use based on species-specific literature reviews.

[2]Primary Migratory Flyway: Definitions of flyways according to Boere and Stroud (2006) except the Central Pacific Flyway which is based on transpacific migration of species such as Bristle-thighed Curlew, Bar-tailed Godwit, and Pacific Golden-Plover (Marks *et al.* 2002; Gill *et al.* 2009; Johnson *et al.* 2012).

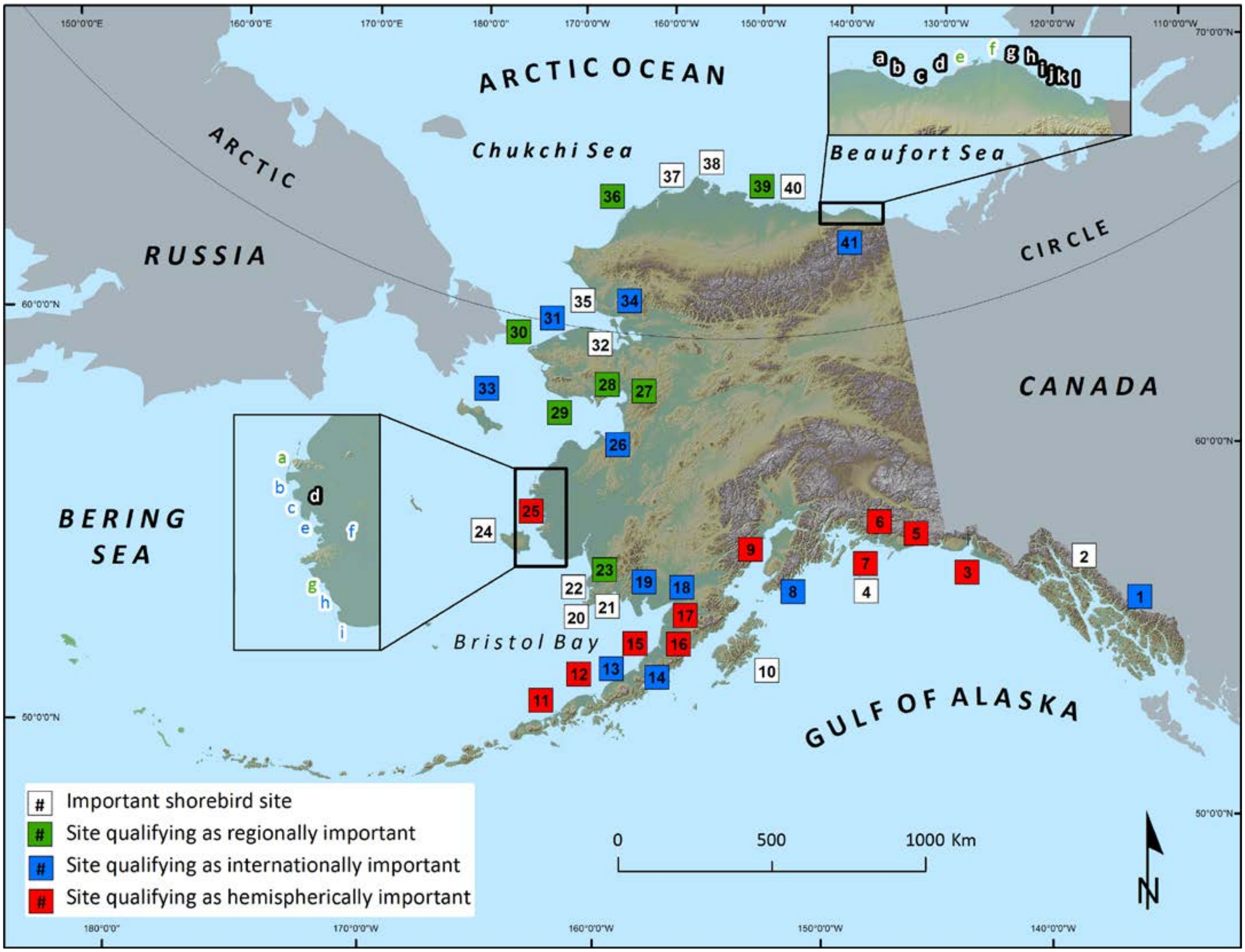
[3]Northbound migration uses Central Americas Flyway; southbound uses Pacific and Atlantic Americas Flyways.

[4]Northbound migration uses Central Americas Flyway; southbound uses Atlantic Americas Flyway.

[5]Northbound migration uses East Asia–Australasia Flyway; southbound uses Central Pacific Flyway.

Juvenile Western Sandpiper
Zak Pohlen

APPENDIX 3. IMPORTANT SHOREBIRD MIGRATION AND NONBREEDING SITES WITHIN EACH BIRD CONSERVATION REGION OF ALASKA



Important sites in Alaska for shorebirds during migration. Numbers correspond to the site numbers (No.) in the table below.

Important shorebird migration and nonbreeding sites within each Bird Conservation Region of Alaska (ordered by site number in column one [No.] below), including key species that occur at each site, major periods of seasonal use, estimate of shorebird abundance at each site, and the Western Hemisphere Shorebird Reserve Network (WHSRN) criteria for estimated population size and percent of population. Species are listed using four-letter banding codes.

No.[1]	Site[2]	Key species[3]	Seasonal Use[4]	No. of Shorebirds[5]	WHSRN Classification pop size[6]	WHSRN Classification % of pop[7]
Northern Pacific Rainforest Bird Conservation Region 5						
1	Stikine River Delta	**WESA,** DUNL	S	several 100,000s	I	H?
2	Mendenhall Wetlands	WESA, RUTU, SURF, LESA, DUNL	S, A, W	few 10,000s	R?	
3	Yakutat Forelands	**MAGO,** WESA, DUNL, LESA	S	few 100,000s	I	H
4	Middleton Island	WESA, BLTU, LESA, PAGP	S, A, W	several 1,000s	R?	
5	Controller Bay	MAGO, REKN, **WESA,** DUNL	S	several 100,000s	H	H
6	**Copper River Delta**	**WESA, DUNL, REKN**, SBDO, LBDO, BBPL	S	several 100,000s	H	H
7	North Montague Island	**SURF, BLTU**	S, W	several 10,000s	R	H
Northwestern Interior Forest Bird Conservation Region 4						
8	**Kachemak Bay**	WESA, SURF, ROSA	S, W	several 10,000s	I	
9	Cook Inlet[2a]	**ROSA,** WESA, SBDO, HUGO	S, A, W	several 100,000s	H	H
Western Alaska Bird Conservation Region 2						
10	Kodiak Island[2b]	WESA, DUNL, RNPH	S, A, W	several 1,000s	R?	
11	Izembek-Moffet Lagoons*	**ROSA,** DUNL, WESA, LESA	A	several 10,000s	R-I?	H
12	Nelson Lagoon/ Mud Bay	**DUNL,** WESA, ROSA, BARG, WHIM	A	several 100,000s	I-H?	H
13	Seal Islands	DUNL, WESA, ROSA, RNPH	A	few 10,000s	R-I?	
14	Port Heiden	DUNL, WESA, ROSA, RNPH, BARG	A	few 100,000s	R-I?	
15	Cinder-Hook Lagoons	**MAGO,** DUNL, ROSA, BARG	S, A	several 10,000s	R-I?	H
16	Ugashik Bay	**MAGO**, DUNL	A	few 10,000s	R	H
17	Egegik Bay	**BARG,** DUNL	A	several 10,000s	R	H

No.[1]	Site[2]	Key species[3]	Seasonal Use[4]	No. of Shorebirds[5]	WHSRN Classification pop size[6]	WHSRN Classification % of pop[7]
18	**Kvichak Bay**	DUNL, BBPL, PAGP	A	several 10,000s	R	
19	**Nushagak Bay**	DUNL, WESA, BBPL, PAGP	A	several 10,000s	R	
20	Nanvak Bay	DUNL, WESA, ROSA, LESA, RNPH	A	few 10,000s	R?	
21	Chagvan Bay	DUNL, WESA, ROSA, LESA	A	few 10,000s	R?	
22	Goodnews Bay	DUNL, WESA	A	few 10,000s	R?	
23	Carter Bay	**HUGO,** DUNL, WESA, ROSA	A	few 10,000s	R	R?
24	Nunivak Island[2b]	**ROSA,** DUNL, WESA	A	few 10,000s	R?	I?
25	**Yukon-Kuskokwim Delta**[2a,^]	**DUNL, WESA, ROSA, REKN, BTCU, BARG, BLTU,** LBDO, RNPH, HUGO	S, A	several 100,000s	H	H
25a	Kokechik Bay	DUNL, WESA, ROSA	S, A	few 10,000s	R	
25b	Hooper Bay	DUNL, WESA, ROSA	S, A	few 100,000s	I	
25c	Angyoyaravak Bay	**REKN,** DUNL, WESA, ROSA, BARG, SHAS	S, A	few 100,000s	I	
25d	Old Chevak, Kanaryarmiut	WESA, DUNL, LBDO, REKN, BARG	S	few 1,000s		
25e	Hazen Bay	DUNL, WESA, ROSA	S, A	several 100,000s	I	
25f	Aropuk Lake	**HUGO**	A	few 1,000s		I
25g	Kolavinarak Bay	**BARG**, **REKN**, DUNL	S, A	several 10,000s	R	R?
25h	Tern Mountain Coast	**BARG**	A	few 10,000s	R	I
25i	Cape Avinof	**BARG**	A	few 10,000s	R	I
26	Stebbins-St. Michael	SESA, DUNL, RNPH, LBDO, SHAS	A	several 10,000s	R-I?	

No.[1]	Site[2]	Key species[3]	Seasonal Use[4]	No. of Shorebirds[5]	WHSRN Classification pop size[6]	WHSRN Classification % of pop[7]
27	Norton Bay	DUNL, SESA, WESA, RNPH	A	few 10,000s	R	
28	Golovin Lagoon	DUNL, SESA, WESA, RNPH	A	few 10,000s	R	
29	Safety Sound	DUNL, SESA, WESA, RNPH	A	few 10,000s	R	
30	Lopp Lagoon	WESA, DUNL, SESA	A	several 10,000s	R	
31	Shishmaref Inlet	WESA, DUNL, PAGP	A	few 100,000s	I	
32	Cape Espenberg	WESA, SESA, DUNL	A	few 10,000s	R?	
Aleutian/Bering Sea Islands Bird Conservation Region 1						
33	St. Lawrence Island	**ROSA,** REPH	S, A	several 1,000s		I-H?
Arctic Plains and Mountains Bird Conservation Region 3						
34	Noatak River Delta	DUNL, WESA, SESA, LBDO	S, A	several 10,000s	R-I?	
35	Krusenstern Lagoon	RNPH, LBDO, WESA, SESA, PESA	S, A	few 10,000s	R?	
36	Kasegaluk Lagoon	DUNL, REPH	S, A	few 10,000s	R	
37	Peard Bay	REPH	A	several 1,000s	R?	
38	Elson Lagoon	REPH	A	few 10,000s	R?	
39	Colville River Delta	DUNL, SESA, RNPH	A	several 10,000s	R	
40	Simpson Lagoon	REPH, RNPH, DUNL	A	few 10,000s	R?	
41	Northeast Alaska Lagoons and Coastal Area[2b]	SESA, RNPH, DUNL, PESA, BBPL, STSA, RUTU, LBDO, SAND, AMGP	S, A	few 100,000s	I	
41a	Staines River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41b	Canning River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	several 1,000s		

No.[1]	Site[2]	Key species[3]	Seasonal Use[4]	No. of Shorebirds[5]	WHSRN Classification pop size[6]	WHSRN Classification % of pop[7]
41c	Katakturuk River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41d	Sadlerochit River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	several 1,000s		
41e	Hulahula/Okpilak River Deltas	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	several 10,000s	R	
41f	Jago River Delta	**SESA**, RNPH, BBPL, DUNL, STSA, PESA	A	several 10,000s	R	R
41g	Niguanak River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41h	Sikrelurak River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41i	Angun River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41j	Aichilik River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	several 1,000s		
41k	Egaksrak River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	few 1,000s		
41l	Kongakut River Delta	SESA, RNPH, BBPL, DUNL, STSA, PESA	A	several 10,000s	R	

[1]Site numbers cross-reference locations on Figure 10. Figure created by D. Ruthrauff.

[2]Sites in bold have been designated by the Western Hemisphere Shorebird Reserve Network (www.whsrn.org). 2[a]Large site that encompasses several smaller, discrete sites, each of which meets WHSRN criteria. 2[b]Large site or discrete region over which the combined shorebird numbers meet WHSRN criteria. *: Site designated as a Wetlands of International Importance by the Ramsar Convention (www.ramsar.org) ^: Site designated by the East Asian–Australasian Flyway Partnership (www.eaaflyway.net). Most sites have also been designated as National Audubon Society Important Bird Areas (IBAs, www.ak.audubon.org/important-bird-areas-4).

[3]Species are listed by order of relative importance of site to each species; those in bold qualify a site as a WHSRN reserve based on percentage of population supported. See Appendix 1 for scientific names. AMGP = American Golden-Plover, BARG = Bar-tailed Godwit, BBPL = Black-bellied Plover, BLTU = Black Turnstone, BTCU = Bristle-thighed Curlew, DUNL = Dunlin, HUGO = Hudsonian Godwit, LBDO = Long-billed Dowitcher, LESA = Least Sandpiper, MAGO = Marbled Godwit, PAGP = Pacific Golden-Plover, PESA = Pectoral Sandpiper, REKN = Red Knot, REPH = Red Phalarope, RNPH = Red-necked Phalarope, ROSA = Rock Sandpiper, RUTU = Ruddy Turnstone, SAND = Sanderling, SBDO = Short-billed Dowitcher, SESA = Semipalmated Sandpiper, SHAS = Sharp-tailed Sandpiper, STSA = Stilt Sandpiper, SURF = Surfbird, WESA = Western Sandpiper, WHIM = Whimbrel.

[4]Seasonal use by key species: S = Spring, A = Autumn, W = Winter.

[5]Numbers of shorebirds at each site derived from published references when available; in absence of published estimates, numbers derive from unpublished works and expert opinion of the Alaska Shorebird Group. Data compiled by R. E. Gill, T. L. Tibbitts, C. M. Handel, R. B. Lanctot, D. R. Ruthrauff, and J. A. Johnson.

[6]WHSRN classifications (Number of shorebirds): Hemispheric Reserve (H) supports >500,000 annually; International Reserve (I) supports >100,000 annually; Regional Reserve (R) supports >20,000 annually. The level at which sites qualify (R, I, or H) is based on total numbers. A question mark indicates that additional study is needed to confirm the level of qualification.

[7]WHSRN classifications (% of the biogeographical population for a species): Hemispheric Reserve (H) supports >30% of the biogeographical population for a species; International Reserve (I) supports >10% of the biogeographical population for a species; Regional Reserve (R) supports >1% of the biogeographical population for a species. The level at which sites qualify (R, I, or H) is based on the bold species listed in the key species column.

APPENDIX 4. KEY GROUPS OR INITIATIVES CONCERNED WITH SHOREBIRD RESEARCH, MONITORING, AND CONSERVATION THAT INCLUDE POPULATIONS OF SHOREBIRDS IN ALASKA

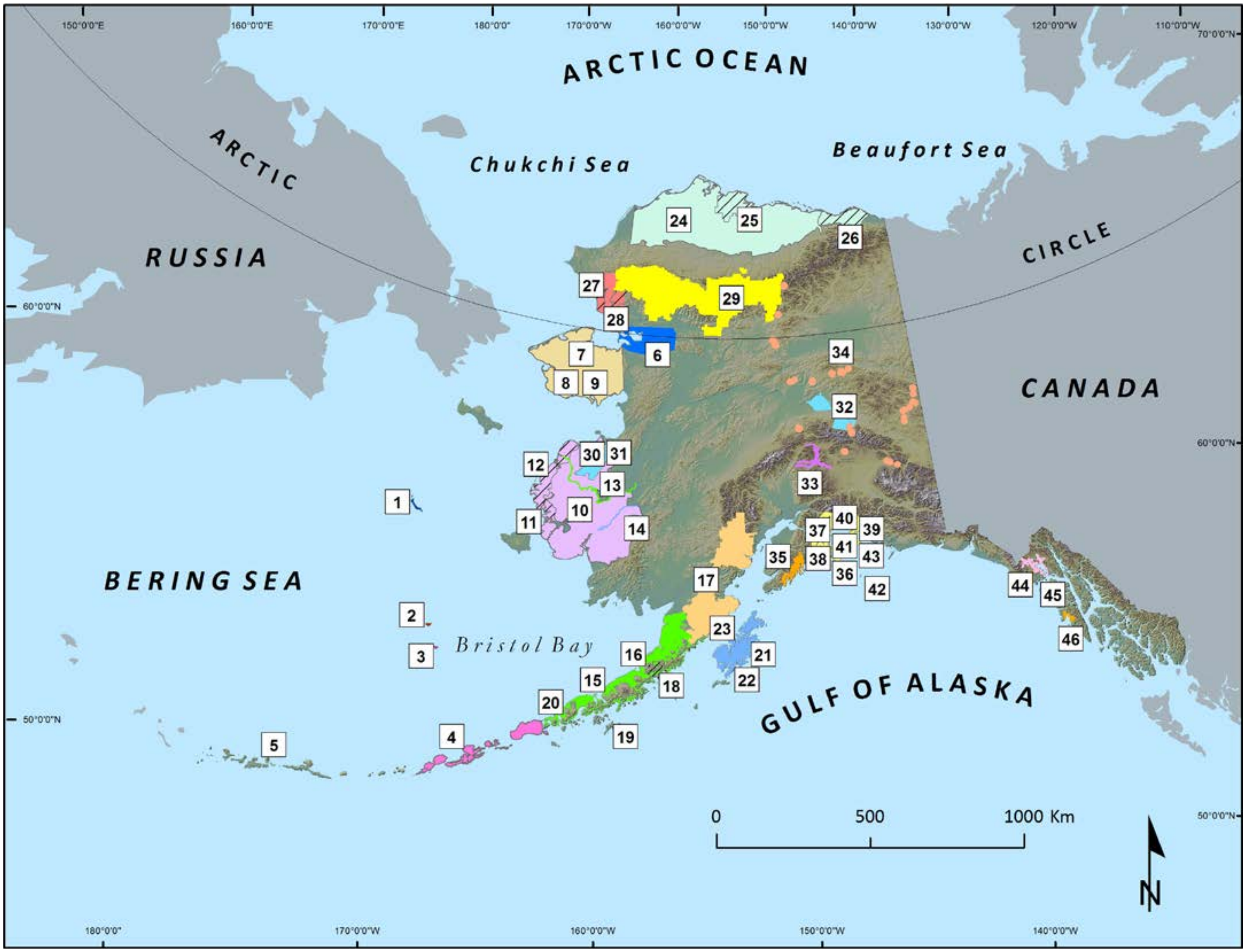
Entity	Website
Alaska Center for Conservation Science, University of Alaska Anchorage	https://accs.uaa.alaska.edu/
Alaska Department of Fish and Game: Threatened, Endangered, and Diversity Program	www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.main
Alaska Migratory Bird Co-Management Council	www.fws.gov/alaska/ambcc/
Alaska Shorebird Group	www.fws.gov/alaska/mbsp/mbm/shorebirds/working_group.htm
Alaska State Wildlife Action Plan (2015)	www.adfg.alaska.gov/index.cfm?adfg=species.wapview
Alliance for (Southern Cone) Grasslands	www.alianzadelpastizal.org/en/
Arctic Migratory Birds Initiative	www.caff.is/arctic-migratory-birds-initiative-ambi
Arctic Shorebird Demographics Network	www.manomet.org/program/shorebird-recovery/arctic-shorebird-demographics-network-asdn
Atlantic Flyway Shorebird Initiative	www.atlanticflywayshorebirds.org
Audubon Alaska	http://ak.audubon.org/
Australasian Wader Studies Group	www.awsg.org.au
Bureau of Land Management	www.blm.gov/programs/fish-and-wildlife/wildlife/about/alaska
Canadian Shorebird Conservation Plan	https://waterbirds.org/wp-content/uploads/CW69-15-5-2000-eng.pdf
Colombian Shorebird Conservation Plan	http://calidris.org.co/plan-para-la-conservacion-de-aves-playeras-en-colombia/
Copper River Delta Shorebird Festival	www.copperriverdeltashorebirdfestival.com/
Copper River International Migratory Bird Initiative	www.fs.fed.us/global/wings/birds/crimbi/welcome.htm
East Asian-Australasian Flyway Partnership's Shorebird Working Group	https://www.eaaflyway.net/
Environment and Climate Change Canada's Canadian Wildlife Service	www.canada.ca/en/environment-climate-change.html
Global Flyway Network in Australia	www.globalflywaynetwork.com.au
Global Flyway Network—Team Piersma	www.teampiersma.org/
International Breeding Conditions Survey	www.arcticbirds.net
International Shorebird Survey	www.manomet.org/program/shorebird-recovery/international-shorebird-survey-iss
International Wader Study Group	www.waderstudygroup.org
Kachemak Bay Birders	www.kachemakbaybirders.org/blog/category/citizen-science/shorebird-monitoring/
Kachemak Bay Shorebird Festival	www.kachemakshorebird.org/
Manomet Shorebird Recovery Program	www.manomet.org/srp
Mexico National Shorebird Conservation Strategy	www.shorebirdplan.org/wp-content/uploads/2013/04/EstrategiaAvesPlayerasMexico.pdf

Entity	Website
Migratory Shorebird Project	www.migratoryshorebirdproject.org/en/home
National Park Service—Inventory and Monitoring	www.science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm
National Park Service—Southwest Alaska Network	https://www.nps.gov/im/swan/nearshore.htm
North American Bird Conservation Initiative	www.nabci-us.org
Pacific Americas Shorebird Conservation Strategy	https://pacificflywayshorebirds.org/
Pacific Birds Habitat Joint Venture	www.pacificbirds.org/
Pan American Shorebird Banding Program	www.canada.ca/en/environment-climate-change/services/bird-banding/pan-american-shorebird-program.html
Point Blue Conservation Science	www.pointblue.org/
Prince William Sound Science Center	www.pwssc.org/research
Program for Regional and International Shorebird Monitoring—Canada	www.birdscanada.org/birdmon/prism/main.jsp
Program for Regional and International Shorebird Monitoring—U.S.	www.shorebirdplan.org/science/program-for-regional-and-international-shorebird-monitoring/
Pukorokoro Miranda Shorebird Centre	www.miranda-shorebird.org.nz/
Shorebird Sister Schools Program	www.fws.gov/sssp
U.S. Fish and Wildlife Service, Alaska Region	www.fws.gov/alaska/mbsp/mbm/shorebirds/shorebirds.htm
U.S. Geological Survey, Alaska Science Center	https://www.usgs.gov/centers/asc/science/shorebird-research?qt-science_center_objects=0#qt-science_center_objects
U.S. Shorebird Conservation Partnership	https://www.shorebirdplan.org/regional-shorebird-conservationplans/
U.S. Regional Shorebird Conservation Plans	https://www.shorebirdplan.org/regional-shorebird-conservation-plans/
Western Hemisphere Shorebird Group	www.westernshorebirdgroup.org
Western Hemisphere Shorebird Reserve Network (WHSRN)	www.whsrn.org
WHSRN: Sspecies-specific conservation plans	www.whsrn.org/conservation-plans
Wetlands International	www.wetlands.org
Wildlife Conservation Society Arctic Beringia Program	www.wcs.org/our-work/regions/arctic-beringia

Please contact Rick Lanctot (richard_lanctot@fws.gov) for more specific information.

Red Knot
Lucas DeCicco

APPENDIX 5. BREEDING SHOREBIRD SURVEYS WITHIN EACH BIRD CONSERVATION REGION OF ALASKA



Locations of breeding shorebird inventories or surveys in Alaska. Numbers correlate to site number (No.) in the table below.

Breeding shorebird surveys that have been conducted over large areas or islands within each Bird Conservation Region of Alaska (ordered by number [No.] below), including study area size and effort, dominant species surveyed, survey type, estimate of shorebird abundance at each site, year(s) of study, and reference.

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
Aleutian/Bering Sea Islands Bird Conservation Region 1							
1	St. Matthew and Hall Islands	330 km^2 (200.3 km of transects)	ROSA	Systematic, line transects	P: 13,480–17,289 ind	2003	Ruthrauff *et al.* 2012
2	St. Paul Island	109 km^2 (205.1 km of transects)	ROSA	Systematic, line transects	P: 988–1469 ind	2001	Ruthrauff *et al.* 2012
3	St. George Island	90 km^2 (170.6 km of transects)	ROSA	Systematic, line transects	P: 2155–3022 ind	2002	Ruthrauff *et al.* 2012
4	Eastern Aleutians	4,917.5 km^2 (68 islands)	BLOY	Boat or beach surveys, observations from cliffs	N: 998 obs	1980–1981	Nysewander *et al.* 1982
5	Eastern Aleutians (Adak, Amlia, and Avatanak Islands)	9,243 km^2 (60 rapid plots at 3 clusters)	ROSA[2a]	Non-random PRISM, 16-ha plots	P: 61,602 ind (CV = 0.58)	2002	McCaffery *et al.* 2012
Western Alaska Bird Conservation Region 2							
6	Selawik Region	15,170 km^2 (35 rapid plots at 21 clusters)	PAGP, SESA, WESA, RNPH, BARG, BLTU, DUNL	Random PRISM, 14–22-ha plots	P: 390,247 ind (CV=0.35)	2002	McCaffery *et al.* 2012
7	Seward Peninsula and W Norton Sound	4,500 km^2 (2814 point counts at 1035 points on 39 grid cells, intensive plots)	BTCU, AMGP, PAGP, WHIM, BARG, WESA, WISN (4 other less common)	Random 10 km x 10 km grid, point counts plus intensive validation plot for BTCU	P: 1,200 breeding pairs of BTCU on Seward Peninsula (CI: 500-1,900); D: 0.03–1.18 birds/point for other species	1988–1992, 2000	Handel, unpubl. data in Marks *et al.* 2002; Tibbitts *et al.* 2006; Handel, Gill, & Tibbitts, unpubl. data
8	Seward Peninsula	3,500 km^2 (247 points on 14 grid cells)	AMGP, BTCU, WESA, WHIM, WISN, PAGP, BARG (9 other less common)	Stratified subset of random 10 km x 10 km grids sampled in 1988, 1989, 2000; replicated point counts	N: 1–303 obs over all points and years; predicted abundance (detections) per point relative to habitat	2012–2014	Thompson *et al.* 2016
9	Seward Peninsula	67,500 km^2 (106 polygons)	REKN, AMGP (10 other less common)	Area search, 10–338-ha polygons on ridges and domes	O: REKN present at 27% of polygons	2011	Johnson *et al.* 2011a

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
10	Yukon Delta National Wildlife Refuge	55,336 km² (621 rapid plots, intensive plots)	WESA, RNPH, DUNL, WISN, BARG, BLTU, LESA, BBPL, LBDO, ROSA, SESA, WHIM, PAGP, SBDO (12 other less common)	PRISM, 16-ha plots plus intensive validation plots	P: 4,720,396–8,321,746 ind	2015, 2016	R. Lanctot, unpubl. data
11	Yukon Delta (Hazen Bay area)	853 km² (78 rapid plots at 9 clusters, intensive plots)	DUNL, RNPH, SESA, WESA, BLTU, BARG, ROSA, BBPL, WISN	Mostly Random PRISM, 9–14-ha plots; plus intensive validation plots	P: 309,371 ind (CV = 0.11)	2002	McCaffery *et al.* 2012
12	Yukon-Kuskokwim Delta (Aerial: Central Coast; Ground: Angyoyaravak Bay)	~3,800 km² (556 km aerial transect, 25 ground transects)	BLTU	Aerial and ground-based surveys, ground transects 1.2–11.2 km long	P: 80,000 ind (CI = 61,000–99,000)	1978–1982	Handel and Gill 1992
13	Yukon River (Holy Cross to Emmonak)[1a]	520–700 km of river/year (650–865 points/year)	WISN, LEYE, SOSA, SPSA (5 other less common)	Boat-based point counts	N: 12–124 obs/species	1998, 2000, 2002	Harwood 1999, 2001, 2003
14	Kuskokwim River (Aniak to Bethel)[1a]	>483 km of river (590–598 points/year)	WISN, LEYE, SOSA, SPSA (5 other less common)	Boat-based point counts	N: 17–72 obs/species	1999, 2001	Harwood 2000, 2002
15	Alaska Peninsula Lowlands (points from Upper Naknek River to end of Alaska Peninsula)	23,100 km² (792 points on 52 grid cells)	DUNL, WISN, SBDO, LESA, RNPH (8 other less common)	Random 5 km x 5 km grid, point counts, all plots with ≥15% of area <100 m elevation	D: 0.5–1.5 ind/point for 5 common species	2004–2007	Savage *et al.* in review
16	Alaska Peninsula	Unknown (51 rapid plots at 6 sites)	DUNL, WISN, RNPH, SBDO, GRYE (6 other less common)	Non-random PRISM, most 16-ha plots	P: 1,803,925 ind (CV = 0.32)	2002	McCaffery *et al.* 2012
17	Katmai and Lake Clark National Park and Preserve	15,175 km² (885 points on 54 grid cells)	AMGP, SEPL, GRYE, LEYE, WHIM, SURF, LESA, WISN (9 other less common)	Random 10 km x 10 km grid, point counts	D: 0.001–0.093 ind/point	2004–2006	Ruthrauff *et al.* 2007

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
18	Aniakchak National Monument and Preserve	2,433 km^2 (136 points on 8 grid cells)	SEPL, LESA, ROSA, WISN (7 other less common)	Random 10 km x 10 km grid, point counts	N: 1–126 obs/species	2008	Ruthrauff and Tibbitts 2009
19	Outer Shumigan Islands (south of Alaska Peninsula)	Unknown (2–4 surveys on coast)	BLOY	Boat-based, followed by beach surveys	D: 0.1–2.5 pairs/km^2	1994, 1995	Byrd *et al.* 1997
20	Izembek NWR isthmus (road corridor from Cold Bay to King Cove)	40 km^2 (120 points)	ROSA, DUNL, SEPL, LESA, RNPH, WISN, SBDO	Systematic grid of point counts	D: ROSA 2.8 ind/point	2007–2009	K. Sowl, unpubl. data
21	Kodiak Island	~400–~1000 km coastline/year	BLOY	Boat-based coast survey	P: ~1,350–1,750 ind	1994–2005	D. Zwiefelhofer, unpubl. data in Tessler *et al.* 2014
22	Kodiak Archipelago	1,465 km^2 (nearshore only; 150 nearshore and 11 offshore island transects)	BLOY	Boat-based coast survey, systematic, 2.5–5-km transects	P: June: 1,410 (CI: 1,191–1,629); P: August: 3,402 (CI: 1,991–4,814)	2011–2013	Corcoran 2016
23	Katmai National Park and Preserve	Unknown (5 sites)	BLOY	Boat-based coast survey, 20-km transects	D: .06–0.12 nests/km	2006–2016	Coletti *et al.* 2017
Arctic Plains and Mountains Bird Conservation Region 3							
24	Arctic Coastal Plain	73,348 km^2 (unknown # of rapid plots, intensive plots)	AMGP, SESA, PESA, DUNL, LBDO, RNPH, REPH (12 other less common)	PRISM, most 16-ha plots plus intensive validation plots	P: NPR–A = 4,540,047; Prudhoe Bay = 1,431,007; Arctic Refuge = 307,611; Total = 6,278,665	1998–2004	Bart *et al.* 2013
25	Teshekpuk Lake Special Area	4,550 km^2 (167 rapid plots)	SESA, PESA, DUNL, RNPH, REPH (8 other less common)	PRISM, 16-ha plots	P: 573,274 ± 38,718 (1 SE)	2006–2008	Andres *et al.* 2012a
26	Arctic National Wildlife Refuge–Coastal Plain	674,000 km^2 (197 rapid plots, intensive plots)	AMGP, SESA, PESA, RNPH, REPH (9 other less common)	PRISM, 16-ha plots plus intensive validation plots	P: 104,122–362,938	2002, 2004	Brown *et al.* 2007

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
27	Cape Krusenstern National Monument and Noatak National Preserve	13,000 km^2 (149 polygons)	REKN, AMGP, SURF (11 other less common)	Area search, 15–700-ha polygons on ridges and domes	D: REKN = 0.31–0.62 pairs/ km^2; O: REKN = 13% of polygons	2010	Johnson *et al.* 2010a
28	Cape Krusenstern National Monument (Kakgrak Hills, Tahinichok Mountains)	Kakgrak: 48 points on 4 transects, 25 km total length), Tahinichok: 36 points on 3 transects over 3 townships	AMGP, BARG, WHIM, WISN, REKN	Accessible townships, transect with point counts	O: Kakgrak = 12.5–77% of points Tahinichok = 21–47% of points	1996	Gill *et al.* 1996
29	Arctic Network of Parks (Cape Krusenstern National Monument, Noatak National Preserve, Kobuk Valley National Park, Gates of the Arctic National Park and Preserve)	67,800 km^2 (1,647 points at 69 sites)	AMGP, LEYE, WATA, WHIM, BARG, SURF, SESA, BASA, PESA, LBDO, WISN (11 other less common)	Random 10 km x 10 km grid, point counts, all areas ≥ 100 m in elevation and < 30° slope	O: 0.1–13.8% of points	2001–2003	Tibbitts *et al.* 2006
Northwestern Interior Forest Bird Conservation Region 4							
30	Southern Nulato Hills[1b]	5,100 km^2 (596 points on 19 grid cells; intensive plot)	BTCU, AMGP, PAGP, SURF, WISN, WHIM (other less common)	Random 10 km x 10 km grid, point counts plus intensive validation plot for BTCU	P: 2,000 pairs of BTCU (CI: 700–3,300); no estimates made for other species	1989, 1991, 1999	Handel, unpubl. data in Marks *et al.* 2002; Handel, Gill, McCaffery *et al.*, unpubl. data
31	Southern Nulato Hills[1b]	5,100 km^2 (249 points at 16 sites)	BTCU, WHIM, PAGP, BARG, other species	Systematically distributed sites, point counts	N: BTCU = 228 obs; WHIM = 121 obs	2012	K. Sowl, unpubl. data
32	Donnelly and Tanana Flats Training Area	Unknown (220 plots)	WISN, LEYE, SPSA, WHIM, SOSA (7 other less common)	Modified PRISM, 16-ha plots	N: 1–216 obs/ species; O: 0.32 occupancy estimate	2017	E. Martin, unpubl. data
33	Upper Susitna River Watershed	2,076.5 km^2 (>2,500 points)	WISN, LEYE, AMGP, RNPH, LESA (7 other less common)	Random grids by vegetation strata, point counts	N: 1–337 obs/ species; O: <0.001–0.235 detections/1,434 counts	2013, 2014	ABR 2018

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
34	Interior Road System (Dalton, Denali, Elliot, Parks, Richardson, Steese, and Taylor, Highways; Stampede Road)	Unknown (279 points on 28 transects)	WHIM, WISN (9 other less common)	Non-random transects, point counts, 2–21 points/ transect	N: 1 species on 63 points; 0 obs on 203 points	2013	Harwood 2016
Northern Pacific Rainforest Bird Conservation Region 5							
35	Kenai Fjords National Park	Unknown (5 transects)	BLOY	Boat-based coast survey, 20-km transects	D: 0.05–0.09 nests/km	2007–2016	Coletti *et al.* 2017
36	Southwestern Prince William Sound	Unknown (5 transects)	BLOY	Boat-based coast survey, 20-km transects	D: 0.06–0.13 nests/km	2007–2016	Coletti *et al.* 2017
37	Prince William Sound	10,000 km^2 (185 transects)	BLOY	Boat-based coast survey, random line transects	P: 709 ± 223 ind (95% CI)	1989 –1993	Agler *et al.* 1999
38	Western Prince William Sound	4,660 km shoreline (1,943 km, 18 transects)	BLOY	Boat-based coast survey, transects, 21–254 km long	N: 291 obs, 94 territories D: 0.03–0.38 pairs/km	2000–2004	Poe *et al.* 2009
39	Eastern Prince William Sound (Nelson Bay to Knoll's Head, Red Head to Galena Bay)	2001: 300 km 2002: 110 km	BLOY	Boat-based coast survey, all shoreline	N: 2001: 8 nests + 3 ind obs; 2002: 31 nests + 5 obs	2001, 2002	Meyers and Fode 2001, Meyers 2002
40	Prince William Sound focus on Hinchinbrook and Hawkins Islands, College Fiord/Port Wells, Cochrane Bay, Blackstone Bay, shoreline between eastern Valdez Arm and Cordova	Unknown (1,300 km of surveys)	BLOY	Boat-based coast survey, some beach walks	N: 101 territories	2007–2009	Poe *et al.* 2013

No.	Site	Study Area Size (effort)	Dominant Species[2*]	Survey Type[3]	Measure of Abundance[4]	Year(s) of Study	Reference(s)
41	Prince William Sound	Unknown (8–9 transects/year over 46 regions)	BLOY	Boat-based survey, split-panel, rotating design, 20-km transects	N: 12–21 territories/year; 317 obs over all years	2012–2017	Cooper 2013; Cooper and Gabrielson 2012; Gabrielson 2014, 2015a, 2016, 2017
42	Middleton Island	12.95 km^2 (all coastline)	BLOY	Land-based coast survey, monthly counts (April–September, February)	P: 781, 716, 703 ind maximum in 2004–2006, respectively D: ave. 9.8 pairs/km in 2004 and 2005	2002, 2004–2006	Gill *et al.* 2004; Guzzetti 2008
43	Eastern Copper River Delta	>225 km^2 (52 km, 11 transects)	LESA, RNPH, SBDO, WISN	Repeated belt transects 3–9 km long, 30 m wide, rope-drag on some transects	D: 20.5–28.8 nests/km^2 for all shorebirds	1978, 1979	Mickelson *et al.* 1980
44	Glacier Bay	Unknown (1,203 km of surveys)	BLOY (3 other less common)	Boat-based and ground surveys, focus on human disturbance sites	N: BLOY = 124–205 pairs[4a]	2003–2005	Arimitsu *et al.* 2007
45	Glacier Bay, Beardslee Islands	Unknown (all coastline)	BLOY	Boat- and beach-based surveys	N: 66 territories	2005	Tessler and Garding 2005
46	Sitka Sound	Unknown (25 sites)	BLOY	Area search, revisit Webster sites and others	N: 8 pairs	2007	Andres and Christensen 2009

Data compiled by R. Lanctot and R. Gates, and accompanying map created by S. Saalfeld. Coverage excludes Breeding Bird Survey routes, Alaska Landbird Monitoring Survey plots, North Pacific Pelagic Seabird Database, and small-scale breeding studies. See Figure 11 for location of sites in Alaska.

[1a]The northern half of these transects is located in BCR 4.

[1b]Some sites in southern Nulato Hills are located in BCR 2.

[2*]Species that are numerically dominant are listed. See Appendix 1 for scientific names. AMGP = American Golden-Plover, BARG = Bar-tailed Godwit, BBPL = Black-bellied Plover, BLOY = Black Oystercatcher, BLTU = Black Turnstone, BTCU = Bristle-thighed Curlew, DUNL = Dunlin, GRYE = Greater Yellowlegs, LBDO = Long-billed Dowitcher, LESA = Least Sandpiper, LEYE = Lesser Yellowlegs, PAGP = Pacific Golden-Plover, PESA = Pectoral Sandpiper, REKN = Red Knot, REPH = Red Phalarope, RNPH = Red-necked Phalarope, ROSA = Rock Sandpiper, SBDO = Short-billed Dowitcher, SEPL = Semipalmated Plover, SESA = Semipalmated Sandpiper, SOSA = Solitary Sandpiper, SPSA = Spotted Sandpiper, SURF = Surfbird, WATA = Wandering Tattler, WESA = Western Sandpiper, WHIM = Whimbrel, WISN = Wilson's Snipe.

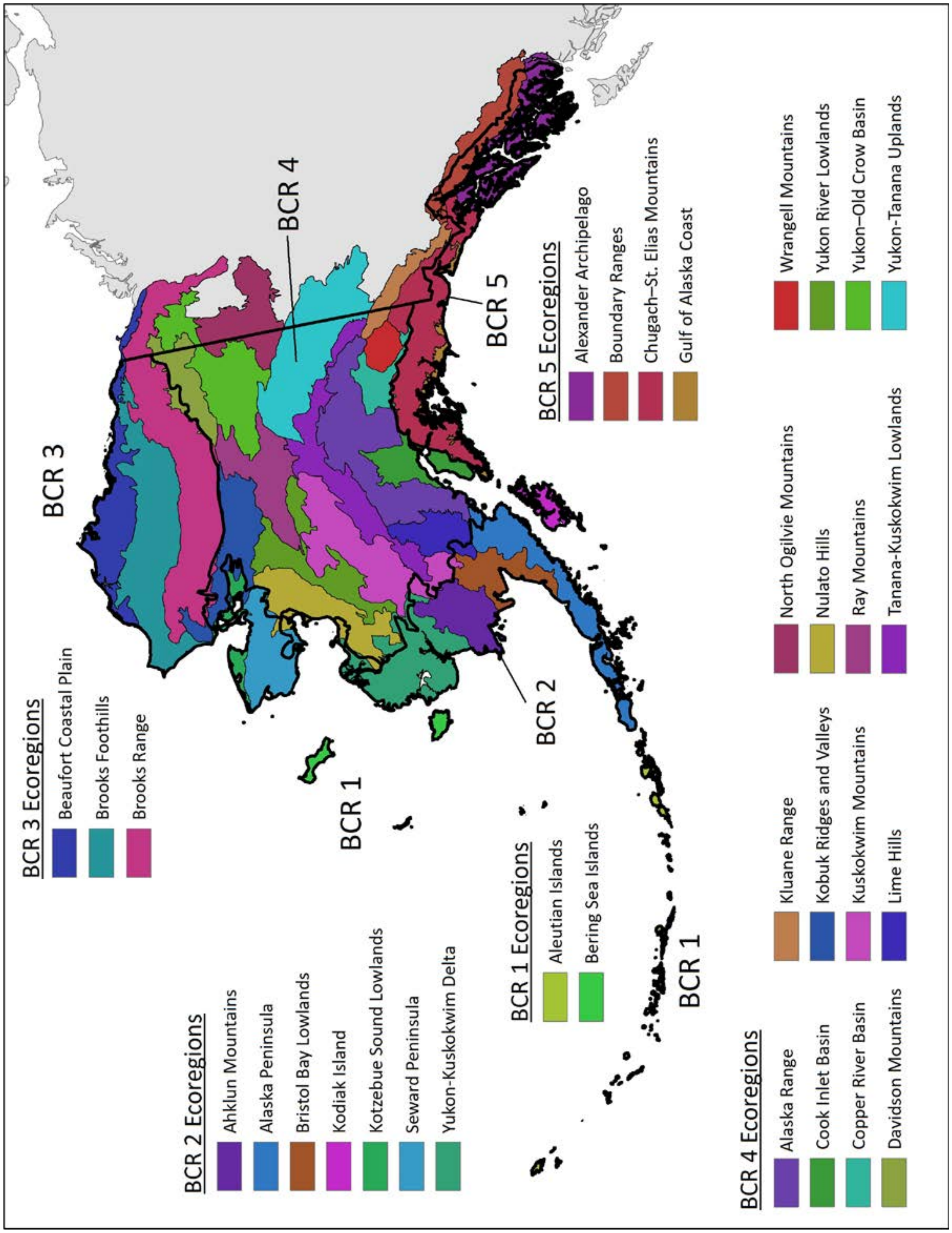
[2a]Surveyors were unable to count Black Oystercatchers on the shore due to fog and rugged topography that made accurate counts impossible.

[3]Survey type includes basic description of methods used to count birds. PRISM = Program for Regional and International Shorebird Monitoring. See references for more details.

[4]Measure of abundance prioritized by listing population estimate first (P, with species, confidence interval [CI], coefficient of variation [CV], standard error [SE], and range provided in some cases), then density (D), number observed (N), and then occurrence (O). Number of individuals (ind) and observations (obs) given where relevant. Measures reflect value for all species observed unless species stated. See references for values of individual species.

[4a]This count includes birds counted by Tessler and Garding 2005.

APPENDIX 6. ECOREGIONS OF ALASKA RELATIVE TO BOUNDARIES OF BIRD CONSERVATION REGIONS.



Ecoregions after Gallant et al. 1995 and Nowacki et al. 2001.

APPENDIX 7. HABITAT PREFERENCES OF SHOREBIRDS IN ALASKA DURING BREEDING (B), MIGRATION (M), AND WINTER SEASONS (W; NOVEMBER–MARCH).

Species	Tundra Meadows[1]	Alpine Rocky Tundra	Woodland & Dwarf Forests	Tall Shrub Thicket	Lacustrine[2]	Mud & Sand Flats[3]	Rocky/ Gravel Shorelines[4]
Black Oystercatcher							B, M, W
Black-bellied Plover	B, M				M	M, W	W
American Golden-Plover	B, M						
Pacific Golden-Plover	B, M					M	
Semipalmated Plover		B			M	M	B
Killdeer	W						B
Upland Sandpiper	B, M		B				
Bristle-thighed Curlew	B, M						
Whimbrel	B, M					M	
Bar-tailed Godwit	B, M					M	
Hudsonian Godwit	B, M		B			M	
Marbled Godwit	B					M	
Ruddy Turnstone	B, M	B				M	M
Black Turnstone	B					M	M, W
Red Knot	M	B				M	
Surfbird		B				M	M, W
Sharp-tailed Sandpiper	M					M	
Stilt Sandpiper	B, M					M	
Sanderling		B				M, W	M, W
Dunlin	B, M					M, W	
Rock Sandpiper	B	B				M, W	M, W
Baird's Sandpiper	B, M	B				M	B
Least Sandpiper	B, M		B			M	
White-rumped Sandpiper	B, M						
Buff-breasted Sandpiper	B, M						
Pectoral Sandpiper	B, M					M	
Semipalmated Sandpiper	B					M	
Western Sandpiper	B					M	
Short-billed Dowitcher	B, M		B			M	
Long-billed Dowitcher	B, M					M	
Wilson's Snipe	B, M, W		B		W	M, W	
Spotted Sandpiper					B, M		B, M
Solitary Sandpiper			B, M	B, M			

Species	Tundra Meadows[1]	Alpine Rocky Tundra	Woodland & Dwarf Forests	Tall Shrub Thicket	Lacustrine[2]	Mud & Sand Flats[3]	Rocky/ Gravel Shorelines[4]
Wandering Tattler							B, M
Lesser Yellowlegs	B, M		B	B		M	
Greater Yellowlegs	B, M		B			M	
Red-necked Phalarope[5]	B				B, M	M	
Red Phalarope[5]	B				B, M	M	

Habitat classifications from Kessel (1979), with the following exceptions:

[1]Includes dwarf shrub meadows, salt grass meadows, wet meadows, and grass fields.

[2]Includes ephemeral ponds.

[3]Includes ephemeral mudflats.

[4]Includes rivers, shorelines, and artificial gravel sites.

[5]Both phalarope species are also associated with pelagic areas, especially ice edges, during migration.

Surveying Shorebirds
Copper River Delta
Mike Ausman

APPENDIX 8: SPECIES ACCOUNTS FOR PRIORITY SPECIES IN ALASKA

Species are listed in taxonomic order within each conservation category.

GREATEST CONSERVATION CONCERN

Bristle-thighed Curlew

The Bristle-thighed Curlew (*Numenius tahitiensis*) is a species of greatest concern because of its small population size (approximately 10,000 total birds, including about 6,400 breeders; C.M. Handel in Marks *et al.* 2002), its restricted breeding range (the Nulato Hills and central Seward Peninsula of Alaska), and anthropogenic threats across its nonbreeding range in central Oceania (e.g., habitat alteration, predation by introduced mammals; Marks and Redmond 1994; Engilis and Naughton 2004). On the Seward Peninsula, climate-moderated increases in shrub cover and density are predicted to negatively affect the abundance of breeding Bristle-thighed Curlews (Thompson *et al.* 2016). Additionally, most sea-level rise models predict that the low-lying atolls and islands that make up the majority of the species' nonbreeding range will be lost in this century (Nurse *et al.* 2014), highlighting the need for curlews to expand their nonbreeding range to include higher elevation islands. A natural re-colonization of a site on Oahu, Hawaii, suggests that Bristle-thighed Curlews have the behavioral capacity to shift their nonbreeding distributions (Tibbitts *et al.* 2016), but most new sites will likely include high islands that will require intensive management to protect birds from predation and provide adequate foods.

Bristle-thighed Curlew. Photo by Daniel Ruthrauff.

Bar-tailed Godwit

The subspecies of Bar-tailed Godwit breeding in Alaska (*Limosa lapponica baueri*) spends the nonbreeding season in New Zealand and eastern Australia, and is one of two Alaska-breeding shorebirds (along with the *arcticola* subspecies of Dunlin) that use stopover sites in East Asia during northward migration. Although the population estimate for *baueri* godwits is relatively high (90,000 birds;; USSCPP 2016), the subspecies ranks as a species of greatest conservation concern because of significant population declines over the past few decades (Studds *et al.* 2017). The New Zealand nonbreeding population appears to have recently stabilized after these declines, but mark-recapture analysis reveals a recent steep decrease in adult survival (Conklin *et al.* 2016). Expert consensus is that these downward trends are related to the rapid loss and degradation of habitats at migratory staging sites in the Yellow Sea (MacKinnon *et al.* 2012; Conklin *et al.* 2014). The species may also be vulnerable to subsistence harvest. In Alaska,

Bar-tailed Godwit. Photo by Daniel Ruthrauff.

it is estimated that 1,115 godwits (species unidentified) are harvested annually, mostly along the south coast of the Yukon-Kuskokwim Delta (L. Naves, unpubl. data). It is likely that Bar-tailed Godwits constitute the bulk of this harvest. In East Asia, levels of active harvest and accidental by-catch in fishing nets are unknown, but may be considerable (MacKinnon *et al.* 2012). The cumulative impacts of hunting on the population are unknown but could be significant. In addition, there is evidence that reproductive rates of Bar-tailed Godwits in Alaska are often quite low; for instance, juveniles typically constituted <3% of staging flocks during postbreeding surveys at coastal sites from 1999–2005 (McCaffery and Gill 2001; McCaffery *et al.* 2006). The causes and consequences of chronically low reproductive output remain unknown.

Red Knot

The *Calidris canutus roselaari* subspecies is one of three Red Knot populations that breed in North America and the only one known to regularly occur in Alaska (Baker *et al.* 2013). The breeding range of *roselaari* encompasses two regions: Wrangel Island, Russia, and northwestern Alaska. In Alaska, knots breed in low densities in montane habitats scattered across the Seward Peninsula north to the western Brooks Range. The size of the Alaska breeding population is unknown. Recent tracking studies suggest that the entire *roselaari* population concentrates at the Bering River and Copper River Deltas, and on the Yukon-Kuskokwim Delta during migratory periods (J. Johnson, unpubl. data; Bishop *et al.* 2016). *Roselaari* Red Knots are considered a species of high conservation concern because of their small population size (21,800 individuals; Lyons *et al.* 2015), restricted number of sites the species occupies during migratory periods (Carmona *et al.* 2015), and suspected population declines (Tomkovich and Dondua 2008). Knots are bivalve (e.g., *Macoma* spp.) specialists and are adversely affected by reductions in prey availability and density (van Gils *et al.* 2006). The introduction and spread of invasive cordgrass (*Spartina* sp.), which inhibits Red Knots from accessing bivalves, is thought to be the primary cause of a substantial decline of knots at Willapa Bay, Washington (a previous major spring stopover site; J. Buchanan, pers. comm.). A recent genetics-based analysis of the population structure of *roselaari* knots determined that the Wrangel Island, Russia, and northwestern Alaska breeding populations are evolutionarily distinct (J. Conklin, pers. comm.). If this information is used to subdivide the subspecies, the two groups would each number only a few thousand individuals each, increasing the risk of threats and stressors throughout the annual cycle.

Red Knots. Photo by Lucas DeCicco.

HIGH CONSERVATION CONCERN

Black Oystercatcher

Black Oystercatchers (*Haematopus bachmani*) are a species of high conservation concern due to their relatively small population size, restricted range, and high vulnerability to threats. The global population numbers fewer than 11,000 individuals, with Alaska supporting a large proportion of breeding individuals (45–70% of the global population; Andres *et al.* 2012b; Weinstein *et al.* 2014). Black Oystercatchers are completely dependent upon a narrow band of intertidal and rocky shoreline habitat throughout their annual cycle, environments where they are highly susceptible to natural and anthropogenic threats, including oil spills, human recreational disturbance, and climate-mediated changes to habitats and food resources. Breeding success is generally low, and productivity is limited primarily by predation and flooding caused by storm tides (Morse *et al.* 2006), although recreational disturbance is becoming an increasing threat. Their strong fidelity to breeding territories, use of beaches also preferred by humans for recreation, conspicuous behavior, and limited

Black Oystercatcher. Photo by Matt Prinzing.

reproductive potential make them particularly vulnerable to local extirpation through persistent disturbance by foxes and humans (Andres 1997, 1998). Broad-scale population estimates are needed to better assess population trends.

American Golden-Plover

The population of American Golden-Plovers (*Pluvialis dominica*) is estimated at 500,000 individuals (Andres *et al.* 2012a), with about half of the population breeding in Alaska (Johnson *et al.* 2018a). The species is considered of high conservation concern due to an unknown population trend and serious potential threats throughout its annual cycle (Clay *et al.* 2010; Andres *et al.* 2012b). Threats include a potential increase in the frequency and severity of storms encountered during southward trans-Atlantic migrations; agricultural practices that may be detrimental to plovers along migration corridors and on nonbreeding grounds; conversion of nonbreeding habitat to other uses: and hunting, particularly in the Lesser Antilles (Clay *et al.* 2010; Stodola *et al.* 2014; Watts *et al.* 2015; Watts and Turrin 2016). On the breeding grounds, the species is considered vulnerable to climate-driven habitat changes (Galbraith *et al.* 2014; Wauchope *et al.* 2017). Population monitoring programs in conjunction with baseline studies to assess the impacts of climate warming are warranted to identify threats throughout the species' annual cycle. Knowledge gaps include long-term information on potential effects of habitat alteration, arthropod availability, and variation in demographic rates (Clay *et al.* 2010; Johnson *et al.* 2018a). Furthermore, recent work by Weiser *et al.* (2018c) indicates that conditions at breeding sites have relatively little effect on adult survival of American Golden-Plovers, underscoring the need to understand factors acting during the migratory and nonbreeding seasons.

American Golden-Plover. Photo by Zak Pohlen.

Pacific Golden-Plover

The population estimate for Pacific Golden-Plovers (*Pluvialis fulva*) is 185,000–250,000, of which 35,000–50,000 breed in western Alaska (Andres *et al.* 2012b). The species migrates along two major pathways to and from primary nonbreeding grounds in Oceania (Johnson *et al.* 2012, 2015). Those breeding from the Alaska Peninsula to the central Yukon-Kuskokwim Delta winter in the Hawaiian Islands and make direct flights to and from Alaska, while those nesting north of the central Yukon-Kuskokwim Delta winter primarily at sites in the Central and South Pacific and migrate north via East Asia. The status of the population on the breeding and nonbreeding ranges is unknown (Andres *et al.* 2012b) as reflected in conservation status designations ranging from "highly imperiled" (Galbraith *et al.* 2014) to "species of least concern" (BirdLife International 2017). Potential threats to the species and research needs mirror those listed above for the American Golden-Plover (see Johnson *et al.* 2018a), but Pacific Golden-Plovers may be especially vulnerable to

Pacific Golden-Plover. Photo by Oscar Johnson.

projected sea-level rise throughout their low-lying wintering grounds in the Pacific (Galbraith *et al.* 2002).

Whimbrel

North American Whimbrels (*Numenius phaeopus hudsonicus*; AOU 1998) breed as two disjunct populations, the eastern located west and south of Hudson Bay, and the western in Alaska and northwestern Canada (Skeel and Mallory 1996). The western population breeds discontinuously in tundra patches within the boreal forest, as well as the continuous tundra beyond tree line. This segment constitutes nearly half (40,000) of the continent's estimated 85,000 individuals and spends the boreal winter along the Pacific Coast, from mainly Mexico to Chile (Skeel and Mallory 1996; Andres *et al.* 2012b). While an apparent decline and low relative abundance in the eastern population has elevated its conservation status (Wilke and Johnston-González 2010), similar information is lacking for the western population (Andres *et al.* 2012b). Nevertheless, conservation concern for the western population remains high because of its small population size and manifold threats on the nonbreeding grounds (USSCPP 2016), including habitat loss/degradation and land-use changes (Wilke and Johnston-González 2010). Potential threats on the breeding grounds include climate change-related stressors such as shrubification (Ballantyne and Nol 2015), although Whimbrels appear to be tundra generalists throughout their range (Skeel and Mallory 1996), suggesting some capacity to adapt to dynamic habitat conditions (e.g., breeding within the fire-prone taiga; Harwood 2016). Priority conservation actions in Alaska include studies to: 1) further illuminate habitat needs, connectivity, movement patterns, and differential survival during the species' annual cycle, 2) refine

Whimbrel. Photo by Zak Pohlen.

distribution and habitat specificity, especially regarding potential conflicts with human resource development, and 3) investigate the importance of social factors in the species' patchy nesting distribution.

Hudsonian Godwit

The Pacific population of Hudsonian Godwits (*Limosa haemastica*) is currently estimated at about30,000 individuals (Andres *et al.* 2012b; Garcia-Walther *et al.* 2017); an unknown, but likely large proportion of these individuals breeds in Alaska, making it home to as much as 40% of the global population during the boreal summer (Walker *et al.* 2011). Recent efforts to track individuals both wintering on Isla Chiloé, Chile, where the majority of the Pacific population spends the nonbreeding season, and breeding in Alaska's upper Cook Inlet region suggest that Alaska-breeding godwits make use of a very few staging sites during northward migration, mostly in central Kansas and Nebraska (Senner *et al.* 2014; L. Espinosa-Gallegos, unpubl. data). During southward migration, most godwits migrate directly to staging sites in Alberta and Saskatchewan before undertaking nonstop flights lasting 5 days to the Amazon Basin in Colombia and Brazil. Once in the Amazon, godwits stopover for

Hudsonian Godwit. Photo by Daniel Ruthrauff.

up to two weeks prior to completing their migration to southern Chile (Senner *et al.* 2014). In preparing for flights from Alaska, godwits stopover at sites in upper Cook Inlet, Bristol Bay, and the Yukon-Kuskokwim Delta (Seppi 1995, 1997; Gill and Tibbitts 1999; McCaffery and Harwood 2000; McCaffery *et al.* 2005). Recent work on Isla Chiloé suggests that while the size of the Pacific population has remained stable over the past 30 years, birds have retracted their nonbreeding range away from highly disturbed sites (Andres *et al.* 2009), concentrating much of the population in a relatively small number of isolated bays. Furthermore, work with godwits breeding in Alaska suggests that their patchy distribution may be the result of conspecific nest aggregations, and not the distribution of specific habitat features (Swift *et al.* 2017). If true, any decline in godwits resulting from changing conditions in South America could trigger an increasingly rapid decline through density-dependent processes acting on the breeding grounds. Finally, the species may suffer from a climate-induced change in their prey phenology that may reduce their productivity (Senner *et al.* 2017).

Marbled Godwit

Alaska hosts a geographically and morphologically distinct breeding population of Marbled Godwits (*Limosa fedoa beringiae*; Gibson and Kessel 1989) believed to number approximately 2,000 individuals, ranking this population among the smallest of any shorebird in North America (Andres *et al.* 2012b). There is a general lack of information on the basic natural history of this subspecies, but it is believed to have a restricted distribution throughout its annual cycle, breeding only along a small section of the central Alaska Peninsula and wintering at coastal sites in the Pacific Northwest (Gibson and Kessel 1989; Ruthrauff *et al.* 2019). Although most sites used by Marbled Godwits are relatively pristine and not subject to future reclamation or development, the species may be susceptible to climate-driven habitat changes (e.g., shrubification; M. Cady, pers. comm.). Furthermore, godwits tracked via satellite telemetry have recently revealed that birds congregate at a few sites (e.g., Controller Bay on the eastern Copper River Delta) during migration (Ruthrauff *et al.* 2018), heightening the population's vulnerability to oil spills and/or mining. Subspecies of the Marbled Godwit were not considered separately in the national conservation ranking process (USSCPP 2016), but the species as a whole merited high concern status. Based on its very small population size, limited annual distribution, and reliance on a few key stopover sites during migration, *beringiae* Marbled Godwits similarly warrant status as a population of high concern.

Marbled Godwit. Photo by Daniel Ruthrauff.

Black Turnstone

The global population of Black Turnstones (*Arenaria melanocephala*), approximately 95,000 birds, breeds primarily along a narrow coastal section of the Yukon-Kuskokwim Delta (Handel and Gill 1992). The species' affinity for nesting in vegetated habitats within 2 km of the coast makes it especially susceptible to loss or change of habitat resulting from projected sea-level rise and increased frequency of storm-driven tides. The Black Turnstone, like the Ruddy Turnstone (see Alaska Stewardship Species section), is an opportunist. Throughout the mid- to late 1900s, >70% of the Black Turnstone population concentrated briefly each spring in Prince William Sound to feed on herring (*Clupea pallasi*) spawn (Norton *et al.* 1990; Bishop and Green 2001). Following the *Exxon Valdez* oil spill in 1989 and the decline of herring (Thorne and Thomas 2008), use of Prince William Sound by Black Turnstones decreased markedly (Bishop and Taylor 2015). It is not known if birds were directly affected by the spill or they altered their distribution in spring, or both.

Black Turnstone. Photo by Ken Plourde.

Nevertheless, because they are an obligate species of rocky intertidal habitats of the northeastern Pacific, and this region has had a history of oil spills, they may be potentially vulnerable to this perturbation. In order to better assess conservation concerns, additional information is needed on the species' breeding population size and density in preferred habitats, on the limits of its current breeding range, and on habitat preferences and use during the nonbreeding season.

Dunlin

Two subspecies of Dunlin (*Calidris alpina*) nest in Alaska. The *pacifica* population nests exclusively in western Alaska whereas the *arcticola* population nests in northern Alaska, with a very small fraction nesting in western Canada (Warnock and Gill 1996). Despite the relatively large population size of *arcticola* (estimate of 500,000 individuals, 95% confidence interval = 304,000–696,000, Andres *et al.* 2012b), this subspecies is of high conservation concern because of a significant population decline documented on the North Slope of Alaska (D. Troy, pers. comm.; USSCPP 2016), low adult survival estimates (Weiser *et al.* 2018c), and the alarming rate of loss of nonbreeding habitat in the Yellow Sea region (Piersma *et al.* 2017). The *pacifica* population size is similarly large, estimated at 550,000 birds (Andres *et al.* 2012b). New estimates from the Yukon Delta National Wildlife Refuge (estimate of 816,064 individuals, 95% confidence interval = 635,902–996,226; R. Lanctot, unpubl. data) suggest that this figure may be an underestimate, and these numbers will undoubtedly increase when other areas of the subspecies' range are included. Unlike *arcticola*, the population size of this subspecies is thought to be stable, leading to its categorization as a species of moderate concern (USSCPP 2016). The subspecies also is considered a stewardship species due to its population breeding solely in Alaska. Dunlin breed throughout moist-wet tundra (*arcticola*) or sedge-graminoid meadows (*pacifica*) in coastal tundra areas, and use similar habitats during migration and nonbreeding, including estuarine mudflats and adjacent agricultural habitats (Warnock and Gill 1996). The tendency of the birds to aggregate at coastal sites

Dunlin. Photo by Zak Pohlen.

to forage on seasonally abundant food resources makes them vulnerable to habitat loss and degradation, human disturbance, oil spills, and contaminants. Habitat alteration is related to reclamation of intertidal areas for food production, shrimp farms, dams, restoration of salt marshes, and invasive species (Fernández *et al.* 2008). Information needs for both subspecies include population trend data from the breeding grounds; better delineation of migratory patterns (especially for *arcticola* where it overlaps with three other subspecies of Dunlin); focused surveys to delineate, protect and manage key conservation sites; determination of factors limiting population growth; and identification of potential vulnerabilities to climate change (Fernández *et al.* 2008; Lanctot *et al.* 2009).

Rock Sandpiper

Four subspecies of Rock Sandpipers have evolved in the Bering Sea region of Alaska, each with a highly restricted distribution (Conover 1944). Two subspecies (*Calidris ptilocnemis ptilocnemis* and *C. p. couesi*) breed and winter almost exclusively in Alaska, while most individuals of a third subspecies (*C. p. tschuktschorum*) breed and winter within the region as well (Gill *et al.* 2002a). Because the Siberian-breeding members of the latter race apparently stage during fall migration in western Alaska, the state supports the entirety of all three populations during at least some portion of the year (Gill *et al.* 2002a). None of the three populations is large, ranging in size from 20,000 (Ruthrauff *et al.* 2012) to 75,000 individuals (Brown *et al.* 2001). The *ptilocnemis* population breeds only on a few islands in the Bering Sea, some of which have been markedly altered by reindeer grazing (Ruthrauff *et al.* 2012). Due to its small population size and restricted range throughout the annual cycle (Ruthrauff *et al.* 2013), this subspecies is considered a population of high concern (USSCPP 2016). The *couesi* and *tschuktschorum* populations are considered Alaska stewardship species due to their strong dependence on sites in Alaska.

Buff-breasted Sandpiper

The Buff-breasted Sandpiper (*Calidris subruficolis*) breeds discontinuously along the Arctic Coast of Alaska (Gotthardt and Lanctot 2002) and migrates primarily through the central portions of North and South America (Lanctot *et al.* 2016; McCarty *et al.* 2015) to reach wintering grounds in coastal northeast Argentina, Uruguay, and southern Brazil (McCarty *et al.* 2017). The species is the only North American shorebird that leks, and males breed with multiple females (and vice-versa) at multiple areas throughout the Arctic annually (Lanctot *et al.* 1997, 2016). Both sexes show very low breeding site fidelity and breed in dry to moist habitats, frequently along rivers (Lanctot and Weatherhead 1997). The species is of high conservation concern because of a large decline from historical numbers, small population size (56,000, range: 35,000–78,000), restricted wintering range, and threats throughout its range (Andres *et*

Rock Sandpiper. Photo by Robert Gill, Jr.

Buff-breasted Sandpiper. Photo by Ted Swem.

al. 2012b; B. Andres, unpubl. data; USSCPP 2016). On the breeding grounds, high-priority action items for the species include supporting broad-scale and focused surveys to delineate and protect key conservation sites, providing guidance to minimize impacts of development, and developing a habitat-selection model to predict and ultimately protect high-priority areas. Across the species' range, high-priority items include documenting population size and trends, migratory patterns and connectivity, and protecting and managing high-priority areas (Lanctot *et al.* 2010).

Pectoral Sandpiper

The Pectoral Sandpiper (*Calidris melanotos*) has an estimated global population of 1,680,000 birds (Andres *et al.* 2012b), of which approximately 70% may occur in Alaska both as breeders and migrants (Bart *et al.* 2012b; Warnock 2017). It is listed as a United States shorebird species of high concern due to recent population declines (USSCPP 2016). Pectoral Sandpipers are a polygynous species that breed in wet, grass-dominated coastal habitats from the Yukon-Kuskokwim Delta north and east to the Arctic Coastal Plain, as well as parts of eastern Russia (Johnson and Herter 1989; Bart *et al.* 2012b; Farmer *et al.* 2013). Male Pectoral Sandpipers are extremely nomadic and may stop to breed at Alaskan breeding grounds and then fly further east into Arctic Canada or west into Russia for further breeding attempts (Kempenaers and Valcu 2017). During migration, birds are also found at interior wetland sites (Farmer *et al.* 2013). Reasons for declines are unknown. In Alaska, potential threats to the breeding grounds mainly relate to climate-driven habitat changes and site-specific activities (e.g., oil and gas drilling).

Semipalmated Sandpiper

The Semipalmated Sandpiper (*Calidris pusilla*) is one of North America's most abundant shorebirds, with a recent global population estimate of approximately 2.25 million, but breeding populations have undergone a substantial decline in the eastern Canadian Arctic (BirdLife International 2016). Contributing factors likely include decreased food resources at migratory stopover sites in the mid-Atlantic (Mizrahi *et al.* 2012), hunting in South America and the Caribbean (Ottema and Spaans 2008; Morrison *et al.* 2012; Watts and Turrin 2016), and habitat loss and degradation in wintering areas (Ottema and Spaans 2008; Morrison *et al.* 2012). The Alaska population (stable at approximately 1.45 million; Andres *et al.* 2012b) breeds in low-lying, coastal tundra from the North Slope south to the Kuskokwim Delta (Hicklin and Gratto-Trevor 2010). On the Beaufort coast, the Canning River Delta is a key staging area for southbound birds (Taylor *et al.* 2010), and the Jago, Kongakut, and Okpilak-Hulahula Deltas also receive high use (Brown *et al.* 2012; Churchwell *et al.* 2017). On the

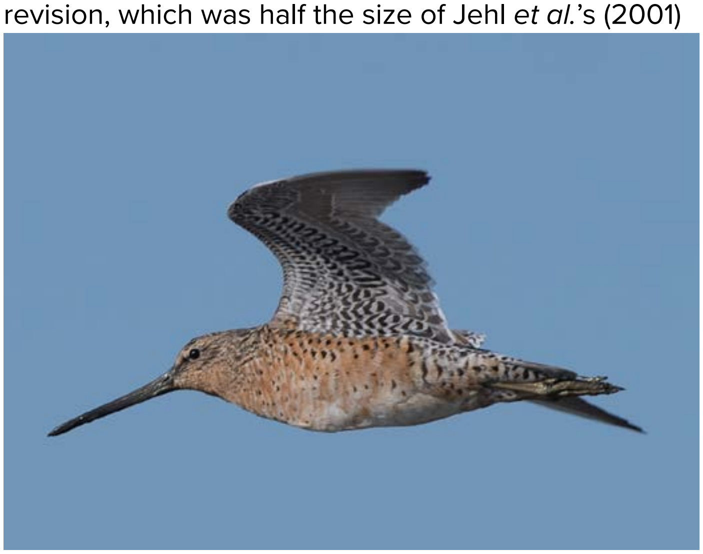
Pectoral Sandpiper. Photo by Zak Pohlen.

Semipalmated Sandpiper Photo by Zak Pohlen.

Chukchi coast, Ikpek/Arctic, Lopp, and Sisualik Lagoons receive high use (Connors and Connors 1982; Mizel and Taylor 2014; Boldenow *et al.* 2016; A. Taylor, unpubl. data). Potential threats to breeding habitat in Alaska include climate-related changes in habitat (e.g., shrubification of graminoid tundra; Andres *et al.* 2012b) and phenology. Primary conservation concerns in Alaska include climate-related impacts to coastal habitat, increased anthropogenic disturbance to foraging birds, and risk of oil spills (Brown *et al.* 2012; A. Taylor, unpubl. data; M. Boldenow, unpubl. data). Given site-specific resources (Churchwell *et al.* 2017), limited availability of suitable intertidal habitat (Connors and Connors 1982; A. Taylor, unpubl. data), and patterns of use (Taylor *et al.* 2010; Brown *et al.* 2012), maintaining an intact network of postbreeding sites is a conservation priority for this species.

Short-billed Dowitcher

There are three recognized breeding populations of Short-billed Dowitchers (*Limnodromus griseus*), distributed in eastern Canada (*L. g. griseus*), central Canada (*L. g. hendersoni*), and western Canada/Alaska (*L. g. caurinus*). Based on known and suspected declines of some races in past years (Andres *et al.* 2012b), the Short-billed Dowitcher is listed as a species of high concern (USSCPP 2016). While not analyzed for trend, data from Kachemak Bay suggest that current numbers of dowitchers at that site have declined since the 1990s (Matz *et al.* 2011a). The most recent population estimate for *caurinus* (75,000 individuals) is derived from Morrison *et al.*'s (2006) revision, which was half the size of Jehl *et al.*'s (2001) population estimate. In Alaska, *caurinus* nest in wetlands, mainly along the coast, from southeast Alaska up to and including the Yukon-Kuskokwim Delta. The migration of Short-billed Dowitchers has been poorly studied, but birds marked in spring in San Francisco Bay, California, and Grays Harbor, Washington, were subsequently detected during migration at the Copper River Delta and in the Bristol Bay region (Warnock *et al.* 2001). Given its population size, relatively restricted breeding distribution, potential threats during the nonbreeding season, and documented declines among the other populations, the *caurinus* subspecies is considered a species of high conservation concern.



Short-billed Dowitcher. Photo by Lucas DeCicco.

Lesser Yellowlegs

The Lesser Yellowlegs (*Tringa flavipes*) is considered a species of high concern because of its declining population size and current threats at breeding, migration, and nonbreeding areas. Although the current continental population of Lesser Yellowlegs is estimated to be 660,000 individuals (Andres *et al.* 2012b), the species is experiencing steep population declines at all monitored sites throughout its range. Analysis of Breeding Bird Survey data from 15% of the breeding range in the contiguous United States and Canada showed significant long-term declines between 1966 and 2011 (Sauer *et al.* 2013). Likewise, a combined analysis of Breeding Bird Surveys (roadside) and Alaska Landbird Monitoring Surveys (off road) in the Northwestern Interior Forest BCR

Lesser Yellowlegs. Photo by Zak Pohlen.

of Alaska showed significant short-term declines from 2003 to 2015 (Handel and Sauer 2017). Long-term trends in numbers at migration sites in eastern North America also suggest a population decline (Bart *et al.* 2007; Ross *et al.* 2012). Finally, observations in South America indicate either dramatic losses of birds from some traditional wintering areas or, less likely, unidentified shifts in their distributions (Ottema and Ramcharan 2009). Wetland habitats in the boreal taiga of Alaska where Lesser Yellowlegs breed are drying due to climate change (Riordan *et al.* 2006; Roach *et al.* 2011), although effects on survival and productivity of boreal-nesting shorebirds have not been documented. Unquantified threats exist to the Alaska population on nonbreeding areas from regulated and unregulated hunting (Watts *et al.* 2015), loss and degradation of habitats, and oil development (Bird Life International 2008).

ALASKA STEWARDSHIP SPECIES

Black-bellied Plover

The Black-bellied Plover (*Pluvialis squatarola*) is an Alaska stewardship species because Alaska supports nearly 75% of the North American breeding population (Andres et al. 2012b). The Black-bellied Plover is widespread but uncommon throughout most of its breeding range, with highest known densities occurring in coastal wetlands of the National Petroleum Reserve–Alaska (Bart and Smith 2012). This species breeds in both dry and wet tundra habitats in western Alaska from Kotzebue Sound south to Port Heiden (Savage and Johnson 2005; McCaffery *et al.* 2012) and on the central portion of the Arctic Coastal Plain (Johnson *et al.* 2007). During the postbreeding season, Black-bellied Plovers congregate on major river deltas of the Arctic Coastal Plain (Kessel and Cade 1958; Brown *et al.* 2012; Churchwell 2015) and on intertidal habitats of the Yukon-Kuskokwim Delta, Bristol Bay estuaries (Gill and Handel 1981, 1990), and Southcentral Alaska, including Kachemak Bay (ADFG 1993) and the Copper River Delta (Isleib and Kessel 1973). Black-bellied Plovers winter along both the Atlantic and Pacific Coasts of North America (Poole *et al.* 2016), although population connectivity is poorly documented. Plovers recently marked with satellite transmitters at Nome and the Colville River Delta wintered along the Pacific Coast from San Francisco Bay, California, to Peru, as well as sites along the Gulf of Mexico on the Atlantic. In addition to its stewardship status in Alaska, the Black-bellied Plover is considered a species of moderate concern (USSCPP 2016), mostly due to its perceived vulnerability to effects of climate change (Galbraith *et al.* 2014). However, plovers forage in both wet and dry habitats, readily nest in small discontinuous patches of tundra, and take a wide variety of prey (Poole *et al.* 2016), so they may not be as vulnerable to climate change as other Arctic-nesting species (Liebezeit *et al.* 2012). Most Black-bellied Plover breeding habitat occurs in areas isolated from human development, however some habitat may be lost due to continued oil and gas development on the North Slope. These effects will likely be localized and small in scale. Primary threats to the species are the loss and degradation of coastal habitats at migration stopover and wintering sites outside Alaska. Information is needed on numbers using stopover areas, migratory connectivity between breeding and wintering sites, and population status and trends.

Black-bellied Plover. Photo by Zak Pohlen.

Ruddy Turnstone

Ruddy Turnstone populations are in decline in various parts of their range (Gratto-Trevor *et al.* 2011; Andres *et al.* 2012b; Clemens *et al.* 2016). *Arenaria interpres interpres*, the primary population that occurs in Alaska, declined over 3% per year in Australia between 1973 and 2014 (Clemens *et al.* 2016). In Alaska, the breeding distribution of Ruddy Turnstones lies mainly along the coast from the northern Yukon-Kuskokwim Delta north through the Arctic Coastal Plain, and on St. Lawrence Island in the Bering Sea (Gabrielson and Lincoln 1959; Nettleship 2000). Tens of thousands of Ruddy Turnstones used to stage in the fall on the Pribilof Islands to fatten on blow fly larvae from slaughtered northern fur seals before dispersing to nonbreeding grounds from the southwestern Pacific islands to eastern Australia (Thompson 1973; Gill and Handel 1981; Davidson and Gill 2008). However, since the cessation of commercial sealing in the 1970s and 1980s, concentrations of turnstones of that magnitude in the Pribilof Islands are no longer seen, but thousands of fall-staging Ruddy Turnstones occur in the Bristol Bay region to feed on dead salmon and their eggs (Davidson and Gill 2008), demonstrating the species' unusual ability to exploit ephemeral food resources (Gill 1986). In Alaska, the most significant threats to the state's roughly 20,000 breeding Ruddy Turnstones (Andres *et al.* 2012b) include loss or modification to breeding habitat due to climate change and effects from disturbance, development, and pollution due to oil, gas, and mining activities at key breeding and staging areas.

Ruddy Turnstone. Photo by Ted Swem.

Surfbird

The Surfbird (*Calidris virgata*) has a relatively small population (70,000 birds), >75% of which breeds over sparsely vegetated alpine dwarf shrub tundra across Southcentral, Interior, and western Alaska (Senner and McCaffery 1997; Gill *et al.* 1999). Alpine breeding habitat in Alaska is secure but may be negatively affected by climate change. Historically, most Surfbirds concentrated for a few weeks during spring migration on traditional staging areas in Prince William Sound, particularly on Montague Island (Norton *et al.* 1990; Senner and McCaffery 1997; Bishop and Green 2001) where they fed on abundant Pacific herring (*Clupea pallasii*) spawn. More recent surveys of these sites in 2010 and 2015 revealed a small fraction of the birds documented in earlier surveys (M. Bishop, unpubl. data). Stocks of Pacific herring in Prince William Sound and the amount of spawn produced have declined dramatically since the early 1990s (Haught *et al.* 2017). It is unclear whether Surfbirds are staging elsewhere or if the decline of this important food resource negatively affected the Surfbird population. Surfbirds winter along the Pacific Coast from the tip of South America to Kodiak Island in Alaska, and the species faces potential threats at these sites related to development, pollution (including oil spills), and rising sea levels associated with climate change.

Surfbird. Photo by Lucas DeCicco.

Sharp-tailed Sandpiper

The occurrence of Sharp-tailed Sandpipers (*Calidris acuminata*) in Alaska is a curious phenomenon: the species occurs almost exclusively during fall migration, and consists almost entirely of juvenile birds (Handel and Gill 2010). The global population

Sharp-tailed Sandpiper. Photo by Zak Pohlen.

of Sharp-tailed Sandpipers is about 160,000 birds (Bamford *et al.* 2008) and occurs mainly along the coast of the East Asia–Australasia Flyway. About 90% of the flyway population spends the nonbreeding season in Australia, where declines of about 6% per year have been documented (Clemens *et al.* 2016). These declines are mainly attributable to severe losses of tidal habitat along their migratory pathway, especially in the Yellow Sea (Clemens *et al.* 2016). Handel and Gill (2010) estimated that up to a few tens of thousands juvenile Sharp-tailed Sandpipers occur in Alaska each fall, likely constituting a large majority of the juvenile cohort. For this reason, the species is considered an Alaska stewardship species. From late August into mid-October of each year, juvenile Sharp-tailed Sandpipers concentrate in western Alaska from just north of the Seward Peninsula south to the Alaska Peninsula and Aleutian Islands (Handel and Gill 2010; Lindström *et al.* 2010). Birds are most commonly found in ponded, coastal mesic to dry sedge and grass meadows and on intertidal mudflats (Handel and Gill 2010), where they accumulate large fuel stores (Lindström *et al.* 2010) before embarking on long-distance flights across the Pacific Ocean (Handel and Gill 2010).

Western Sandpiper. Photo by Zak Pohlen.

Western Sandpiper

The Western Sandpiper (*Calidris mauri*) is one of North America's most common shorebirds (numbering approximately 3.5 million; Andres *et al.* 2012b), and virtually all breed in Alaska, confirming its status as a stewardship species. The population may be declining (Fernandez *et al.* 2006; Matz *et al.* 2011a), although trends are variable (Drever *et al.* 2014). Western Sandpipers stop at numerous sites during migration (Warnock and Bishop 1998), but they concentrate only at a few key sites, increasing risks of disturbance and mortality during critical phases of their annual cycle (Fernández *et al.* 2006). For instance, during spring migration over 80% of the Pacific Flyway population of Western Sandpipers may use the Copper River Delta (Bishop *et al.* 2000), which lies adjacent to major shipping lanes for oil tankers. Generally a coastal migrant, most of the world's population of Western Sandpipers breed in coastal wetlands in western Alaska between the Alaska Peninsula and the Seward Peninsula, as well as in smaller numbers on the North Slope. Western Sandpipers rank as a species of moderate concern due to the uncertainty surrounding the species' population trend and its proclivity to concentrate at relatively few sites during migration (USSCPP 2016).

Long-billed Dowitcher. Photo by Zak Pohlen.

Long-billed Dowitcher

The Long-billed Dowitcher (*Limnodromus griseus*) breeds from northeastern Russia to northwestern Canada (Takekawa and Warnock 2000). In Alaska it breeds from the North Slope west and south to the Yukon-Kuskokwim Delta (Johnson *et al.* 2007; McCaffery *et al.* 2012). The species' North American breeding population occurs almost entirely in Alaska (USSCPP 2016), leading to its designation as a stewardship species. Long-billed Dowitchers migrate primarily through the western United States, wintering along the Pacific and Gulf of Mexico coasts, as well as into Mexico (Takekawa and Warnock 2000). The migration of Long-billed Dowitchers has been poorly studied, but birds radio-tagged at San Francisco Bay, California, during spring migration in 2001 were detected at the Copper River Delta (Warnock *et al.* 2001). Primary threats to the species are associated with loss and degradation of wetland habitats, primarily at wintering and migration stopover sites, and exposure to pesticides and other contaminants along the migration route (Takekawa and Warnock 2000). Very little research has been conducted on Long-billed Dowitchers, with much work still needed to describe basic breeding biology, survivorship, migration routes, and population status and trends (Takekawa and Warnock 2000).

Solitary Sandpiper

The global population size of the Solitary Sandpiper (*Tringa solitaria*) is estimated at 189,000 individuals, with the Alaska-breeding race (*T. s. cinnamomea*) estimated at 63,000 individuals (Andres *et al.* 2012b). The species is most commonly found in boreal forest or tall shrub habitats and generally around freshwater wetlands and rivers (Moskoff 2011). They breed in low densities throughout the state, but rarely north of the Brooks Range (Moskoff 2011; Armstrong 2015). Breeding Bird Survey data for the western United States from 2005–2015 suggest the *cinnamomea* population is variable but stable (Sauer *et al.* 2017). The trend estimate for Solitary Sandpipers in BCR 4 of Alaska suggests a decline, albeit non-significant, over the period 1993–2015 (Handel and Sauer 2017). The primary threat on the breeding grounds in Alaska concerns the loss of boreal wetland habitat and declines in productivity due to effects of climate change (e.g., Corcoran *et al.* 2009). Threats on the nonbreeding grounds include hunting, loss of habitat, and oil development (BirdLife International 2008).

Solitary Sandpiper. Photo by Ted Swem.

Wandering Tattler
The Wandering Tattler (*Tringa incana*) has a relatively small population size (17,500), an unknown population trend (Andres *et al.* 2012b; USSCPP 2016), and it is believed that ~90% of the population breeds in Alaska, with the remainder occurring in Canada and eastern Russia (Gill *et al.* 2002b). Tattlers are generally dispersed breeders in montane alpine habitats (e.g., Tibbitts *et al.* 2006), yet small clusters of nesting birds have been reported (Gill *et al.* 2015). Breeding areas in Alaska include major mountain systems of Southcentral, Interior, and western Alaska (Isleib and Kessel 1973; Kessel and Gibson 1978; Kessel 1989; Gill *et al.* 2015), where birds are often associated with creeks and streams (Gill *et al.* 2002b). Breeding site fidelity appears high (Gill *et al.* 2015), but there is limited information on nonbreeding site fidelity (but see Clapp and Wirtz 1975; Gill *et al.* 2010). During migration and throughout the nonbreeding season, tattlers are generally widely dispersed along rocky shorelines of the Pacific Coast of North America and on atolls and islands throughout Oceania (Gill *et al.* 2002b); concentrations have been reported in Alaska from Middleton Island (20–40/day, maximum about 400; DeCicco *et al.* 2017) and Prince William Sound (10–50/day; Isleib and Kessel 1973). Due to the species' association with fluviatile waters, placer mining in the breeding range may pose some risk to breeding populations, but the effects are largely unknown. Tattlers' use of hard substrate littoral habitats throughout the annual cycle puts them at risk from coastal oil spills (King and Sanger 1979) as well as potential risks associated with climate-driven sea-level rise (Nurse *et al.* 2014). Studies that estimate basic demographic rates and document migratory connectivity are needed to guide the management and conservation of Wandering Tattlers.


Wandering Tattler. Photo by Zak Pohlen.

Red-necked Phalarope
Alaska is home to about half of North America's 2.5 million breeding Red-necked Phalaropes (*Phalaropus lobatus*), however accurate population estimates are difficult to obtain because the breeding population is spread across remote tundra areas and wintering populations are entirely pelagic (Andres *et al.* 2012b).


Red-necked Phalarope. Photo by Zak Pohlen.

Red-necked Phalaropes are considered a species of moderate concern (USSCPP 2016) due to declines on the breeding grounds and major declines at migration stopover sites (Andres *et al.* 2010). In the Bay of Fundy in eastern Canada, the decline in numbers of migratory Red-necked Phalaropes from 2–3 million to negligible numbers during the 1980s has been linked to changes in local food abundance and major El Niño events (Duncan 1996; Brown *et al.* 2010; Nisbet and Veit 2015). Potential threats on the breeding grounds include climate-driven landscape changes (e.g., shrubification, wetland drying), anthropogenic disturbance, and changes in predator abundance (Liebezeit *et al.*

2009). During migration, large concentrations of individuals in coastal waters make phalaropes vulnerable to oil spills (Day and Murphy 1997). Plastic ingestion may be an increasing problem for this surface-feeding species, as plastic debris has been found in both Red and Red-necked Phalaropes (Conners and Smith 1982; Moser and Lee 1992). Many Red-necked Phalaropes stopover at hypersaline lakes in the western United States, and changes to the salinity of these lakes due to drought and water use by agriculture affect food availability at these sites (Rubega and Inouye 1994). While little is known about the species' wintering ecology, changes in sea-surface temperature and consequent changes in food availability and distribution may affect over-winter survival (Nisbet and Veit 2015). Further study, especially during migration and the nonbreeding season, is essential for a more complete assessment of population estimates, trends, and to identify threats facing the species.

Shorebird Tracks, Copper River Delta. Photo by Melissa Gabrielson

Tundra near Nome
Samantha Franks


Alaska Shorebird Group
ASG