2015 ALASKA WILDLIFE ACTION PLAN

A plan for managing fish and wildlife species and their habitats to help prevent listings under the Endangered Species Act.

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Executive Summary

A rare clear day across Alaska. On many days, clouds cover much of Alaska, obscuring large portions of the state's 664,384 square miles of land. The south coast of Alaska has the dubious distinction of being the cloudiest region of the United States, with some locations averaging more than 340 cloudy days per year. Image taken 17 June 2013. NASA Photo.

This 2015 Alaska Wildlife Action Plan is a major revision of the original plan, published in 2006, and fulfills the 10-year revision requirement of the federal State Wildlife Grant (SWG) program. The program provides states with funding to proactively address the conservation needs of wildlife with the ultimate goal of preventing species from becoming listed as threatened or endangered under the Endangered Species Act (ESA). The plan, developed with input from conservation partners and the public, is intended to guide state use of those funds.

In this revised plan, we identified "species of greatest conservation need," or SGCN, using multiple criteria, including species whose population is small, declining, or under significant threat ("at-risk" species); species that are culturally, ecologically, or economically important; species that function as sentinel species (indicators of environmental change); and stewardship species (species with a high percentage of their North American or global populations in Alaska).

The action plan identifies 326 vertebrate taxa as SGCN in Alaska, including 58 fish, 5 amphibians, 192 birds, and 71 mammals. Invertebrate SGCN include 5 orders of freshwater invertebrates, 4 orders of marine zooplankton, 36 species and one phylum of larger marine invertebrates, and 5 orders of terrestrial arthropods. SWG funding can be spent only on activities related to SGCN and their habitats; eligible activities include research, monitoring, habitat assessments, conservation actions, and planning.

The plan describes the distribution of each SGCN within 6 terrestrial and 3 marine bioregions in Alaska and identifies the key habitats used by each species. Potential threats to wildlife, their habitats, and the spectrum of possible conservation actions to address threats in Alaska are also identified and discussed.

The plan discusses the species, habitats, threats, and conservation actions of highest priority in Alaska. The prioritization is intended as general or strategic guidance. Other factors related to budgets, capacity, partnerships, and cost-benefit analyses will drive annual decisions on what specific research, monitoring, and planning projects to conduct.

Priority species—Species of highest priority are those with a combination of the following: small populations, declining populations, populations under threat, or species for which Alaska has high stewardship responsibility. The plan identifies 15 taxa (including subspecies) as examples of high priority SGCN that meet these factors. Secondary factors such as ecological and cultural importance, and their utility as a sentinel species, will influence project-level prioritization.

Priority habitats—The plan identifies sea ice; tundra; glacially influenced rivers, streams, and fjords; and permafrost associated wetlands as priority habitats because they are diminishing in extent as a result of climate change. Beaches and sea cliffs (important for shorebirds and seabirds), temperate rain forest (important for old-growth associated species), and marine nearshore and shelf are also high priority habitats because of their particularly high productivity and importance.

Priority threats—Climate change is the preeminent threat to wildlife and their habitat in Alaska. Of particular concern are the effects of diminishing sea ice habitat, permafrost melting, and ocean acidification. These changes will have significant consequences for species that depend on sea ice for resting and foraging (ice seals, walrus, polar bear), for marine food chains that are supported by zooplankton (virtually all), and for waterbirds (e.g., waterfowl, shorebirds, loons) that nest on, or feed in, the many lakes, ponds, and wetlands that exist because of permafrost.

Other priority threats include the risk of chronic or catastrophic oil spills, especially in arctic waters where ice cover will complicate cleanup efforts. Invasive species pose an important threat, particularly marine invertebrates, freshwater aquatic plants, and mammals (especially rats) on islands with seabird colonies.

Priority conservation actions—A high priority conservation action in Alaska is data acquisition. Alaska needs better and more monitoring to identify species that are potentially in trouble. For those species that are at risk or declining, research is required to understand why they are declining, and where conservation action is needed. Other priority conservation actions include surveys to identify high-use areas by SGCN in the state so that development activities can be directed away from sensitive or highly valuable areas. Finally, although Alaska does not have a large number of invasive species, controlling them is one of the most effective conservation actions we can take.

Overall, Alaska has very healthy habitats and abundant wildlife populations. This is due to its location, large size, small human population, and minimally modified lands. It is, by far, the least developed landscape in the United States, and its rich wildlife resources reflect that fact. This plan, developed with input from partner agencies, nongovernmental organizations, academic institutions, and the public, will provide the strategic guidance necessary to help ensure Alaska's remarkable wildlife remains abundant into the foreseeable future.

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Introduction

Mt. Denali, in the Alaska Range, is North America's highest peak at 20,310 feet above sea level. Ken Conger, NPS.

The United States Congress created the State Wildlife Grants (SWG) program in 2000. The program provides critical funding to every state and territory to plan and implement proactive conservation actions to prevent the nation's fish and wildlife from becoming endangered. Funding is provided to the states through the U.S. Fish and Wildlife Service (USFWS). SWG is the only federal program with the explicit goal of preventing endangered species listings. This program continues the long history of cooperation between the federal government and the states to manage and conserve wildlife species, going back to landmark laws like the 1937 Pittman-Robertson Wildlife Restoration Act and the 1950 Dingell-Johnson Sportfish Restoration Act. Congress intended state action plans to be adaptive, requiring that they be revised periodically to incorporate new information and reflect up-to-date projected threats and priorities.

Using SWG funding, each state and territory developed a State Wildlife Action Plan (SWAP). These plans bring together the best science available to conserve priority fish and wildlife species and their habitats. The plans identify species with important conservation needs and offer a set of actions to address key threats, providing a voluntary, nonregulatory alternative to the federal listing process. Grant funds must be used for activities that address conservation needs identified within a state's plan, such as research, surveys, monitoring, and species and habitat management.

Prior to SWG, funding typically was only available for conservation of a fish or wildlife species after it had reached perilously low numbers, or was officially listed as threatened or endangered. While the Endangered Species Act (ESA) has been a valuable conservation law, it has been criticized by some as

Attaching a transmitter to an Olive-sided Flycatcher to track movements. ADF&G photo.

Fish and Game biologist Michael Kohan relocating radiotagged bats from the air. ADF&G photo.

expensive and inefficient (e.g., Bunnell et al. 2004a, 2004b). The perceived shortcomings can be broadly summarized as follows: (1) most funding has not been spent on habitat necessary to facilitate recovery, (2) monitoring and recovery tasks have rarely been focused on threats to species, (3) recovery efforts are most successful when they begin while populations (and ranges) are larger relative to historic levels, and (4) priority ranking systems have not been used to guide expenditures (Bunnell et al. 2004a).

Since 2000, the State of Alaska has received 38.1 million dollars from Congress (about 2.5 million per year) to implement the program. The state and its partners have contributed more than 12 million in matching dollars. In Alaska, this funding was used to accomplish needed work on a wide variety of taxa of concern, including marine mammals, seabirds, fish, shorebirds, and landbirds. Activities funded have included surveys, monitoring, and research on habitat use, vital rates (e.g., reproductive success, mortality), and movements of various species.

Currently listed or petitioned species in Alaska that have received SWG funding include Kittlitz's Murrelet, Marbled Murrelet, Yellow-billed Loon, wood bison, seals (bearded, harbor, ringed, ribbon, and spotted), Steller sea lion, and little brown myotis. In the last 10 years, SWG funding in Alaska has supported survey, monitoring, and research work on more than 100 species of nongame animals and their habitats.

Over the last year, the Alaska Department of Fish and Game (department) has reviewed the original plan, new status assessments, and the pertinent scientific literature of the last decade. In consultation with our partners, the action plan was revised to identify priority species threats, and conservation actions envisioned for the next 10 years.

A conscious effort was made to simplify this revised plan compared to the previous plan. Experience with that plan showed it is not the most practical or effective approach to provide information about every species in Alaska, all possible threats, and all possible conservation actions in the plan itself. An encyclopedic treatise would bury the key needs and priorities. This revision provides concise information on the distribution, abundance, habitat use, and conservation status of SGCN.

Alaska Department of Fish and Game authored this plan on behalf of the State of Alaska: The department is the state's recipient of SWG funds. These funds are used within the department to meet plan priorities. Funds support efforts of the Division of Wildlife Conservation's Threatened, Endangered, and Diversity Program (formerly the Wildlife Diversity Program), and the divisions of Sport Fish and Habitat.

Partners and the public were consulted in development and review of the plan with the hope that it will provide useful guidance for a wide array of nongovernmental organizations (NGOs), agencies, and others interested in conservation. This consultation will continue as the department works to implement this plan. This is a plan to ensure that Alaska's wildlife and fish remain healthy and abundant into the future—a goal all Alaskans share.

Travis Booms, ADF&G biologist, releases a radiotagged Short-eared Owl. Photo by Lincoln Parrett, ADF&G.

Congress directed that states include the following 8 elements in their revision:

1. Information on the distribution and abundance of species, including low and declining populations that are indicative of the diversity and health of the state's wildlife.

2. Descriptions of locations and relative condition of key habitats and community types essential to conservation of species identified in (1).

3. Descriptions of problems that may adversely affect species identified in (1) or their habitats, and priority research and survey efforts needed to identify factors that may assist in restoration and improved conservation of these species and habitats.

4. Descriptions of conservation actions proposed to conserve the identified species and habitats and priorities for implementing such actions.

5. Proposed strategies for monitoring species identified in (1) and their habitats, for monitoring the effectiveness of the conservation actions proposed in (4), and for adapting these conservation actions to respond appropriately to new information or changing conditions.

6. Descriptions of procedures to review the Wildlife Action Plan at intervals not to exceed 10 years.

7. Strategies for coordinating the development, implementation, review, and revision of the Wildlife Action Plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state or administer programs that significantly affect the conservation of identified species and habitats.

8. Provisions to ensure broad public participation in the development, implementation, and revision of the Wildlife Action Plan, and associated projects and programs.

Road Map to Plan Elements

Wolf tracks in wind-driven snow. Photo by Neil Barten, ADF&G.

This revision to the State of Alaska's Wildlife Action Plan represents a major update to the original 2006 document. The state is required to provide a summary of all significant revisions, describe how the revision meets the original required 8 elements, and provide a "road map" to locate revisions in the plan. This chapter addresses those 3 requirements.

The assessment process included speaking with agencies and NGOs about their perceptions of the original plan, including aspects they found more or less useful. Most found the plan helped justify their research or monitoring work on a particular species or group covered in the plan. However, few people had read the document in its entirety, or used it to expand or shift their research to new species or threats they were not already working on. One reason for this was the length of the plan. At 842 pages, few had sufficient time or interest to read the entire document. Another perceived deficiency was overpromising what could be, and would be, accomplished with the resources at hand. Hundreds of conservation actions were prescribed for featured species, but the available resources allowed progress on only a handful. In addition to a desire to make the revised plan shorter and more strategic, sufficient new information was available on species status and threats (especially climate change) to warrant a major revision. The State of Alaska's intent to revise the action plan was communicated to Region 7 of the U.S. Fish and Wildlife Service (USFWS) by letter on 30 May 2014.

The plan was revised with the goal of making it less encyclopedic, more strategic, and more readable. It focuses on strategic approaches that will guide project-level decisions and priorities over the next 10 years. Length was reduced by incorporating information by reference rather than replicating text from primary sources. To improve readability, scientific names are not included in the text, and measures are reported in U.S. customary units (English) rather than metric. Scientific jargon was minimized.

Consistent with the best practices guide (AFWA 2012), planning is directed at the largest spatial scale that is meaningful. Standard classification systems for habitats were adopted. Regions and habitat types are similar to those adopted by other agencies, groups, and authors. The regions are fewer in number, more familiar, and more useful than those used in the 2006 plan (e.g., 6 versus 32 terrestrial ecoregions).

The 2006 SWAP avoided the term "species of greatest conservation need" (SGCN). Instead, it identified 419 vertebrates as "nominee species" Nominee species were liberally included if any agency, organization, individual or NGO had flagged it as a concern at the national or statewide level. The revised SWAP adopts the recommended term of SGCN (AFWA 2012), or species of greatest conservation need, and uses it throughout. The new plan recognizes significantly fewer vertebrate species as SGCN than the nominee species in the original Plan (326 versus 419). The reduction is similar across all groups of animals except fishes (Table 1).

Table 1. Number of Nominee Species by taxonomic category in the 2006 State Wildlife Action Plan (SWAP) versus species of greatest conservation need (SGCN) in the 2015 revised plan. Numerals refer to number of species and subspecies, unless another taxonomic level is indicated. Categories not used by one or the other plans are left blank.

TAXA	2006 SWAP	2015 SWAP
Marine worms	1 phylum (Nematoda)	
Amphipods	1	
Arthropods	1 phylum (Arthropoda)	
Insects	5 phyla and 19 species	
Mollusks	2 phyla and 12 species	
Intertidal and shallow subtidal bivalves	Unstated-various	
Eel-grass associated invertebrates	Unstated-various	
Corals, Tunicates and Sponges	Unstated-various	
Salt marsh-associated invertebrates	Unstated-various	
Zooplankton	Unstated-various	
Benthic grazers	Unstated-various	
Cave-dwelling invertebrates	Unstated-various	
Freshwater invertebrates		5 orders and 3 species
Marine Zooplankton		3 orders, 1 subclass
Terrestrial Invertebrates (arthropods)	6 phyla, 19 species	5 orders
Crabs		8
Cockles, Scallops, Clams, Mussels and Abalone		10
Octopus and Squid		3
Shrimp		6
Chitons and Snails		2
Sea Cucumbers, Sea Stars and Sea Urchins		1 phylum 3 species
INVERTEBRATE TOTAL	**Not comparable**	**Not comparable**
Freshwater fish	26	13
Saltwater fish	18	26
Anadromous fish		19
FISH TOTAL	**44**	**58**
Amphibians	6	5
Reptiles	4	0
AMPHIBIAN AND REPTILE TOTAL	**10**	**5**
Loons	6	3
Grebes	3	0
Albatrosses	3	3
Shearwaters and Petrels	2	0
Storm-Petrels	5	1
Cormorants	4	2
Frigatebirds	1	0

TAXA	2006 SWAP	2015 SWAP
Herons and Bitterns	2	0
Cranes	0	1
Ducks Geese and Swans	11	18
Grouse and Ptarmigan	5	0
Hawks and Eagles	14	7
Falcons	7	4
Rails and Coots	2	0
Plovers	7	4
Oystercatchers	1	1
Sandpipers	45	26
Skuas, Gulls, Terns and Jaegers	14	11
Auks, Murres and Puffins	11	15
Pigeons	1	0
Owls	11	6
Swifts	3	1
Hummingbirds	2	1
Kingfishers	1	1
Woodpeckers	6	6
Flycatchers	5	6
Shrikes	1	1
Vireos	2	0
Jays	1	2
Crows and Ravens	2	1
Larks	1	1
Swallows	5	3
Chickadees	3	4
Nuthatches	1	0
Creepers	1	2
Wrens	8	7
Dippers	1	0
Kinglets	1	2
Thrushes	11	4
Wagtails, Pipits	3	1
Waxwings	1	1
Warblers	7	11
Tanagers	1	0
Sparrows	11	26
Grosbeaks	1	1
Blackbirds	3	2
Finches	6	6
BIRD TOTAL	**243**	**192**
Shrews	11	12
Bats	6	5
Canids	1	2
Mustelids	12	1
Walrus	1	1
Seals	9	7
Bears	2	1
Whales	14	10
Porpoises	1	1
Deer	1	0
Rodents	60	28
Pikas	1	1
Hares	3	2
MAMMAL TOTAL	**122**	**71**
VERTEBRATE TOTAL	**419**	**326**

Salmon species are culturally important as subsistence food for Alaskans. Photo by David Holen, ADF&G.

Reasons for the reduced number of species include the following:in the revised plan are as follows:

- Continental/global status was prioritized over state status (e.g., peripheral species were dropped).
- Fewer hunted and trapped species were included.
- Taxonomic assessments were updated (some subspecies no longer considered valid were dropped).

The 2006 Alaska SWAP included information on distribution, abundance and habitat use for 74 featured species and species groups.[1] The revised plan provides this information (if known), for all SGCN, as required (see Appendices B–E). Scattered throughout the revision are highlighted examples of species of greatest conservation need in Alaska.

The 2006 plan also provided "Conservation Action Plans" for the 74 featured species and species groups. These conservation action plans include species descriptions; detailed notes on distribution and abundance; problems, issues, and concerns; location and condition of important habitat types; conservation objectives and actions; plans for monitoring species and their habitats; and recommended timeframes for reviewing species status and trends. This information is still valid and available in Appendix 4 of the 2006 plan,[2] which, due to its length (430 pages) is incorporated here by reference.

In contrast to the 2006 SWAP, the revision considers cultural, ecological, and economic importance in defining SGCN (AFWA 2012), and not just risk, or species declines. The result is inclusion of species such as salmon in the 2015 revised plan.

Because of Alaska's large size, location, and pristine habitat, it is important habitat for significant percentages of the populations of many species. To reflect Alaska's high stewardship responsibility in these cases, any species with more than 60% of its North American population in Alaska at any time was qualified as an SGCN. Hunted species were excluded from SGCN unless a listing petition had been filed

[1] Alaska Department of Fish and Game. 2006. Comprehensive Wildlife Conservation Strategy, Appendix 3. http://www.adfg.alaska.gov/static/species/wildlife_action_plan/appendix3.pdf (Accessed 16 September 2015)

[2] Alaska Department of Fish and Game. 2006. Comprehensive Wildlife Conservation Strategy, Appendix 4, links a-q. http://www.adfg.alaska.gov/index.cfm?adfg=species.wapview. (Accessed 16 September 2015)

(e.g., Alexander Archipelago wolf) or traditional funding (Pittman-Robertson) was deemed inadequate for conservation (e.g., a number of sea ducks).

Species that can serve as sensitive indicators of pending environmental change were labeled "sentinel species," and included as SGCN in the 2015 plan. All criteria used to identfy SGCN are explained in the Species of Greatest Conservation Need chapter. A table documenting the qualifications of each SGCN is in Appendix A.

Whereas the original 2006 plan focused heavily on terrestrial species, the current plan gives more balanced treatment to terrestrial and aquatic species, including more fish (58 versus 44 species). Treatment of marine species is largely restricted to those that are harvested, and for which minimal population and ecological data are available. Invertebrate SGCN in the marine realm mostly inhabit the intertidal zone, or nearshore marine waters.

Icy Bay has the highest population density of the Kittlitz's Murrelet (also known as the Glacier Murrelet) anywhere in the world. NOAA photo, ShoreZone program.

The revised plan broadens the eligibility requirements for species of greatest conservation need to include not only species with population declines of concern, but also those which can be sentinels of environmental change, or which have disproportionate ecological importance (e.g., keystone species). These are subjective categorizations, but were necessary to include species which warrant monitoring, even if current populations are abundant.

This revised plan is clearer about how priorities for work in the next 10 years will be set during development of work plans by the department. Consistent with the recommendations in the best practices guide (AFWA 2012), the standard terminology suggested by Salafsky et al. (2008) is used to characterize threats and actions. High priority threats are those that have the greatest likelihood of changing populations in ways that will likely decrease numbers significantly, and lead to more endangered species. The priority conservation actions, however, consider more than the importance of the threat. Action priorities are guided by the likelihood of improving the conservation status of a species, by internal capacity, and by work other agencies and NGOs are currently engaged in. More discussion on this topic is provided in the Plan Development, Implementation, and Review chapter.

The revised plan points to priorities in general terms (e.g., filling data gaps, monitoring declining populations, identifying recovery bottlenecks, studying declining habitat types, focusing on at-risk species), but does not deliver a list of specific projects and timelines for the next decade.

Alaska is experiencing significant effects from climate change. Those effects are being studied by a variety of in-state agencies, including the U.S. Geological Survey (USGS, Alaska Climate Science Centers), the USFWS (Landscape Conservation Cooperatives), the U.S. Forest Service (USFS, Climate Change Resource Centers), the University of Alaska (Scenarios Network for Alaska + Arctic Planning), the State of Alaska (the governor's Climate Change Sub-cabinet) and various nongovernmental organizations around the state and the world. From these and other sources, the revised plan assembles an updated and more complete picture of the primary threats facing wildlife and their habitats in Alaska from climate change.

In contrast to the 2006 plan, developing the revision did not require starting from scratch. Partners and other experts were involved through small group and individual meetings rather than in large facilitated workshops. Because this was a revision, partner involvement leaned more heavily on product review than product creation. This approach provides an efficient means of engagement that respects limitations on other's available time and resources and doesn't duplicate previous efforts.

As described in the Introduction, any state wildlife action plan must minimally satisfy 8 required elements. To ease the writing and review of this revision, the information for each element is presented in a separate chapter. Those chapters and which of the 8 elements they address are shown in Table 2.

Table 2. Locations in this document where the 8 required plan elements are addressed.

Required Element	Description	Chapter
1	Identify species that are indicative of the diversity and health of the state's wildlife, including low and declining populations (i.e., species of greatest conservation need).	Species of Greatest Conservation Need
1	Information on the distribution and abundance of SGCN.	Distribution and Abundance of Wildlife in Alaska
2	Descriptions of location and and condition of habitats and community types essential to SGCN	Key Habitats of Wildlife in Alaska
3	Descriptions of problems that may adversely affect SGCN or their habitats.	Threats to Wildlife
3	Priority research and survey efforts needed to identify factors which may assist in restoration and improved conservation of SGCN or their habitats.	Alaska Priorities
4	Descriptions of conservation actions proposed to conserve SGCN or their habitats.	Conservation Actions
4	Priorities for implementing such actions.	Alaska Priorities
5	Proposed strategies for monitoring SGCN and their habitats, and for monitoring the effectiveness of the conservation action.	Monitoring and Evaluation
6	Descriptions of procedures to review the plan at intervals not to exceed 10 years.	Plan Development, Implementation, and Review
7	Strategies for coordinating the development, implementation, review, and revision of the plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state.	Plan Development, Implementation, and Review
8	Description of public participation of developing and revising this plan.	Plan Development, Implementation, and Review

Alaska Overview

Arctic National Wildlife Refuge. Photo by Steven Chase, USFWS.

Alaska is the largest, most northerly, and most sparsely populated state in the nation (1.2 people per square mile). At 665,384 square miles in size, it is one fifth the size of the contiguous U.S. states, which Alaskans call the "Lower 48." Overlaid on the Lower 48, Alaska would span them from north to south and east to west.

One third of the state lies above the Arctic Circle, and Alaska is the only state with a coastline on the Arctic Ocean. The large geographic and latitudinal extent of the state encompasses a wide range of climates, such as polar deserts in the north with cold temperatures, short summers, and low precipitation; continental climates in the interior with very cold winters and short, but warm summers; and maritime climates along the southern coast with cool year-round temperatures and high precipitation. The vegetation is similarly varied. Alaska contains extensive arctic tundra in the north, boreal forest dominates the interior, maritime tundra covers the western deltas and islands, and the coastal regions of Southcentral and Southeast Alaska are primarily temperate rain forest.

Alaska is one of the most geologically active regions in North America. Much of Alaska is marked by tectonic uplift and great vertical relief. Alaska is situated where the northeast end of the Pacific Plate collides directly with the North American Plate. The megathrust boundary between the plates results

in both the 2,500 mile-long Aleutian Trench and the arc of active volcanoes that parallel the trench. Along the trench, the rate of plate convergence is about a tenth of an inch per year. Convergence results in uplift and mountain building along Alaska's coasts. The St. Elias Range, along the Gulf of Alaska coast, rises from sea level to over 18,000 feet in just 6 miles, making it the steepest mountain belt in the world. Alaska boasts a total of 39 mountain ranges, 17 of the 20 highest mountains in the U.S., and the tallest mountain in North America (Denali, at 20,310 feet).

Anchorage, Alaska's largest city, celebrates the outdoors with many lakes, parks and developed trails for walking, biking, and skiing throughout the city. Photo by Ken Marsh.

People

Because of its remote, northern location, Alaska has seen relatively little of the urbanization and land conversion (e.g., for agriculture, ranching, housing) common in many areas of the Lower 48. About 40 percent of Alaska's 736,400 residents live in a single city (Anchorage), and most development is centered in a narrow north-south "Railbelt" that parallels the Alaska Railroad route between the Kenai Peninsula, Anchorage, and Fairbanks. The state's capital, Juneau, is in Southeast Alaska. It is the state's third-largest city, with about 33,000 residents, and is not connected to the road or rail system, except by marine ferry. Alaska continues to grow; the population increased 13% between 2000 and 2010, with growth concentrated in the Southcentral region. In addition to urban centers, Alaska has more than 200 small communities, typically with hundreds of residents. Most of these are populated

Resident and nonresident anglers contribute 1.4 billion dollars annually to the state's economy. Photo by Mr. Omykiss.

Left: Grizzly bear. Residents and visitors in Alaska spend over 3 billion dollars a year in hunting and viewing activities. Photo by Gregory Smith.

Below right: Oil from the North Slope flows to a marine terminal in Valdex via the trans-Alaska pipeline. The pipeline traverses 800 miles, crosses 3 mountain ranges and over 30 major rivers and streams. It was completed in 1977 at a final cost of more than 8 billion dollars. Photo by Steve Hillebrand, USFWS.

predominately by Alaska Natives who are living on ancestral lands used by their tribes. There are 229 federally-recognized Alaska Native Tribes (40% of Tribes in the United States). In 2013, Alaska Natives made up 15% of the state's total population.[3]

Because so much of Alaska contains pristine lands, abundant fish and wildlife, and spectacular scenery, it is not surprising that a relatively high percentage of the state has been protected under public ownership as state and federal parks, preserves, refuges, and national forests. State and federal lands, combined, account for 87.5% of all lands in Alaska. Alaska holds 70% of all national park lands in America, 80% of wildlife refuge acreage, and 53% of designated wilderness in the nation. These acres are largely protected from development, and managed to conserve fish and wildlife populations in natural settings.

Because of healthy habitats and well-managed use, Alaska has abundant populations of fish and wildlife that draw residents and visitors alike to outdoor activities. In a recent study on the economic valuation of wildlife in Alaska (ECONorthwest 2014) residents and visitors spent 3.4 billion dollars in Alaska in one year (2011) on hunting and wildlife viewing activities. More than 868,000 households, 77% of them visitors to Alaska, went wildlife viewing in 2011. Visitors alone spent 1.2 billion dollars in Alaska on wildlife viewing activities, and 150 million dollars on hunting. Moose, marine mammals, and brown (grizzly) bears were the species most sought by viewers. Recreational fishing is enjoyed by almost a half million resident and nonresident anglers, who contribute an estimated 1.4 billion dollars annually to the state's economy.

[3] United State's Census Bureau- State and County QuickFacts - http://quickfacts.census.gov/qfd/states/02000.html (Accessed 27 August 2015).

Commercial fishing is the second largest industry in Alaska. Photo by Doug Knuth.

While wildlife viewing and tourism have seen growth as an economic sector in the last 10 years, they pale in comparison with the resource extraction industries that drive Alaska's economy. In 2013, Alaska's gross domestic product (GDP) was the highest in the nation on a per capita basis (70,113 dollars; DCCED 2014). Oil and Gas is the largest economic sector, accounting for about 25% of the state's GDP. North Slope oil and gas production in Alaska has declined steadily to about 25% of its peak in 1988. Despite declining onshore reserves on the North Slope, there are high expectations for increased production from National Petroleum Reserve–Alaska (NPRA) and from offshore oil fields in the Arctic Ocean.

Using 2010 figures, the 2 largest Alaska industries are oil and gas (6.2 billion dollars, 4,840 jobs) and commercial fishing (5.6 billion dollars, 53,000 jobs). Other industries are one tenth the size or less, and include mining (933 million dollars, 3,872 jobs), logging (165 million dollars, 619 jobs), and farming (31 million dollars, 680 farms) (DCCED 2010).

Although tourism does not produce goods, in 2013 it drew 1.96 million visitors to the state, who spent 2.42 billion dollars (DCCED 2014). The tourism industry employs 46,500 people in Alaska during the peak season. Alaska's other significant sources of revenue come from investment earnings (4.5 billion dollars per year from the 54 billion dollars in assets managed by the Alaska Permanent Fund), the Federal Government (2.4 billion dollars per year) and fees, permits, and licenses (900 million dollars per year).

Of Alaska's industries, it is the extractive industries—oil and gas, fishing, and logging—that pose the greatest potential threats to wildlife and wildlife habitat in Alaska, though with careful management these threats can be minimized.

Landscape

Some of the broad habitat types that characterize Alaska include ice (pack ice and glaciers), tundra (arctic, alpine, and maritime), forests (boreal and temperate rain forest), streams and lakes, wetlands, and marine waters. Alaska is the only state in the nation with pack ice, boreal forest, and arctic tundra. Alaska harbors populations of many northern species that no other state has, including beluga whale, ice seals, polar bear, muskoxen, Kittlitz's Murrelet, Pribilof Rock Sandpiper, and McKay's Bunting, to name just a few.

Where tall mountains occur along the coast, orographic lifting of moisture-laden maritime air results in high snowfall, which develops into persistent ice and snow fields. The massive weight of accumulated snow and ice at high elevations creates immense "rivers" of ice that slowly flow seaward as glaciers. Not surprisingly, Alaska has more glaciers (644 named) and more glacial ice (33,000 square miles) than any other state. In fact, all of the glaciers in the Lower 48 combined would be smaller than one of Alaska's glaciers (the Bering Glacier, North America's largest, at 2,000 square miles).

Primarily due to warming climatic conditions, most of the glaciers in Alaska are undergoing a rapid loss of mass. Glacial runoff currently accounts for about half the total freshwater input into the Gulf of Alaska, adding enough water to raise the global ocean level 0.006 inches per year. Glacial melt plays an important and generally positive role in the dynamics and high productivity of nearshore systems.[4] The disappearance of glacier ice altogether would have adverse impacts on a number of Alaska's wildlife species, including the harbor seal, which pups and rests on ice floes calved from glaciers, and the Kittlitz's Murrelet, which nests on barren, newly-exposed terrain near glaciers and feeds near tidewater glaciers.

Former tidewater glaciers in College Fjord, Prince William Sound, are now grounded above high tide. Glaciers in Alaska are losing about 75 billion tons of ice a year. NOAA photo, ShoreZone program.

[4] See poster illustration prepared by the Alaska Climate Science Center: From icefield to ocean: how do glaciers impact Alaska's coastal ecosystems, and what do glacier changes mean for the future of this ecologically and economically valuable system? https://csc.alaska.edu/sites/default/files/Timm.K.Glacier-System-Poster-2014.pdf (Accessed 28 August 2015)

Arctic sea ice is a regular and important feature of the marine environment in both the Arctic Ocean and the Bering Sea. Alaska is the only state with permanent pack ice habitat. As the climate warms, however, the ice pack in the Arctic is diminishing. Within the central Arctic Ocean, the coverage of old ice between 1982 and 2007 declined by 88% and ice that was at least 9 years old essentially disappeared (Maslanik et al. 2007). This change toward younger ice translated to a decrease in mean thickness of ice over the Arctic Ocean from 2.6 meters in March 1987 to 2.0 meters in 2007 (Stroeve et al. 2008). From these trends, the Arctic may be seasonally ice free as early as 2030 (Stroeve et al. 2008).

Wildlife

Pack ice provides important habitat for many marine mammals, including ice seals, polar bears, and Pacific walrus. As the pack ice grows during winter and shrinks during summer, the ice edge moves over hundreds of miles of shallow continental shelf. For walruses, which rest on the ice edge and dive to the sea floor to feed on benthic invertebrates, changes in the location of the pack ice edge carry them over constantly new feeding areas. A problem develops, however, if the ice edge in summer retreats so far that the edge lies over deep, non-shelf waters. When walruses can no longer reach the bottom to feed, their only option is to leave the ice pack, and swim to land. There, they face decreased access to food, and increased risk of mortality from stampedes caused by disturbance from airplanes, people, or bears.

Alaska's Emperor Goose overwinters along the Aleutian Islands. Photo by Mike Boylan, USFWS.

In addition to uniquely hosting marine mammals that rely on pack ice, Alaska has other habitats and wildlife species that are not necessarily unique to Alaska but have far greater representation here than elsewhere.

Alaska has more than 40% of the nation's surface water resources, including more than 12,000 rivers, 3 million lakes greater than 5 acres, and numerous creeks and ponds. Alaska has 174 million acres of wetlands, or 63% of the nation's total. As a result, it is a prolific producer of waterfowl and other waterbirds. Alaska is the breeding ground for 20% of all waterfowl in the U.S., including 80% of the world's population of Black Brant, 90% of the world population of Emperor Geese, and 50% of North America's Northern Pintails. Alaska supports 100% of the U.S. breeding populations of Tule Greater White-fronted Geese, Greater White-fronted Geese, Cackling Geese, Dusky Canada Geese, Pacific Black Brant, Long-tailed Duck, Spectacled Eider, King Eider, Steller's Eider, Common Eider, Black Scoter, White-winged Scoter, and Surf Scoter. The boreal forest and tundra habitats are important breeding

areas for many species of songbirds that migrate to wintering grounds through the Americas. Alaska's birds migrate to all 7 continents, and contribute greatly to the diversity and abundance of birds enjoyed by people throughout the U.S. (Figure 1).

Alaska has 33,904 miles of marine shoreline, which is 38 percent of the shoreline in the entire U.S. This extensive shoreline, combined with its northern location and abundant breeding habitat, makes Alaska a particularly important place for shorebirds. Alaska annually hosts 7 million to 12 million shorebirds, representing up to 50% of all the shorebirds in North America. Seventy-six species of shorebird have been recorded in Alaska, representing fully one third of the world's shorebird species (Gibson et al. 2015)

Alaska contains most of the world's breeding population of 3 shorebird species (Bristle-thighed Curlew, Western Sandpiper, and Black Turnstone) and the entire global population of numerous subspecies, including Rock Sandpiper (*ptilocnemis and couesi*), Bar-tailed Godwit (*baueri*), Marbled Godwit (*beringiae*), Black-bellied Plover (*squatarola*) and Dunlin (*pacifica* and *arcticola*). In terms of essential habitat, Alaska has more than 50 shorebird migration staging or stopover sites that qualify as Western Hemisphere Shorebird Reserve Network sites.[5] At 10 of these sites, concentrations exceed 1 million

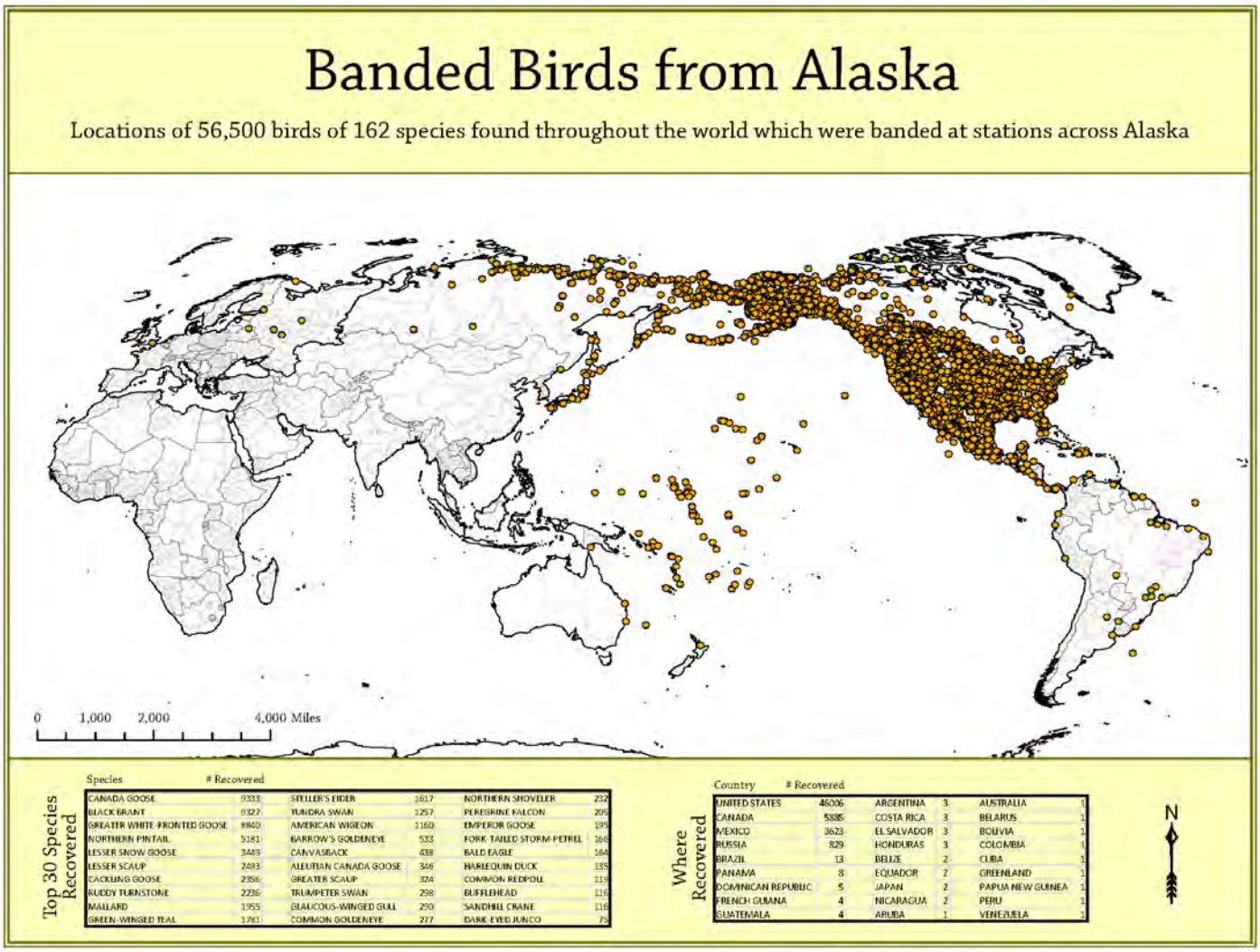


Figure 1. Relocations of bird species banded in Alaska. Map courtesy of Audubon Alaska.

[5] WHSRN – Western Hemisphere Shorebird Reserve Network. http://www.whsrn.org/ (Accessed 28 August 2015).

Alaska contains most of the world's population of two subspecies of Dunlin. Photo by Jim Dau, ADF&G.

The Pacific Golden Plover breeds in western Alaska, and overwinters on islands in the central and South Pacific. Photo by Daniel Ramirez.

birds, with sites like the Copper River Delta hosting between 5 million and 8 million shorebirds each spring.

One of Alaska's exceptional contributions to the world's avifauna is its seabirds. Alaska's coastal and offshore waters provide habitat for upwards of 100 million seabirds from 66 species. About 50 million seabirds nest on Alaska's coast each summer, representing nearly 90% of all the seabirds in the U.S. Eight seabird species nest only in Alaska and nearby parts of Russia, including the Red-faced Cormorant, the Red-legged Kittiwake, and the Whiskered Auklet. The Arctic Tern, which nests in Alaska, is considered the world's longest distance migrant, traveling as much as 44,000 miles round-trip annually between the Arctic and the Antarctic.[6]

The Arctic Tern's annual round-trip travel between its Arctic breeding grounds and its wintering grounds in Antarctica may cover 44,000 miles. Photo © Mark Emery.

The global significance of Alaska's seabirds can be measured by the large number of globally important bird areas (IBAs; discrete areas with >1% of the world's population) in the state. Based on breeding colony counts, biologists have identified 61 Alaska IBAs with globally significant populations of 22 species and 30 million birds present (Smith et al. 2014). These areas, representing just 15% of all mapped breeding colonies in Alaska, contain 89% of its colonial nesting seabirds. But important areas for seabirds extend well beyond their nesting colony sites. They must also find their food (forage fish and krill) at sea, in patches that are highly ephemeral. Biologists have identified 64 pelagic (open ocean) IBAs for 45 species. These IBAs encompass over

[6] World's Longest Migration Found—2X longer than thought. National Geographic. http://news.nationalgeographic.com/news/2010/01/100111-worlds-longest-migration-arctic-tern-bird/ (Accessed 28 August 2015).

23 million seabirds (Smith et al. 2014). The IBAs contained about 38% of all pelagic seabirds in Alaska waters, within only 6% of the total water area covered by IBAs.

One of the most impressive IBAs, numerically speaking, is centered in Unimak Pass, in the Aleutian Islands. Upwards of 7 million seabirds use these waters, including globally significant populations of Short-tailed Shearwaters (3.4 million) and Sooty Shearwaters (1.1 million). These birds are drawn here by the upwelling waters and abundant food resources available. Unimak Pass also happens to be on the great circle route between North America and Asia that 3,000 tankers and cargo ships travel each year (8–9 per day). These ships, with a median bulk fuel load of 1.6 million gallons, pose an obvious threat to these birds should an accident or grounding occur here (Transportation Research Board 2008).

Avian species dependent on terrestrial habitats (landbirds), constitute the largest and most ecologically diverse component of Alaska's avifauna (Handel and Stenhouse *In Prep*). Notable groups include grouse and ptarmigan, raptors, woodpeckers, and passerines. Most landbird species are migratory, and four major global migration flyways merge in Alaska. As a result, birds travel to breed in Alaska from all over the world, and reproductive success in Alaska affects populations in both North and South America. Alaska's largest area of landbird habitat is interior boreal forest, which comprises the westernmost portion of the Northern Forest Avifaunal Biome. Collectively with Canada, this biome is considered a "veritable Neotropical migrant factory" for species, such as thrushes, warblers, vireos and flycatchers

The Lapland Longspur is a common songbird of the arctic tundra. Photo by Jim Dau, ADF&G.

(Rich et al. 2004). Alaska supports 100% of the U.S. breeding population of Gyrfalcon, Rough-legged Hawk, and Snowy Owl, as well as large proportions of other raptor subspecies.

There are 2,670 named islands in Alaska, including 8 of the 10 largest islands in the United States. Tens of thousands of smaller islands are distributed in the 2 largest archipelagos in the U.S., the Aleutian Islands and the Alexander Archipelago. Some of the most important islands for birds occur in the Bering Sea, often far removed from the mainland (e.g., Pribilof Islands, St. Matthew Island, St. Lawrence Island). The existence of so many remote islands in Alaska has led to an exceptionally high level of endemism, especially among small mammals, which have limited dispersal capabilities.

State territorial waters extend to 3 miles offshore, and waters between 3 and 200 miles offshore are under federal management authority (foreign fishing vessels are not allowed within this 200-mile zone). This plan will cover many of the fish and wildlife species that use marine waters out to the 200-mile limit, with a particular emphasis on species known to be at risk, and those of high commercial, cultural, or ecological importance.

Pollock and other groundfish account for over 4 billion pounds of seafood harvest per year in Alaska. Photo by John Hyde, ADF&G.

Much of the marine area covered in the plan lies over relatively shallow continental shelf waters, especially in the Bering Sea, and is highly productive for fish. Alaska accounts for 56% of total commercial fishery harvest volume in the U.S., nearly 4 times more than the next largest seafood-producing state.

Commercially important species of seafood from Alaska include 5 species of salmon, 5 species of

The salmon harvest in Alaska is valued at 577 million dollars per year. Photo by Fawcett5.

Commercial fishing for sockeye salmon in Bristol Bay. Photo © Mark Emery.

crab, walleye pollock, Pacific halibut, Pacific cod, sablefish, herring, 4 species of shrimp, several species of flatfish and rockfish, lingcod, geoducks, sea cucumbers, and sea urchins. Groundfish account for the greatest volume of catch—over 4 billion pounds per year. In 2014, the salmon harvest in Alaska was valued at 577 million dollars,[7] and the shellfish harvest at 399 million dollars. Two thirds of Alaska's seafood harvest is exported (2.3 billion dollar value), with China purchasing the greatest share, followed by Japan, Central Europe, and Korea.

One species that has high commercial and cultural value is Pacific herring. Statewide harvests of herring average 83 million pounds, with a value of approximately 13 million dollars (Woodby et al. 2005).

In Alaska, important forage fish species include eulachon, sandlance, capelin, and lantern fish. These fish species constitute critically important food for larger predatory fish, seabirds, and marine mammals. Some of these fish have over 20% fat content (Iverson et al. 2002), making them particularly valuable for higher trophic levels. Forage fish species are not harvested commercially in Alaska and information about their population status, trends, and ecology is limited. Gathering more of this type of information is a priority.

[7] Alaska Department of Fish and Game, Alaska Commercial Salmon Harvests and Exvessel Values. http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisherySalmon.exvesselquery (Accessed 31 August 2015).

Summary

In summary, Alaska is large, relatively pristine, and relatively protected compared with other states and territories. Its fish and wildlife populations are relatively abundant and healthy. Our challenge in this plan is to predict which taxa will be most vulnerable to current and future threats, and to identify what conservation actions Alaska can take to mitigate those threats and prevent the need for listings under the ESA. Alaska has a wealth of fish and wildlife, including many species that exist nowhere else in the nation. The state recognizes its role in conserving and managing these resources for the public good, and will make use of this plan to guide its efforts.

A double rainbow in Wrangell–St. Elias National Park. Photo by Eric Rolph.

Species of Greatest Conservation Need

The polar bear was listed as a threatened species due to climate change. Photo by Ansgar Walk.

This chapter identifies how wildlife species[8] in Alaska were qualified as species of greatest conservation need (SGCN). State Wildlife Grant funding received by Alaska will be available only to projects that address SGCN and their habitats. While this chapter mentions some species to highlight our planning process, the full list of SGCN, along with why each species was included, is provided in Appendix A.

There are more than 1,200 named vertebrate species in Alaska and its territorial waters, including 601 species of fishes (Mecklenberg et al. 2002), 505 species of birds (Armstrong 2015), 116 species of mammals (MacDonald and Cook 2009), 6 amphibians, and 4 reptiles.[9]

The number of species is not static. New species are still being discovered in Alaska, and as the climate changes, more species are headed north (Parmesan and Yohe 2003). Between 1976 and 1991, 74 new avian taxa were documented in Alaska (Gibson and Kessel 1992). By 2007, there were 21 more (Armstrong 2008), and since 2007, 84 more have been added (Gibson et al. 2015). While some of this increase may reflect more Alaska birders with better skills, there is a well-documented poleward shift

[8] Our use of the word "species" in this document refers as well to subspecies, stocks, and Distinct Population Segments (DPS).

[9] Alaska Department of Fish and Game, Reptiles and Amphibians. http://www.adfg.alaska.gov/index.cfm?adfg=animals.listreptiles (Accessed 31 August 2015).

of many species (Perry et al. 2005; Parmesan 2006; Hitch and Leberg 2007; LaSorte and Thompson 2007).

The sections below describe the rules applied to exclude some taxa from consideration (e.g., peripheral species, most invertebrate species, and plants), and define the criteria for including taxa. The diverse list of SGCN is considered to be "indicative of the state's wildlife."

Excluded Species

Plants

Although some state wildlife action plans include rare or sensitive plant species, most consider wildlife only. Vegetation work can be incorporated into studies where wildlife species depend on vegetation as an important component of their habitat (e.g., eel-grass beds, old-growth forest, riparian willows, etc.), or where external factors, such as climate change or logging, will cause significant changes in the composition, structure, and function of vegetation (Murphy et al. 1986; Kirchhoff and Schoen 1987; Beier et al. 2008). In addition, if invasive plant species are determined to threaten SGCN, studies for monitoring or investigating control measures are appropriate.

Hunted and Trapped Species

Alaska is home to many iconic North American wildlife species, including caribou, moose, muskoxen, wolves, wolverines, brown bears, and polar bears. Many of these species are hunted or trapped, and are of high cultural and economic importance to Alaskans. Most hunted and trapped species receive funding for their management and conservation (e.g., Pittman-Robertson funds[10]). Where hunted and trapped species are currently receiving significant research and management attention, with adequate Pittman-Robertson (or other) funding, they are excluded from this plan. Hunted or trapped species that have inadequate funding for research and conservation are included, as are all species currently listed, or petitioned for listing, under the ESA (e.g., bowhead whale, polar bear, Alexander Archipelago wolf, Pacific walrus). Should there be significant conservation concerns raised with other hunted species in the future, new work related to species not identified in this action plan can still be proposed and approved for SWG funding during the period covered by the plan. This involves a brief letter to the USFWS describing the emerging issue, and the conservation work that is needed on a particular species or habitat.

Marine Aquatic Species

There are thousands of marine aquatic species that could be included in this plan—diverse species of the intertidal zone, little-known life forms in the deep sea trenches, and free-floating microzooplankton. By some estimates, there are at least 5,000 species of fish yet to be discovered in the world's oceans—more than all mammal species known today (Myers et al. 2000). Marine aquatic invertebrates pose a particular challenge. The Aleutian Islands alone harbor more Echinoderm species and more cold-water coral species than any other place in the world.[11] The Aleutians have more than 100 species of Echinoderms named in 45 genera, and another 25 species presently under description.[12] These species are exposed to some risk because they can be bycatch in commercial fisheries (Stone 2006). In state and

[10] Pittman-Robertson funds are paid to each state from federal excise taxes to help manage and conserve game populations and their habitats. The fund is named for the chief sponsors of the 1937 Federal Aid in Wildlife Restoration Act that created the excise tax.

[11] Exploring Corals of the Aleutian Seas. http://www.alaskascienceoutreach.com/coralsite/corals.html (Accessed 31 August 2015).

[12] Echinoderms of Alaska and the Aleutian Islands. http://www.jaxshells.org/starfish.htm. (Accessed 31 August 2015).

King and Tanner crab (red king crab pictured here) are commercially important species. Peak harvests occurred in the early 1980s. Environmental conditions changed and in recent decades crab stocks have no longer been capable of sustaining similar harvest levels. Photo by Davic Csepp, NOAA.

federal waters along the Aleutian Islands, vast areas have been closed to bottom trawling and several coral gardens have been closed to any commercial fishing gear bottom contact.

We opted to include aquatic species for which at least some information on their population sizes, trends, and importance is available. Most of the aquatic species included as SGCN are either used by Alaskans (culturally or economically important), have been recognized as having high ecological value (forage fish, some invertebrate orders), or are well-known species of concern (e.g., large whales, ice seals, polar bears, walrus).

Peripheral Species

Another early challenge was to identify, and exclude, species that are peripheral (Bunnell et al. 2004b) in the state. These are species that occur in small numbers on the Alaska side of the state boundary. Because of Alaska's size and proximity to both the North American and Asian continents, it has many species that fall in this category. Some are merely accidental occurrences. Asiatic birds may be blown off course in a storm during migration, and appear, temporarily, on western islands in the Aleutian chain. Excluded were 57 bird species that had only 1–2 records, ever, in Alaska (Gibson et al. 2015) such as the Siberian Blue Robin, the European Golden-Plover, the Oriental Pratincole, and the Northern Boobook.

The Short-tailed Albatross is the largest seabird in the North Pacific, and it is found offshore in Alaska. Once numbering in the tens of millions, commercial hunting for feathers decimated breeding colonies, and the species was declared extinct in 1949. Fortunately, a few individuals survived at sea, and the population is slowly recovering. The species is listed as endangered under the Endangered Species Act. Photo by Noah Kahn, USFWS.

More common is the case where the "fuzzy edge" of a species' normal range touches or slightly overlaps with Alaska's political boundary. The location of that species' range boundary is a function of the species' niche, and environmental conditions at the edge that either allow or preclude habitation. No level of conservation can make small populations at the edge of their range persist continually, much less become abundant. Species excluded for this reason include 145 casual and 51 rare bird species. These included such birds as the Eastern Spot-billed Duck, White-tailed Eagle, Long-toed Stint, and Anna's Hummingbird. Similar criteria were applied to mammals and fish, based on visual examination of their range maps and numbers of records in Alaska. Species such as the bushy-tailed woodrat, Guadalupe fur seal, ocean sunfish, and skipjack tuna were dropped from SGCN consideration.

Although peripheral taxa should be generally excluded for purposes of conservation planning, there is one important exception: Sometimes small numbers of a species are found some distance from their normal range in a regularly occurring persistent population. These so-called "disjunct" peripheral populations (Bunnell et al. 2004b) may use different habitats, feed on different food items, or exhibit different

Species of Conservation Need: Gray-headed Chickadee, Poecile cinctus lathami

The Gray-headed Chickadee is a widespread resident breeder throughout subarctic Scandinavia and Northern Asia, where it is called the Siberian Tit. The bird is also found in North America, with a small, disjunct population occurring in Central Alaska, northern Yukon, and the Northwest Territories. The Gray-headed Chickadee is rare in Alaska, and nothing is known of its population sizes or trends. The small population, and lack of knowledge about its life history, makes it a species of conservation needs. Photo by Estormiz (Siberian Tit, from Finland).

behaviors than populations in the core of the species' range. If so, these could be new species in the making, and their conservation thus quite important for protecting biodiversity. Therefore, if a species population is disjunct from its normal range, and is abundant enough to be surveyed for population trend estimation, it qualified as a SGCN. Species qualified as SGCN for this reason included Arctic Loon, Short-tailed Albatross, Western Screech-Owl, and Gray-headed Chickadee.

Reptiles

The only reptiles in Alaska are aquatic (4 sea turtle species). Sightings of these species in Alaska within 200 miles of shore are rare. Over the last 50 years, there have been 19 reports of leatherback sea turtles, 15 reports of green sea turtles, 3 reports of Olive Ridley sea turtles and 2 reports of loggerhead sea turtles (Hodge and Rabe 2008). All 4 species are listed as threatened or endangered under the Endangered Species Act, and are labeled threatened by the International Union for the Conservation of Nature (IUCN). However, they are excluded from the plan as peripheral species because their conservation status does not hinge on conditions in Alaska waters, and they are too uncommon to effectively survey, monitor, or research in Alaska.

Taxonomic Status

An additional important consideration in identifying SGCN was whether to recognize subspecies, stocks (commonly used for marine mammals, fishes, and some waterfowl), and distinct population segments (DPS) as valid taxonomic entities on our list. The best practices guidance (AFWA 2012) encourages recognizing and planning for the conservation of any taxonomic entity that could be listed under the ESA, including valid subspecies and distinct population segments. These subdivisions were treated as follows:

Distinct Population Segments—Distinct Population Segment (DPS) is a term with specific legal meaning which is used for listing, delisting, and classification purposes under the federal ESA. Such designation involves not only distribution and level of genetic interchange, but also management and conservation regulation. These lines can follow political boundaries. Existing distinct population segments were included in this revised plan.

Stocks—The term "stock" is similar in meaning to DPS. It does not carry legal meaning from an ESA standpoint, but could under other laws, such as the Marine Mammal Protection Act. It is a term used in management of separate populations of fish and marine mammals by ADF&G and the National Marine Fisheries Service. Some distinct marine mammal "stocks" (e.g., western and eastern sea lion stocks) are recognized if the stock has legal DPS status. Different stocks of marine sea ducks that occur in the Pacific (western stock) versus Atlantic (eastern stock), are also recognized as distinct. However, fish stocks are not recognized even though some anadromous fish species that pass through Alaska waters during their life cycle have been listed as an Endangered DPS in the Lower 48.[13]

Subspecies—Inclusion of subspecies in the plan is complicated by disagreements among taxonomists over what subspecies designations are valid, as with the Alexander Archipelago wolf (e.g., Weckworth et al. 2015). To our knowledge, there is no universally accepted reference or source that legally designates species or subspecies as valid. For mammals, the Alaska Species Ranking System (ASRS) was used to reflect taxonomic standing (Gotthardt et al. 2012). For birds, Gibson and Withrow (2015)

[13] NOAA. Endangered, Threatened, and Candidate Species under NMFS's Authority in Alaska. Updated April 2014. http://alaskafisheries.noaa.gov/protectedresources/esa/ak_nmfs_species.pdf (Accessed 31 August 2015).

Species of Conservation Need: North Pacific Right Whale, Eubalaena japonica

The North Pacific right whale (eastern stock) occurs in the Bering Sea and Gulf of Alaska, generally preferring coastal or shelf waters. The species is called the right whale because it was considered by whalers the "right" whale to target for its slow swimming speed and high blubber content that caused it to float when killed. It is a baleen whale that filters small fish and krill from the water for food. It may live more than 100 years. The right whale population today is a fraction of what it once was. An estimated 20,000 to 30,000 were taken in 9 years alone in the mid-1800s. Today, an estimated 250 mature right whales remain in the entire North Pacific, and there are fewer than 30 individuals in the eastern population that inhabits Alaska waters. Critical habitat has been established in the southeast Bering Sea. The lack of recovery, despite current protection from whaling, is not understood. Threats to this species include ship strikes and entanglement in commercial fishing gear. Photo by John Durbin, NOAA.

was the authority. Taxonomic designation or recognition in the plan may be changed if more compelling information later indicates subspecies status is not warranted.

Criteria for Inclusion as SGCN

Wildlife species qualified as SGCN under one or more of the following criteria:

- At-risk species.
- Stewardship species.
- Culturally important species.
- Economically important species.
- Ecologically important species.
- Sentinel species.

At-Risk Species

Given the purposes of the State Wildlife Grant program, primary weight was given to species that are listed as threatened or endangered under the Endangered Species Act, or are at risk of being listed. Typically, at-risk species are identified based on a small population, a small range, a declining population, or a population or habitat that is threatened in some way. To identify at-risk species, we use an inclusive combination of population size and trend data when available, and existing lists highlighting species of conservation concern.

Variations of this rubric form the basis for most species ranking systems, including the IUCN Red List (IUCN 2014), Partners in Flight (PIF) Watch list (Panjabi et al. 2012), State of the Birds (NABCI 2014) and NatureServe (Faber-Langendoen et al. 2012). None of these rankings, alone, was adequate for our needs. PIF, for example, assesses only landbirds, and specifically excludes Alaska data from its assessment process. IUCN cuts across taxa, and is scientifically objective (Rodrigues et al. 2006), but data are lacking for most species, and it does not assess subspecies. NatureServe rankings at the global

scale mimic IUCN closely, but for state-level rankings, it gives high scores for small populations of many species that are common, but peripheral. The Alaska Species Ranking System discounts species for which conservation concerns are already recognized, resulting in poor correspondence with other lists. All ranking systems that attempt to assess "threats" necessarily inject some amount of subjectivity into the scoring, and can be difficult to standardize across species (Master 1991, Beissinger et al. 2000).

Population size and population trend are the two variables best correlated with extinction risk (O'Grady et al. 2004). Population size is difficult to measure for most species due to the widespread and variable distribution of animals, some of which are very difficult to access or find. However, population trend can be assessed with no knowledge of abundance by using counts in specific locations as an index of abundance. Examples include catch per unit effort in fisheries, counts of scat, tracks, or other sign for large mammals, or direct counts of animals by sight or sound (Simons et al. 2007) in easily accessed locations (e.g., Breeding Bird Surveys along roadsides, or Christmas Bird Counts [Niven et al. 2004; Butcher et al. 2006]). These methods provide reliable trend information if the counts fairly represent the population as a whole (Buckland et al. 2008). If a bird species showed a significant decline based on Breeding Bird Survey and/or Christmas Bird Count data (Butcher and Niven 2007; Sauer et al. 2012), it was recognized as a SGCN.

We also added at-risk species as SGCN from existing lists highlighting species of conservation concern. These included lists from NatureServe, IUCN, and recently updated conservation plans for Alaska's landbirds (Handel and Stenhouse, *In Prep*), seabirds (U.S. Fish and Wildlife Service 2009), and shorebirds (Alaska Shorebird Group 2008). Although the processes used to develop these various lists each has its

Biologists studying the condition and behavior of harbor seals. Dramatic declines in harbor seals have been documented in many parts of Alaska. Photo by Amy Carroll, ADF&G.

own set of limitations, these plans were vetted by species experts, and the products are familiar and in wide use. If this plan is to be embraced by other agencies and users, aligning this plan with efforts by our partners is important.

Species that qualified as "at risk" met one or more of the following criteria:

- A species, subspecies, stock, or DPS formally listed under ESA as threatened or endangered, or for which a 12-month status review was being conducted.
- A species which IUCN has designated as critically endangered (CE), endangered (EN), vulnerable (VU), or near threatened (NT) under its Red List scoring rules.
- A species which NatureServe has designated as critically imperiled (G1), Imperiled (G2) or Vulnerable (G3).
- A species identified as a red or yellow Watch List species, or a "Common Bird in Steep Decline" in the 2014 "State of the Birds Report" under the North American Bird Conservation Initiative.
- A species identified as a high priority conservation concern (conservation Category 4 or 5) in the Alaska Shorebird Conservation Plan.
- A species identified as "highly imperiled" or of "high concern" in Alaska by the Alaska Seabird Conservation Plan.
- A taxon identified in the Alaska Landbird Plan as (a) a "high continental conservation concern, (b) a species or subspecies for which Alaska has high stewardship responsibility, or (c) common species whose populations have declined by >50% since the mid-1960s.
- A species that is significantly declining in North America, as indicated by Breeding Bird Survey data and/or Christmas Bird Count Data.
- A species of concern identified by the Alaska Raptor Group.
- A species of concern identified by ADF&G's Waterfowl Program.
- A species of concern identified by the National Marine Fisheries Service.

This process is biased towards birds as at-risk taxa, simply because there is high public interest in birds and therefore greater effort is expended by conservation organizations and resource agencies monitoring populations and developing conservation plans for these species. For most species in the state there is little information on population size or trend, and, therefore, a weak basis for evaluating extinction risk. Other factors besides extinction risk were considered as alternative criteria for including taxa as SGCN. Those additional categories are described below.

Stewardship Species

A "stewardship species" is any taxon with a large percentage of its population or range in Alaska. This is particularly relevant in Alaska because (1) its large size makes it more likely to support a significant percentage of a taxon, (2) it has extensive island archipelagos (Aleutian Islands, Kodiak Archipelago, Alexander Archipelago, isolated Bering Sea islands) on which many endemic subspecies have evolved; and (3) many migratory bird species concentrate in Alaska to breed or stage before dispersing.

Species of Conservation Need: Arctic Warbler, Phylloscipus borealis

The Arctic Warbler is the only member of a large group of Old World (Europe and Asia) warblers that has established a foothold in North America. Alaska is its sole breeding place in North America, and it rarely strays southward in the New World. It migrates East across the Bering Strait and south through Eastern Asia to winter in Southeast Asia, including the Philippines and Indonesia. It is a common breeder in the Arctic, Central, and Western regions of Alaska, and prefers streamside willow thickets for habitat. It is threatened by habitat loss on the wintering grounds, and may be negatively impacted by climate change. Photo by Osado.

In identifying SGCN stewardship species, landbirds identified as either continental or regional stewardship species in the Alaska Landbird Conservation Plan were included. Also qualified was any species (or subspecies) with more than 60% of its North American population in Alaska. Percentages for shorebirds and seabirds were taken from their respective conservation plans. For mammals, stewardship status was awarded if more than 60% of the species' range was within Alaska.

Culturally Important Species

The best practices guide (AFWA 2012) recommends that action plans consider cultural, economic, and ecological importance of a species when determining status as an SGCN. Many culturally important species are hunted or trapped. As noted previously, these are excluded from this draft plan if adequate funding from other sources is available. All other culturally important species were considered eligible.

Information on important subsistence species from around the state were provided by Dr. James Fall, program manager for the Division of Subsistence at the Alaska Department of Fish and Game. These

Species of Conservation Need: Arctic Lamprey, Lethenteron camtschaticum

The Arctic lamprey is a jawless fish. It lives its adult life in the ocean, and migrates into freshwater in the fall. It overwinters in streams, and spawns in the spring, then dies. In freshwater, they are found along the coast from the Kenai Peninsula west and north through the Arctic Ocean, and in large interior rivers. A single female can lay up to 100,000 eggs. Eggs hatch and the young larval fish live in freshwater for 3 to 7 years before metamorphosing into adults and migrating to the ocean. Adults are parasitic, attaching themselves to marine fish. Little is known about the marine distribution of adults. Population levels for this species are unknown, but they are captured by the tens of thousands in freshwater subsistence fisheries every fall. There is no significant commercial fishery for this species, and subsistence harvests appear sustainable. Photo by Parker Bradley.

data include all aquatic species harvested for subsistence, as well as selected species that provide subsistence harvest opportunities but do not receive substantial funding for management from other sources (e.g., some seabirds and sea ducks). Regional harvest reports of the Alaska Migratory Bird Co-Management Council (AMBCC)[14] were also used to identify culturally important species that are eligible for SGCN status.

Economically Important Species

These include aquatic species harvested commercially, such as crabs, salmon, pollock, sablefish, and halibut. Furbearers have commercial value, but are excluded as hunted or trapped animals. Exceptions occur where they are petitioned for listing under ESA (e.g., Alexander Archipelago wolf) or they are considered endemic or sentinel species (e.g., Alaska hare, arctic fox). Economically important species in Alaska are also culturally important.

Ecologically Important Species

Most ecologically important species are other important prey for some other species, or they exert "top-down" control on community structure. In the model of a keystone species, ecologically important species exert disproportionate influence on ecosystem structure or composition (Mills et al. 1993; Paine 1995). An example is the role sea otters play in the northeast Pacific, where their impact on populations of sea urchins (kelp grazers) has a strong effect on kelp forests and associated fish species. One of the key species in the Arctic is the Arctic cod, because it is a critical link between lower trophic levels (copepods and under-ice amphipods) and birds, seals, and whales. Under this category, vertebrate species that are abundant, and provide a critical source of food for species at upper trophic levels, such as forage fish (Cury et al. 2011) and small mammals (Delibes-Mateos et al. 2011), qualified as SGCN.

Sentinel Species

Sentinel species are used as indicators of ecosystem health or environmental change (Caro and O'Doherty 1999; Pearce and Venier 2005). Because global climate change is expected to have large effects on ecosystems and wildlife in Alaska (see Threats chapter), species that are expected to show shifts in distribution or changes in abundance as a result of climate change make logical sentinel species. Species predicted to be most affected by habitat loss in the next few decades, and therefore logical surrogate or sentinel species for climate change, are Gyrfalcon, Northern Harrier, Savannah Sparrow, Upland Sandpiper, Long-tailed Jaeger, and Bristle-thighed Curlew (Marcot et al. 2015). Other examples of sentinel species are river otter (Bowyer et al. 2003), sea otter (Jessup et al. 2004), Pigeon Guillemot (Prichard et al. 1997), Cassin's Auklet (Wolf et al. 2010), marine mammals generally (Bossart 2006), upper trophic level (UTL) species generally (Moore et al. 2014), range restricted species (ice dependent or alpine dependent, Parmesan 2006), and "income breeders" that gain nutrients for reproduction on their breeding grounds (e.g., shorebirds and eiders, Winkler et al. 2002).

Results

Combined, our analysis resulted in qualifying 326 vertebrate taxa as SGCN in Alaska. The SGCN total includes 5 orders of freshwater invertebrates (insects), 4 orders of marine zooplankton, 5 orders of terrestrial arthropods, plus 1 phylum (Echinodermata) and 36 species of marine invertebrates. Of the vertebrates, the SGCN list includes 58 fish, 5 amphibians, 192 birds, and 71 mammals. A complete list of all SGCN and the basis for their inclusion is shown in Appendix A.

[14] Alaska Migratory Bird Co-Management Council http://www.fws.gov/alaska/ambcc/harvest.htm (Accessed 1 September 2015).

Distribution and Abundance of Wildlife in Alaska

A view of Alaska in winter, from space. Photo by Jeff Smaltz, NASA.

The first requirement of the revised plan is to describe the "distribution and abundance of wildlife… that are indicative of the health and diversity of the state's wildlife." In describing distribution of these species, we do not report every place the species has ever been seen. We describe where the species occurs regularly and in significant numbers—its characteristic distribution. The abundance information, if known, reflects the best available population estimate of the species, subspecies, DPS or stock. We make clear what population the estimate applies to, and we eliminate estimates deemed highly unreliable because the survey methodology was inappropriate or insufficient.

Distribution of SGCN

For describing distribution, the spatial framework of biogeographic regions was adopted (Figure 2). This is the framework others have used to describe the distribution of birds (Armstrong 2015) and mammals (MacDonald and Cook 2009) in the state. It also has the benefit of aligning fairly closely with Bird Conservation Regions (NABCI 2000), and Landscape Conservation Cooperative (LCC) planning areas in Alaska.

There are 6 terrestrial biogeographic regions: North Alaska, West Alaska, Central Alaska, Southwest Alaska, Southcentral Alaska, and Southeast Alaska. For marine species, there are 3 regions: Arctic Ocean, Bering Sea, and Gulf of Alaska.

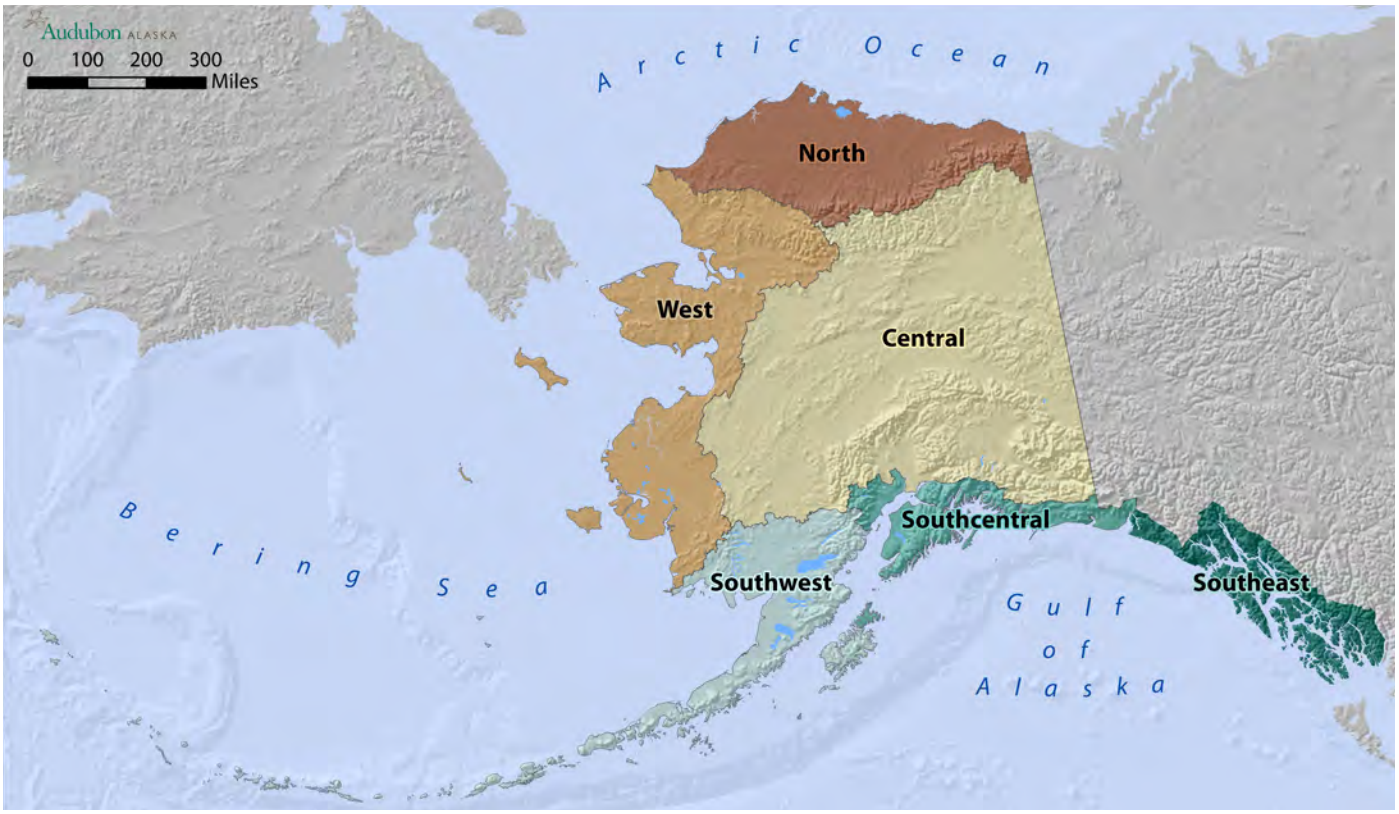


Figure 2. The 9 biogeographic regions of Alaska (6 terrestrial and 3 oceanic). Terrestrial regions follow Kessel and Gibson (1978). The map is courtesy of Audubon Alaska.

For each biogeographic region the following information is reported:

- Land area.
- Physiography, including major mountain ranges and other significant landscape features.
- Prevailing climate.
- Typical vegetation.
- Vertebrate wildlife species (representative examples).

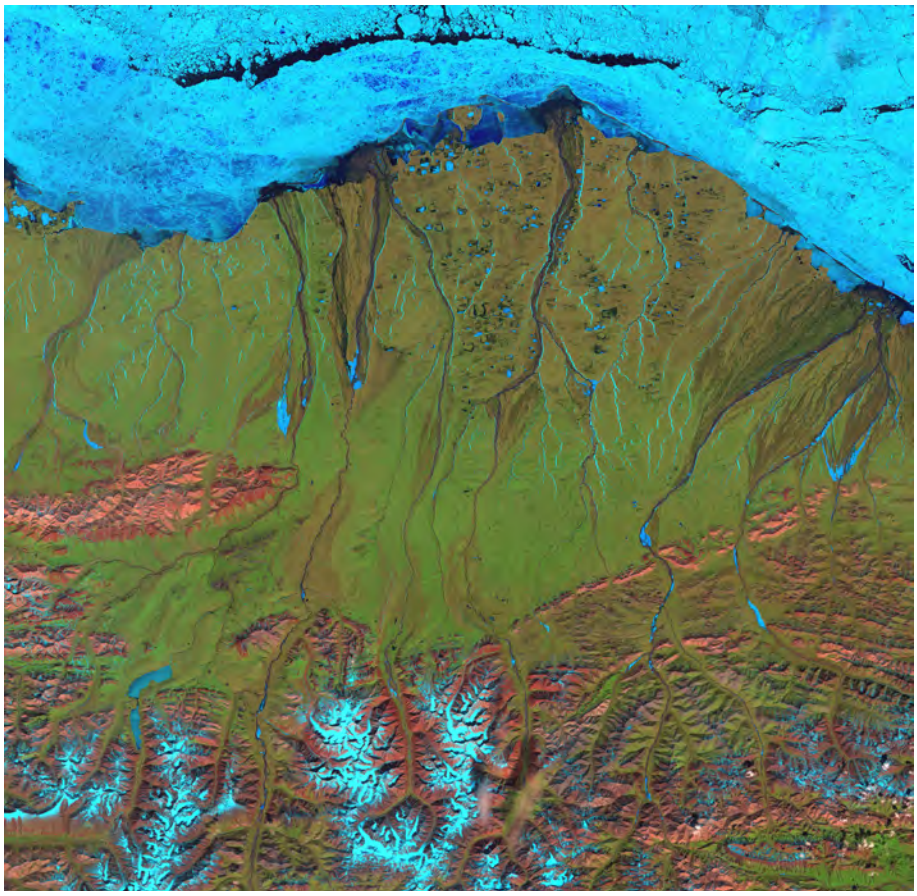
This chapter provides a broad overview of species distribution and important attributes of the 9 regions. The distribution of each SGCN is reported in Appendix B.

North Alaska

The North Alaska biogeographic region is also referred to by some as the Arctic region. It encompasses 78,904 square miles and is bounded by the Beaufort Sea and Chukchi Sea to the north and the Brooks Range to the south. It includes the Arctic coastal plain as well as the northern foothills of the Brooks Range.

The Arctic coastal plain is a treeless, windswept landscape stretching across the Alaska coast of the Arctic Ocean and into Canada. This region is characterized by an abundance of lakes, wetlands, and permafrost-related features such as pingos, ice-wedge polygon networks, peat ridges, and frost boils. Permafrost is almost continuous across the region, so soils typically are saturated and have thick organic horizons. The plain gradually ascends from the coast southward to the foothills of the Brooks Range.

Numerous large, braided rivers originate in the Brooks Range and drain northward across the coastal plain. Small streams dry up or freeze completely in the winter. Thousands of shallow rectangular lakes cover up to 50% of the coastal plain in a north-northwest orientation caused by prevailing winds. Due to the abundance of lakes and saturated soils, much of the coastal plain is considered wetland.



The North, or Arctic, region of Alaska encompasses the coastal plain and the foothills of the Brooks Range. The Arctic Ocean, ice-covered in this image, adjoins the North Slope. NASA photo.

The Brooks Range foothills, just to the south of the Arctic coastal plain, consist of long, linear ridges, gently rolling hills, glacial moraines, and mesas composed of tightly folded sedimentary rocks that divide narrow alluvial valleys. In contrast to the coastal plain, lakes are uncommon, but many swift streams and rivers originating in the Brooks Range cross through the foothills, occasionally braiding across gravel flats. Some streams freeze solid each winter but many of the larger of these rivers are spring-fed and maintain flow year-round, creating large aufeis (layered ice) deposits that last well into summer.

A dry, polar climate produces short, cool summers and long, cold winters. For the coastal plain, proximity to the Arctic Ocean and abundant sea ice contribute to the cool and frequently foggy summers. The foothills are somewhat warmer and wetter than the coastal plain. Annual precipitation is low (4 to 10 inches) and mostly falls as snow during the winter. The average annual temperature varies from 8° to 20°F.

On the coastal plain, vegetation is dominated by wet sedge tundra in drained lake basins, swales, and floodplains, and by tussock tundra and sedge-*Dryas* tundra on gentle ridges. Low willow thickets grow on well-drained riverbanks. Predominant vegetation in the foothills is mixed shrub-sedge tussock tundra with *Dryas* tundra occurring on ridges. Vegetation along rivers is dominated by willow.

North Alaska provides globally important habitat for breeding waterfowl and shorebirds (e.g., American Golden-Plover, Dunlin, Pectoral Sandpiper), mesopredators like the Snowy Owl and arctic fox; raptors, such as the Rough-legged Hawk and Gyrfalcon; and landbirds such as Arctic Warbler, Lapland Longspur, and Common and Hoary redpolls. The Beaufort and Chukchi seas provide summer habitat for polar bears and spotted seals, and fall feeding grounds for bowhead whales. Many species of waterfowl nest on the coastal plain, including Brant, King Eider, Steller's Eider, and Long-tailed Duck. Red-throated, Arctic and

Snowy Owls nest and hunt on the open tundra. In years when prey are scarce, many snowy owls migrate south of their normal range, showing up in winter in the Lower 48 states. Photo by Bert de Tilly.

Yellow-billed Loon breed on the coastal plain.

Many seabirds, including fulmars, auklets, guillemots, puffins, and murres, can be found here in the summer. Most of the U.S. breeding populations of Long-billed-billed Dowitcher; Dunlin; and Semipalmated, Pectoral, and Buff-breasted sandpipers occur here. In total, more than 2 dozen shorebird species breed in North Alaska, with more than 6 million birds estimated to breed on the National Petroleum Reserve–Alaska (NPRA) alone. Many shorebird species also use the coastal areas of the region for staging prior to migrating to southern parts of the western hemisphere, Southeast Asia, Oceania, Australia, and New Zealand. Smith's Longspurs breed in the foothills of the Brook's Range. Snowy Owls are common.

Small mammals common in northern Alaska include singing, root, and northern red-backed voles, tundra and barren ground shrew, snowshoe hare, Alaska marmot and arctic ground squirrel, and collared and brown lemming. No land mammal species is restricted solely to the North bioregion of Alaska (MacDonald and Cook 2009). Offshore waters support Pacific walrus; bearded, spotted, and ringed seals; beluga and Pacific gray whales; and polar bears. Dolly Varden, Arctic and Bering cisco, and Arctic grayling spawn and overwinter in the larger rivers and small populations of pink, chum, and king salmon spawn in small and large coastal rivers.

Species of Conservation Need: King Eider, Somateria Spectablis

King Eider is a large, spectacular duck of northern coastal waters. It breeds across the North American Arctic, but splits into two geographically distinct wintering populations in the north Atlantic and North Pacific. In Alaska, it nests in vegetation adjacent to small lakes and ponds, or on small islets along the arctic coastline. The species winters as far north as the ice pack allows. They feed on mollusks and crustaceans on the sea floor, with one recorded feeding at a depth of 180 feet in the Bering Sea. Surveys of the western (North Pacific) population as it passes by Point Barrow suggest a 56% decline since the mid 1970s. It is an important subsistence species along the North Slope. Knowledge of this arctic species natural history, demographics, and migratory behavior is sparse. Photo by Ron Knight.

West Alaska

The West Alaska biogeographic region encompasses 109,265 square miles and is bounded by the Chukchi Sea to the north and the Bering Sea to the west. Various ranges such as the westernmost portion of the Brooks Range foothills, the Nulato Hills, and the Ahklun and Kilbuck mountains define the eastern boundary of this biogeographic region. This region includes the Seward Peninsula in the north, and the vast Yukon-Kuskokwim Delta in the south. An additional feature of West Alaska is the presence of the Bering Sea islands, including St. Lawrence, Nunivak, St. Matthew, and Hall, and the 2 Pribilof Islands of St. George and St. Paul.

The coastal plains surrounding Kotzebue Sound are generally less than 330 feet (100 meters) in elevation and tend to be poorly drained. As in North Alaska, permafrost-related features dominate the landscape, with pingos around the Selawik River and many thaw lakes throughout. The low, rolling Nulato Hills form a divide between the Bering Sea and the Yukon River, and the Ahklun and Kilbuck Mountains define the divide between the drainages into Kuskokwim and Bristol bays. These mountains are steep and angular, with elevations reaching 4,950 feet. Past glaciers carved broad U-shaped valleys. Large "finger" lakes fill valleys on the south side of the mountains. Permafrost exists in most low-lying areas. The Yukon–Kuskokwim Delta is the result of deposition of heavy sediment loads from the glacial Yukon and Kuskokwim rivers. Abundant thermokarst lakes, meandering streams, and highly productive brackish marshes and wet meadows characterize this flat coastal plain. Isolated basalt hills and volcanic cinder cones less than 400 feet high punctuate the landscape. Discontinuous permafrost impedes drainage and contributes to shallow organic soils. There are large tidal fluctuations along the coast and occasional storm tide surges that flood coastal areas with salt water, creating invertebrate-rich coastal marshes.

Because the West Alaska region spans 10 degrees of latitude, and rises in elevation as one moves east, it has a widely-varying climate. In the north, the dry polar climate produces short, cool summers and long, cold winters. Annual precipitation is desert-like, averaging 4 to 12 inches and average annual temperature varies from 20° to 23°F. Along the Seward Peninsula, the moist polar climate is characterized by cold and windy winter conditions and summer fog along the coastline. The average annual precipitation is 10 to 20 inches in the lowlands and more than 40 inches in the mountains. The average annual temperature in the mountains varies from 21° to 28°F.

The southern portion of Western Alaska includes the vast Yukon-Kuskokwim Delta. About the size of the state of Oregon, it is one of the largest river deltas in the world, and an important nursery for many of the nation's waterfowl and shorebirds. The region is cold and windswept during long winters, but comes to life when the days lengthen, the ice on the rivers goes out, and the birds arrive. Precipitation across the delta is variable, averaging 15–40 inches at lower elevations, and up to 75 inches at higher elevations. The average annual temperature varies from 25° to 39°F.

In the mountainous areas of the region, the vegetation pattern is reflective of elevation and terrain. Higher elevations are barren, or support alpine tundra of *Dryas*-lichen or sedge-ericaceous shrubs. At lower elevations, vegetation changes to dwarf shrubs, tall shrubs (willow-birch-alder), or spruce and birch forests. Valleys may contain shrublands and wetlands mixed with forests of white spruce, balsam poplar, or mixed white spruce and paper birch. Due to the presence of peat mounds, sand dunes, and volcanic soils, upland areas support dwarf shrub communities of birch and ericaceous (heath) shrubs. Inland bogs contain tussock-forming sedges and sedge-moss communities. Willow thickets form along

rivers and on better-drained slopes, and alders and stunted spruce and birch grow along the major streams.

The Yukon-Kuskokwim Delta is classified as wet maritime tundra. The coastal areas are flat, treeless, and extremely wet. Sedge or sedge-tussocks can dominate these areas due to the wet soils. In the better-drained areas upriver and to the east, white spruce, willows, alder, and paper birch may occur. Grasses grow on drier microsites and spruce-hardwood forests occur in up-river valleys. In the transitional area between arctic and subarctic tundra, diversity of tundra plants is high due to the historical connection to Asia and the presence of both acidic volcanic rock and limestone.

Emperor Geese on the Yukon River Delta. Photo by D. Dewhurst, USFWS.

The Bering Sea islands are treeless, rocky, volcanic islands characterized by moist tundra meadows of sedges, grasses, low shrubs, and lichens. The shorelines are a mix of rocky sea cliffs and sand dunes.

Just as the climate of Western Alaska is varied due to its expansive reach along the coast and elevation gradients, so are the fish and wildlife resources present. In the northern part of this region, polar bears; spotted, bearded, and ringed seals; beluga, bowhead, and gray whales; and Pacific walruses are seen near the coast and on adjacent ice floes. The northern part of this region is an important breeding area for two relatively rare Alaska bird species, the Arctic Loon (Alaska population) and the Bristle-thighed Curlew. Common terrestrial mammals include singing voles and tundra shrews. All 5 species of Pacific salmon ascend area rivers to spawn. Dolly Varden spawn and overwinter in most rivers, and Arctic grayling are resident in larger streams. Bering cisco, Alaska blackfish, burbot, and sheefish are common residents of the freshwaters.

On the Yukon-Kuskokwim Delta, the combination of lakes, streams, tidal flats, wet tundra, and sedge flats supports abundant populations of waterfowl and shorebirds, including more than 20 species of waterfowl and 10 species of shorebirds that breed here. Spectacled Eider, Bristle-thighed Curlew, Bar-tailed Godwit, Black Turnstone, Red Knot, Semipalmated Sandpiper, and Dunlin all occur on the delta. The offshore waters provide habitat for beluga whales, Pacific walruses, and bearded, spotted, and ringed seals.

The Bering Sea islands of this area provide important habitat for numerous marine mammals and seabirds. The Walrus Islands group, in Bristol Bay, gets its name from the large number of bachelor walruses that haul out on its beaches each summer. The largest concentration occurs on Round Island, where Steller sea lions also haul out. Gray and beluga whales feed along the coast. The Pribilof Islands

provide habitat for approximately 3 million seabirds, including nearly the entire world population of Red-legged Kittiwakes. Other large breeding colonies exist on the islands for the Crested Auklet and Red-faced Cormorant. In the winter, polynyas (ice-free areas surrounded by ice) south of St. Lawrence Island attract virtually the entire global population of Spectacled Eiders. The Pribilof Rock Sandpiper breeds only on the Bering Sea islands. McKay's Bunting, the only passerine endemic to Alaska, breeds only on St. Matthew and Hall islands.

Two species of shrew (the Pribilof Island shrew and the St. Lawrence Island shrew) and one vole (insular vole) occur only in the West region, on Islands in the Bering Sea. Other land mammals of importance include the Alaska Hare, taiga and root voles, arctic ground squirrel and red squirrel, and American beaver.

One of the richest pockets of invertebrate life in the Bering Sea is found near St. Lawrence Island, where extremely productive benthic communities, including bivalve mollusks and amphipods, support marine mammals and waterfowl. A diverse mix of marine fish, including pollock, halibut, salmon, and forage fish, such as herring and capelin, also contribute to the abundance of birds and mammals. Breeding and wintering walruses inhabit the open ocean near St. Lawrence Island along with wintering bowhead whales. The ice-associated seals—ringed, bearded, and spotted—can be found at the northern islands. The Pribilof Islands provide critical breeding grounds for Steller sea lions and approximately 80% of the world's northern fur seals. An important gray whale feeding area is located just north of St. Lawrence Island in the Chirikov Basin. Bowhead, beluga, sei, northern right, humpback, and gray whales swim through the waters of the Bering Sea shelf. Dolly Varden and coho salmon spawn in rivers on St. Lawrence and Nunivak islands.

Central Alaska

The Central Alaska biogeographic region, covering an area also known as Interior Alaska, encompasses 267,759 square miles and stretches from the Brooks Range in the north, to the Yukon River in the west, Canada in the east, and the coastal mountain ranges in the south.

Species of Conservation Need: Great Gray Owl, Strix nebulosi

The Great Gray Owl is considered the largest owl in the world (by body length). It is found throughout the boreal coniferous forests of Central Alaska, and the coastal temperate rainforest of Southcentral and Southeast Alaska. It hunts in openings, typically muskegs, meadows, or fields adjacent to the forest. It feeds primarily on small mammals, especially rodents. It has exceptionally keen hearing, able to detect rodents tunneling under 18 inches of snow from 100 yards away. Depending on the practices used, logging can impact owls positively (by creating small openings in which they hunt), or negatively, (by creating openings too large for hunting or removing snags used for nesting and perching). Photo by Paul Reynolds.

The Brooks Range occurs in the northernmost portion of Central Alaska and spans the entire state, east to west. It represents the northern extension of the Rocky Mountains. The range is characterized by steep mountains composed of uplifted sedimentary and metamorphic rock, with scattered glaciers above 5,940 feet. Within the Brooks Range, elevations range from 1,640 to 8,530 feet. Near the southern boundary of the Central Alaska region is the Alaska Range. The mountains of the Alaska Range ecoregion are high, very steep, and covered with glaciers, rocky slopes, and ice fields. Elevations vary from broad valleys at 2,000 feet to peaks greater than 12,000 feet, with the tallest mountain in North America, Denali, rising to 20,310 feet. Glaciers have shaped these mountains, so cirques and U-shaped valleys are common features. Streams and rivers, heavy with sediment, run swiftly down mountain ravines and braid across valley bottoms. The Wrangell Mountains and Kuskokwim Mountains are found in the southern portion of Central Alaska. While the Wrangell Mountains are steep and covered with ice fields and glaciers, the Kuskokwim Mountains are rolling mountains with elevations generally below 4,000 feet. Lowlands in Central Alaska are shaped by large rivers, including the Yukon, Tanana, Kuskokwim, Copper, Porcupine, and Old Crow rivers. Permafrost tends to be discontinuous and retreating due to climate warming. Thawing results in thaw lakes, collapse-scar bogs, and fens. Glacial moraines and kettle lakes across the lowlands are evidence of past glaciation, and oxbow lakes exist where river routes have changed.

The prevailing climate is continental, with long, cold winters and short, warm summers, with temperature extremes ranging from about -50° to 90°F. Some upland areas of Central Alaska can experience dry, warm summers and this contributes to a greater frequency of wildfires. Average annual precipitation ranges from 6 to 30 inches across Central Alaska.

Vegetation in Central Alaska is diverse. In the north, it includes mixed shrub-sedge tussock tundra with willow thickets along rivers and streams and sparse conifer-birch forests at lower elevations. Steep slopes and slopes at higher elevation are barren, while upper and intermediate slopes contain alpine heath communities. When vegetation is present, it features shrub birch, dwarf shrub communities, or *Dryas*-lichen tundra. In the southern part of this region, boreal forest is extensive, and features stands of black spruce and white spruce. Floodplains are dominated by black spruce bogs, and tamarack. On slopes and uplands, there are white spruce, white birch, and trembling aspen.

Areas affected by recent forest fires have tall willow, birch, and alder shrubs. In lowland areas, vegetation varies with soil drainage. Along the major rivers, highly productive stands of white spruce and balsam poplar prevail. Where the meandering streams have left oxbows or cut-off sloughs, wet sedge meadows, grass marshes, shrub swamps, and aquatic vegetation occur. Tall alders, birch, and willows dominate active floodplains and river bars.

There are small mammals, such as snowshoe hares, brown and northern bog lemmings, meadow, tundra, and taiga voles, and little brown bats. Common, dusky, and tundra shrews, can be found in the wide valley floors of Central Alaska. The woodchuck is restricted to the Central region in Alaska. Pike, burbot, whitefish, and grayling are widely distributed in rivers and lakes. Headwater streams in the mountains support resident populations of dwarf Dolly Varden. All 5 species of Pacific salmon migrate up the Yukon and Kuskokwim rivers to spawn in tributary streams, and commonly occur throughout Central Alaska. The boreal forest supports a large variety of birds, including Surfbirds that breed in rocky areas above tree line. The forests along river valleys attract Belted Kingfishers. Open, mixed deciduous-conifer forests support a large variety of birds including Boreal Chickadees, Northern Flickers, and

Boreal Owls. Landbirds inhabiting this area include Golden Eagles, Olive-sided Flycatchers, Blackpoll Warblers, Great Horned Owls, Great Gray Owls, and Rusty Blackbirds. The rich aquatic habitats attract millions of waterbirds, including breeding species such as Lesser Scaup, Northern Pintail, Surf and Black Scoters, American Widgeon, and Red-throated Loon.

Southwest Alaska

The Southwest Alaska biogeographic region encompasses 63,863 square miles and includes the Alaska Peninsula and the Aleutian Islands, as well as the lowlands around Bristol Bay. These lowlands are primarily morainal (i.e., deposited by glaciers) and elevations range from sea level to 500 feet. The Alaska Peninsula separates the Gulf of Alaska from the Bering Sea, and its dominant feature is the Aleutian Range, the peninsula's volcanic spine, which reaches elevations of 8,580 feet above sea level. This area was historically covered by extensive glaciers, and because glaciers remain on some high peaks, many lakes and rivers contain suspended glacial flour. The lowlands of the peninsula contain many lakes and large river basins, which terminate in broad estuarine areas on the Bering Sea. Much of the shoreline of Bristol Bay and the Bering Sea is characterized by mixed sand and gravel beaches and exposed mudflats. The protected bays and lagoons often have eelgrass beds, which support the food base for many fish and waterfowl. Izembek Lagoon contains one of the largest eelgrass beds in the world. The rugged Gulf Coast has intertidal and subtidal algal forests, characterized by kelp attached to rocky substrates.

The Alaska Peninsula features some of the most scenic and least-explored landscapes in Alaska. Photo © Mark Emery.

Arcing 1,200 miles westward from the Alaska Peninsula to the island of Attu, the Aleutian Islands are a chain of volcanic islands that were formed by the Pacific plate being forced beneath the Bering Sea plate. Fog often shrouds the steep, rubble-covered peaks, which rise up to 6,000 feet above sea level. Icecaps or small glaciers occur on many of the volcanoes, and past glaciation is evident. The archipelago's location over an active seismic fault results in frequent volcanic and seismic activity. Forty of the 76 volcanoes in the chain have been active in the past 250 years.

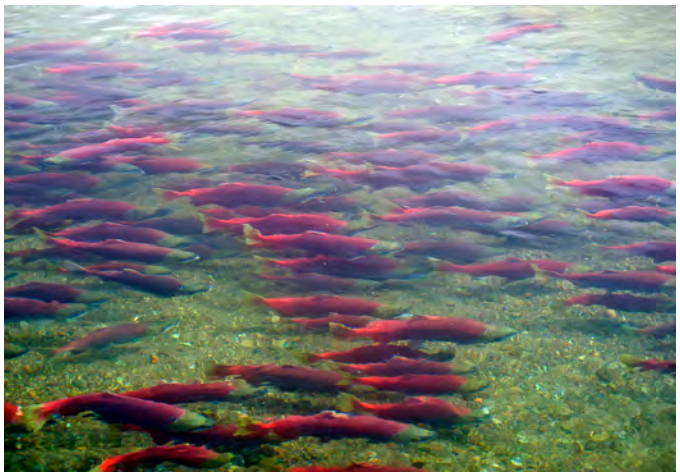
In the lowlands around Bristol Bay, the climate is transitional between maritime and continental. Average high temperatures in winter hover around freezing and average summer highs are 64°F. Precipitation ranges from about 13 to 32 inches. A maritime climate dominates the Alaska Peninsula and the Aleutian Islands, with average annual precipitation ranging from about 24 to 82 inches and average annual temperature ranging from about 34° to 39°F. Rain, fog, and persistent winds are common and sea ice does not form, except in a few protected bays and inlets.

Species of Conservation Need: Red-throated Loon, Gavia stellata

The Red-throated Loon is the smallest and slenderest of the loons. This arctic species has a broad circumpolar distribution, and occurs along the entire coastline of Alaska. It inhabits smaller and shallower lakes than other loons, and unlike other loons, can take off from the water without a running start. This is the only loon that regularly forages away from its nesting pond, flying to larger lakes or the sea not only to feed but also to carry a single fish back to its young. In winter, they can often be found foraging on submerged mudflats and are generally found in shallower, more protected water than other loons, usually within a mile of the coast. The population of Red-throated Loons in Alaska has declined 53% in the last 20 years, and populations are believed to be in decline across the species' range. Reasons for the decline are not known. Oil spills and habitat loss are major threats. Photo by Gregory Smith.

In the lowlands around Bristol Bay and the Alaska Peninsula, moist and wet tundra dominates the landscape. Low and dwarf shrub communities of willow, birch, and alder, as well as mosses and tussock-forming sedges, characterize these wetlands. Spruce and birch forests occur along major rivers and streams and sand dunes are present along bluffs on the coast and riverbanks. Most of the Alaska Peninsula and Aleutian Islands are treeless. Tundra vegetation predominates below the barren ice-covered peaks. The alpine tundra is a semiarid habitat that supports low shrubs, lichens, mosses, and grasses. Moist tussock tundra of mosses, lichens, and tufted hair grass occurs in mountain valleys and along plateaus. High brush communities of alder and willow dominate floodplains. The flora of the Aleutian Islands is a blend of species from the North American and Asian continents. The alpine tundra contains species not found to the north or in Central Alaska, including Alaska arnica, Siberian spring beauty, caltha-leaved avens, western buttercup, and Kamchatka rhododendron. Low shrub communities of willow, birch, and alder dominate mountain flanks and coastlines, interspersed with ericaceous- heath, *Dryas*-lichen, and grass communities. Uplands are characterized by peat and mats of heath tundra with sedges. Shallow marine waters contain eelgrass beds.

All 5 species of Pacific salmon spawn in this region, as do other anadromous species such as Dolly Varden. The Kvichak River may be one of the most productive sockeye systems in the world, and the Nushagak River supports the third-largest king salmon run in the world. Over the last 30 years, the annual harvest of salmon in Bristol Bay has exceeded 25 million fish, of which over 95% were sockeye salmon, making this the richest commercial fishery in Alaska. In 2015, a record return of nearly 54 million salmon is forecast. The streams and rivers of Bristol Bay also support populations of rainbow trout and Arctic grayling. The Aleutian Islands unit of the Alaska Maritime



These bright red sockeye salmon are spawning in a Bristol Bay stream. Photo © Mark Emery.

National Wildlife Refuge is thought to have more salmon spawning streams than any other refuge in the country, providing a rich food resource for birds, and terrestrial and marine mammals.

Common small mammals include arctic and red ground squirrels; collared and brown lemmings; singing, root, and meadow voles; collared pika; both Alaska and snowshoe hares; dusky and tundra shrews; and little brown bats.

Nushagak and Egegik Bays host large concentrations of shorebirds annually, including Dunlins, Rock Sandpipers, and Western Sandpipers. Up to one third of the global population of the *baueri* race of bar-tailed Godwits uses Egegik Lagoon in the fall. Lowlands around Bristol Bay may host roughly 10% of the breeding population of Red-throated Loons. Other coastal wetlands, lagoons, and bays in Southwest Alaska provide staging areas for large seasonal aggregations of waterfowl and shorebirds. Izembek and Moffet lagoons host concentrations of more than 500,000 shorebirds each spring, including Marbled Godwits and Rock Sandpipers, as well as nearly 100% of the global populations of Pacific Black Brant and Emperor Geese. Aleutian Terns, Red-faced Cormorants, Cassin's Auklets and Kittlitz's Murrelets breed here. The Alaska Peninsula and Aleutian Islands support endemic species of both birds and mammals. Landbirds, including Blackpoll Warblers and Rusty Blackbirds, breed in the forests. McKay's Buntings and Sanderlings overwinter in Southwest Alaska.

Southwest Alaska supports a diverse assemblage of marine species including beluga whale, gray whale, Northern sea otter, and Pacific walrus. Rookeries and haul outs for Steller sea lions are distributed primarily along the Gulf Coast. Sea otters have recolonized the lower half of the peninsula, but the population has decreased dramatically in recent years. Fin whales, humpback whales, and killer whales feed in the nearshore and offshore waters in the summer.

Surfbirds breed in rocky alpine tundra. In migration, and during winter, they are almost always within a few meters of the shoreline. Photo by Jacob Klinger.

Southcentral Alaska

The Southcentral Alaska biogeographic region encompasses 29,384 square miles and spans from Kodiak Island in the southwest to the Malaspina Forelands in the east. This region includes Cook Inlet and Prince William Sound, as well as the Kenai Peninsula and Chugach and St. Elias mountain ranges.

Elevation in Southcentral Alaska spans from sea level to 14,750 feet. Gently sloping lowlands were extensively glaciated during the Pleistocene epoch. Hundreds of small lakes, swamps, and bogs occur on ground moraines. Several large rivers, including the Susitna, Kenai, and Copper rivers, drain from surrounding mountains. The Copper River Delta constitutes the largest contiguous wetland on the Pacific Coast of North America at 700,000 acres. The rugged, ice-covered Chugach and St. Elias mountains serve as the backdrop for these lowlands, forming a crescent behind the Gulf of Alaska coastline and reaching from the southern tip of the Kenai Peninsula around to the Fairweather Range in Southeast Alaska. These rugged mountains contain the largest area of ice fields and glaciers outside of the polar region. Fjords and archipelagos are common and small lakes occur high in glacier-carved valleys.

Glacial outburst floods, land subsidence, isostatic rebound, and localized high-wind events continue to dominate and influence landscape patterns.

The marine environments in Southcentral Alaska vary from exposed coastlines to sandy barrier islands to deep fjords. In Prince William Sound, water depths reach > 2,500 feet and icebergs float at the base of tidewater glaciers. Tides here are large, and a large amount of freshwater flows into the ocean from the land. During the summer, meltwater from the snow and ice flows along the base of the glaciers and eventually forms swift, short streams in valleys or inundates coastal flats. Nutrient and mineral contributions from ice-melt into glacial fjords make them some of the most productive marine habitats in the world.

The climate in Southcentral Alaska is a mix of continental and maritime. Within the continental climate areas, which are found primarily in the mountain ranges, temperatures range from a winter average minimum of 5°F to a summer average maximum of 64°F. Annual precipitation is about 12 to 160 inches. In contrast, the maritime climates exhibit little seasonal temperature variation, with an average annual temperature range of about 30° to 42°F. Clouds and fog are common, and precipitation is heavy, ranging from 50 to 160 inches annually.

In the western part of Southcentral Alaska, Sitka spruce and black cottonwood have only recently established on the islands; the dominant vegetation consists of willow and alder thickets or wet and moist sedge meadows. Barrens or alpine tundra exist in the higher elevations. From Afognak Island moving eastward, spruce and hardwood forests dominate the landscape, but the varying climatic influences, sporadic permafrost, and rolling topography support diverse vegetation. Lowlands with wet, organic soils support black spruce stands, and ericaceous shrubs are dominant in open bogs. Tall shrub communities, wet graminoid (grass) communities, and wet forb (broad-leaved plant) communities also occur. Uplands have mixed forests of white and Sitka spruce, aspen and birch. Tall shrub communities, dominated by willow and alder, occur in floodplains. Moving farther east, along the shoreline and on mountain slopes, a lush temperate rain forest dominated by western hemlock and Sitka spruce grows. Cottonwood and alder stands occur along river valleys. At the highest elevations, thin and rocky soils support alpine tundra composed of sedges, grasses, and low shrubs.

Prince William Sound in Southcentral Alaska, as seen from Portage Pass near Whittier. Photo by Frank Kovalchek.

Fall colors near Eagle Lake trailhead, Southcentral Alaska. Photo by Len Turner.

The diverse habitats and milder climate present in Southcentral Alaska result in a great diversity of species ranging from amphibians to marine mammals. This region is the northernmost range of the western toad. Small mammals include northern flying squirrel, arctic ground squirrel and red squirrel; singing, root, and tundra meadow voles; the collared pika and snowshoe hare; and common, dusky and tundra shrews. The endangered Cook Inlet beluga whale population lives entirely within the region, and is fully isolated from other beluga whale populations. Northern sea otters, Steller sea lions, and humpback whales occur in high numbers.

Numerous lakes, ponds, and wetlands attract large numbers of shorebirds and waterfowl. As stated previously, one of the most important shorebird stopover sites in North America is the Copper River Delta. Along with nearby Controller Bay (Bering River Delta), the area supports the largest spring concentration of shorebirds in the Western Hemisphere (Bishop et al. 2000). Thirty-six species of migrating shorebirds have been counted in the Copper River Delta alone, with the 2 most abundant species being Dunlin and Western Sandpiper. Significant numbers of Western Sandpipers, Dunlins, Rock Sandpipers, Short-billed Dowitchers, and Hudsonian Godwits also use Cook Inlet for breeding, resting, or wintering. Other waterfowl and shorebird species of importance in the region include the entire breeding population of Dusky Canada Geese and sizable populations of Aleutian Terns, Red-throated Loons, and Black Oystercatchers. This area supports a large concentration of Surfbirds each spring and high nesting concentrations of Bald Eagles and Marbled Murrelets occur here. Cassin's Auklets and

Species of Conservation Need: Dolly Varden, Salvelinus malma

Dolly Varden char are abundant in many rivers in Alaska, from Southeast to the North Slope. These fish are important ecologically both as predators and as prey, and as important subsistence food for Alaskans. Dolly Varden spawn and overwinter in fresh water. At age 3, juveniles migrate to marine waters to feed, and then return each year to fresh water to overwinter. Fish normally spawn at age 7, and may spawn 2 or 3 times before dying. These fish also exist as dwarf resident forms that do not migrate to the ocean, and reach maturity at less than 6 inches. These dwarf populations are often isolated high in the headwaters of drainages. In much of their northern distribution, limited spawning and overwintering habitat makes these populations especially vulnerable to decreases in water flows and increases in water temperatures caused by climate change. Photo by Fred DeCicco.

other seabirds nest in cliff colonies along the rocky shorelines and Kittlitz's Murrelets are also common breeders. Yellow-billed Loons and many species of sea ducks winter along the coast in Prince William Sound. Sensitive landbirds in the region include Olive-sided Flycatchers and Blackpoll Warblers.

The Matanuska and Susitna drainages are home to all 5 species of Pacific salmon, rainbow trout, Dolly Varden char, Arctic grayling, and whitefish. The Kenai River has a unique run of the world's largest Chinook salmon. Dolly Varden, rockfish, halibut, and lingcod all occur throughout Prince William Sound. Alaska blackfish are known to occur in the Tsiu River, far south of the main portion of their normal range.

Southeast Alaska

The Southeast Alaska biogeographic region encompasses 33,634 square miles and includes the entire Alaska Panhandle. It spans from Glacier Bay National Park in the north to the southern tip of Prince of Wales Island in the south and includes the Alexander Archipelago as well the North Coast Mountain range. Other major islands besides Prince of Wales Island include Admiralty, Baranof, Chichagof, Kuiu, and Kupreanof. The region's islands are interlaced with coastal inland waters including Icy Strait, Lynn Canal, Stephens Passage, Chatham and Clarence straits, and Frederick Sound.

Southeast Alaska is an archipelago of forested islands. NOAA photo, ShoreZone program.

The Coast Mountains straddle the border between Alaska and

British Columbia, with elevations ranging from sea level to 9,840 feet. During the Pleistocene, massive ice sheets covered these mountains. Today heavy winter snows still feed ice fields and glaciers in this ecoregion, but steep, rugged peaks are exposed and retreating glaciers have left U-shaped valleys. During the summer, melting ice feeds swift streams and rivers to the coast. Several interior rivers pass through these mountains—including the Taku, Stikine, Unuk, and Whiting. This area includes the southernmost extent of tidewater glaciers (LeConte Glacier, near Wrangell) on the North American continent.

The Alexander Archipelago consists of thousands of Islands, including Prince of Wales, the third largest island in the U.S. Past glaciers carved deep, U-shaped valleys, which filled with seawater when the glaciers retreated. Elevations in the archipelago range from sea level to over 3,280 feet (1,000 meters). Rolling moraine landforms dominate the hills and valley bottoms. Tectonic movement and the forces of rebound after glacier retreat have raised and lowered marine terraces, forming rich coastal lowlands and estuaries. Glacial inputs of nutrients and minerals strongly influence the nearshore marine environment, particularly where glaciers flow into bays and fjords. Limestone underlies parts of the ecoregion, and karst topography of sinkholes, caves, underground streams, and fractured bedrock fosters high levels of endemism in plants. With many narrow passages for tidewaters to transit, tidal range and currents can be extreme.

The primarily maritime climate results in large amounts of precipitation and surprisingly warm temperatures, given the extent of ice present. The average annual temperature ranges from about 33° to 46°F, though frost is possible at any time of year. Precipitation averages about 30–220 inches per year. The northern part of the ecoregion experiences the drier and colder weather.

The temperate rain forest, consisting primarily of western hemlock and Sitka spruce, reaches from the shoreline to 1,200 feet elevation on mountain slopes. Salal and western red cedar are also found in the southern parts of the archipelago. Mixed conifer, black cottonwood, and lodgepole pine occur on drier sites. Where bedrock is not exposed, the forest gradually transitions elevationally to shrublands and alpine tundra. Water-tolerant plants such as sphagnum moss, sedges, and shore pine occur in peat lands. Poorly drained soils support open muskeg and forested wetlands.

The large Hubbard Glacier flows down from the Coast Range, entering the sea in Disenchantment Bay. Photo by Anonymous.

The coastal streams, headwater lakes, and rivers support large runs of all 5 Pacific salmon species, which transport important, marine-derived nutrients back to the freshwater and terrestrial ecosystems and draw Bald Eagles and other scavengers. Other resident and anadromous fish species in these watersheds include Dolly Varden, steelhead, and cutthroat trout. Large spawning concentrations of eulachon occur during spring near the mouths of some rivers, attracting large concentrations of Bald Eagles and Steller sea lions. In fact, Southeast Alaska holds the highest nest density of Bald Eagles in the world. Other birds of interest in this region include Red-breasted Sapsuckers, Varied Thrush, Rufous Hummingbirds, Black Oystercatchers, Marbled Murrelets, Kittlitz's Murrelets, Western Screech-Owls, and Northern Goshawks (inclusive of its subspecies, the Queen Charlotte Goshawk). Southeast Alaska supports the largest breeding Marbled Murrelet population in the world and Glacier Bay, in northern Southeast Alaska, holds the largest known breeding population of Kittlitz's Murrelets.

The natural fragmentation of the archipelago has influenced species distribution and promoted high level of endemism for Alaska. Wolves occur throughout the region, except on Admiralty, Baranof, and Chichagof islands. Wolves in Southeast Alaska belong to the subspecies *C. l. ligoni* (Alexander Archipelago wolf), and are smaller and darker than wolves elsewhere in Alaska and Canada. As a result of Southeast Alaska's unique island biogeography and variable glaciation through time, populations of many endemic birds, invertebrates, and mammals occur here. This ecoregion is also rich in species compared to more northerly regions of the state. Here there are amphibians, including rough-skinned newts, northwestern salamanders, long-toed salamanders, wood frogs, spotted frogs, western toads and 6 species of bat. The region contains 13 taxa found in no other region of the state, including 5 bats, southern red-backed vole, meadow jumping mouse, root and meadow voles, northwestern deermouse, and the Glacier Bay water shrew.

A Steller sea lion on Biali Rocks, south of Sitka, with an embedded ring (material unknown) around its neck. ADF&G photo, research activities were conducted pursuant to a NMFS permit.

Marine mammal life is abundant in Southeast Alaska and includes many species, such as northern sea otter, humpback whale, and Steller sea lion. The Forrester Island complex supports the largest Steller sea lion rookery in Alaska.

Arctic Ocean

The Arctic Ocean biogeographic region encompasses about 415,000 square miles and includes all marine waters, coastline, and ocean floor between Cape Prince of Wales and Demarcation Point, including the Chukchi Sea, Kotzebue Sound, and the western portion of the Beaufort Sea. The Alaska tidal coastline of the Arctic Ocean is approximately

4,500 miles long, and consists primarily of low topographic features and shallow coastal waters. Much of the northern coastline is characterized by shallow, barrier islands which form productive lagoons and estuaries. In the Beaufort Sea, the continental shelf is relatively narrow, extending between 30 and 60 miles offshore, whereas the Chukchi Sea is shallow throughout, with depths less than 200 feet.

Pomarine Jaeger at Barrow, Alaska. Photo by Andrei Taranchenko.

Most of the Arctic Ocean is ice-covered for much of the year, and productivity is relatively low overall. Air temperatures are generally low, even during the ice-free season, averaging -4°F during January and 32°F during July. Annual precipitation is very low, averaging less than 10 inches per year, most of which falls as snow. Surface water temperatures range from 28°F in winter to over 50°F in midsummer.

The Chukchi Sea is more productive than the Beaufort due to mixing with nutrient-rich North Pacific waters that flow through the Bering Strait. The Chukchi Sea receives warmer, low salinity water flowing from the Yukon River up through the Bering Strait; circulation is primarily wind driven from south to north during the 3–4 months of the ice-free season. Water circulation in the Beaufort Sea is generally westerly, however, with a subsurface undercurrent flowing to the east. Spring sea ice melt creates a productive nearshore corridor used by marine and anadromous fish, and shorebirds and other waterfowl. Most marine mammals in the Beaufort Sea generally remain with the sea ice as it retreats northward. Kotzebue Sound is a large, shallow, productive bay fed by nutrient rich waters of the Kobuk and Noatak rivers, and serves as the overwintering area for a large population of sheefish.

The Arctic Ocean region supports populations of a number of marine mammals, including Pacific walrus; bowhead, beluga, killer, and gray whales; bearded, ringed, ribbon, and spotted seals; and polar bears. The Arctic Ocean is a summer home to many seabird species, including Pacific, Red-throated, and Yellow-billed loons, auklets, Northern Fulmar, Black Guillemot, Thick-billed and Common murres, Tufted Puffin and Horned Puffin, Black-legged Kittiwake, Ross's and Glaucous gulls, jaegers, Arctic Tern, and Red-necked and Red Phalaropes. Characteristic marine species include snow crab, Pacific blue mussel, squid, sea cucumber, sea stars, salmon (king, chum, and pink), pond and rainbow smelt, capelin, Pacific sand lance, Pacific herring, Arctic and saffron cod, stickleback, cisco (broad, Arctic and Bering), Dolly Varden char, and Arctic lamprey.

Bering Sea/Aleutian Islands

The Bering Sea/Aleutian Islands biogeographic region encompasses approximately 770,000 square miles and includes all marine waters and ocean floor (i.e., U.S. territorial waters) south of Cape Prince of Wales and north of the Alaska Peninsula and including both sides of the Aleutian Islands from Unimak Pass west. Approximately 44% is continental shelf, 13% is a continental slope, and 43% is in a deep-water basin. In the area of the Aleutian Islands, the shelf is very narrow and most of the area is deep-water basin. The Aleutian Basin contains a number of deep water marine canyons, ocean-floor ridges, and seamounts. The broad continental shelf of the Bering Sea is highly productive, and there are also extremely productive regions near the slopes of some major ridges, oceanic canyons, and seamounts. Productivity is strongly related to the Alaska Stream and Alaska Coastal Current, fed in part by the Kuskokwim and Yukon rivers, and by upwelling from the Bering Sea Gyre.

The region includes Norton Sound, Kuskokwim Bay, and Bristol Bay, as well as St. Lawrence and St. Matthew islands, and waters north of the Aleutian Islands. The Alaska tidal coastline of the Bering Sea/Aleutian Islands biogeographic region is approximately 7,000 miles long, most of which is within National Conservation Units, including the Yukon Delta National Wildlife Refuge, Togiak National Wildlife Refuge, and Izembek National Wildlife Refuge.

Weather and climate are highly variable in the region, due in part to the span of latitude between the southern and northern ends of the region. Surface water temperatures range between about 28° and 46°F, with much of the northern part of Bering Sea ice-covered for most of the year. The annual formation and subsequent melt of sea ice strongly influences salinity and water temperature. The region is generally characterized by strong winds and periodic severe storms, particularly from November through April.

The region is home to about 300 species of fish, including many that are commercially and ecologically important, as well as hundreds of species of crustacean and mollusk, some 50 species of seabirds, and 26 species of marine mammal. Marine mammals found in the region include Pacific walrus; Steller's sea lion; bowhead, sei, fin, gray, right, humpback, beluga, and killer whales; 6 species of seal; harbor porpoise; Northern sea otters; and polar bear. Many seabirds feed in these waters during nesting season, including Red-throated, Yellow-billed, and Pacific loons; Laysan, Black-footed, and Short-tailed albatrosses; Fork-tailed Storm-petrel; cormorants; auklets; murrelets; guillemots; murres; puffins; kittiwakes; Mew, Glaucous-winged, and Glaucous gulls; jaegers; and Arctic and Aleutian terns. The world's population of Spectacled Eiders winters in the sea ice south of St. Lawrence Island. Aquatic SGCN in the region include 8 species of crab, scallop, abalone, mussel, clam, shrimp, 5 species of pacific salmon, steelhead, salmon shark, sablefish, halibut, flounder, smelt, capelin, eulachon, cod, stickleback, rockfish, whitefish, sheefish, and Dolly Varden.

Gulf of Alaska

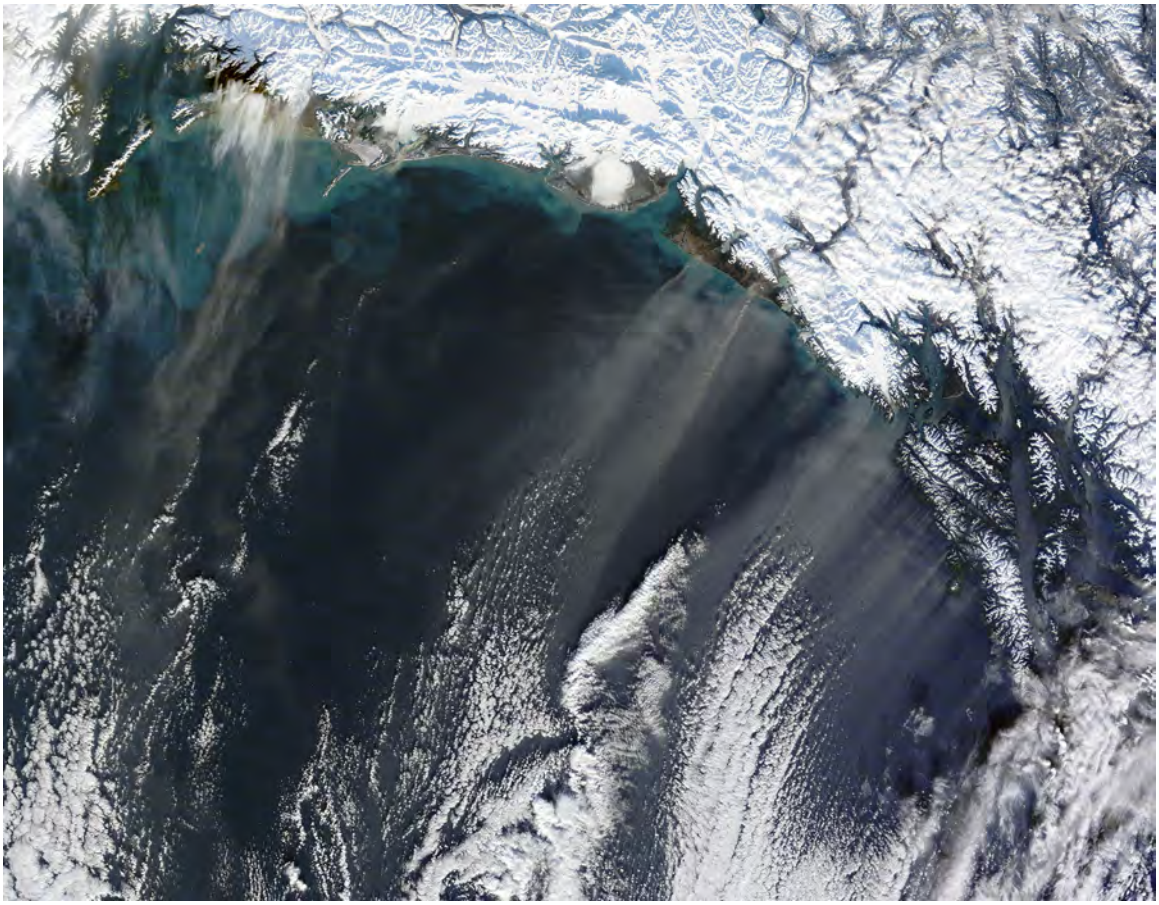
The Gulf of Alaska biogeographic region is a relatively open marine system encompassing approximately 592,000 square miles (within U.S. Territorial waters) and includes all shoreline, marine waters, and ocean floor to the south between the Canadian border at Cape Muzon on Dall Island in the east to Unimak Pass to the west. The area includes the marine waters of the Alexander Archipelago, Prince William Sound, Cook Inlet, Kodiak Island, and the southern shoreline of the Alaska Peninsula.

The coastline of the region is approximately 24,700 miles long, and includes many glacially-carved fjords and estuaries. Much of adjoining lands lie within National Conservation Units, including the Alaska Peninsula National Wildlife Refuge, Kodiak National Wildlife Refuge, Katmai National Park and Preserve,

Lake Clark National Park and Preserve, Kenai National Wildlife Refuge, Kenai Fjords National Park, the Chugach National Forest, Wrangell-St. Elias National Park and Preserve, Glacier Bay National Park and Preserve, and the Tongass National Forest.

The Gulf of Alaska region consists primarily of deep ocean basins, with a narrow continental shelf that makes up only 10% of the total area (approximately 62,000 square miles). The region is strongly influenced by the Alaska Current which is part of a huge counter-clockwise gyre in the Gulf of Alaska. Almost all of the area is ice-free year-round, and nearshore surface water temperatures range between 32° and 57°F. Offshore surface temperatures tend to be slightly warmer, ranging from 39° to 57 ˚F. Weather is wind-dominated, and the region is well known for generating significant storm events, driving precipitation patterns for much of Alaska, the west coast of Canada and the Lower 48.

The region contains populations of hundreds of fish species, marine invertebrates, marine mammals, and many species of seabirds. Mammal SGCN that are commonly found in the region include Steller sea lion; sei, fin, gray, right, humpback, beluga, and killer whales; northern fur and Pacific harbor seals; harbor porpoise; and northern sea otter. Seabirds in the region include loons, albatrosses, Fork-tailed Storm-petrel, cormorants, auklets, murrelets, Pigeon Guillemot, Thick-billed and Common murres, Tufted and Horned puffins, kittiwakes, gulls, jaegers, and Arctic and Aleutian terns. The region is also used as a fall migratory corridor for passerines. The Gulf waters are home to many invertebrate and fish species, including 8 species of crab, scallops, abalone, mussels, clams, 6 species of shrimp, all 5 species of Pacific salmon, salmon shark, sablefish, halibut, flounder, smelt, capelin, eulachon, cod, stickleback, and many species of rockfish.



Strong offshore winds carry sand and dust from beaches out across the Gulf of Alaska. Photo by Jeff Schmaltz, NASA.

Abundance of SGCN

Given the large size and remoteness of Alaska, abundance estimates for most nonexploited species are not available. It is safe to assume that some species, such as forage fish, pollock, and many marine and freshwater invertebrates are very abundant, numbering in the tens to hundreds of millions. Species such as salmon, crab, and many small mammals are also abundant, numbering in the millions to tens of millions.

In cases where populations are suspected to be small, more work has been conducted to arrive at credible population estimates. Where species have been proposed for ESA listing or are already listed, relatively good population estimates are available—some with confidence intervals to show precision. All available Alaska population estimates for SGCN are given in Appendix C.

Key Habitats of Wildlife in Alaska

An arctic ground squirrel surveys its habitat. Photo by Tim Rains, NPS.

This chapter identifies the key habitats used by species of greatest conservation need (SGCN) in Alaska. It includes the following categories (and habitat types):

- Forest (interior and coastal).
- Shrub (tall and low).
- Tundra (arctic, alpine, and maritime).
- Wetlands (grass, sedge, bog, and marsh).
- Freshwater (lakes, rivers and streams).
- Marine (nearshore, shelf, oceanic, beaches and sea cliffs).
- Ice (shorefast and pack).
- Other (rocks-caves, disturbed-sparse, and artificial structures).

As with any habitat classification, habitat types are rarely separated by bright lines. For example, the boreal forest and temperate rain forest types have finer scale inclusions of grass, sedge, marsh, bog, river, lake, and stream habitats. A fish that lives in a coastal rain forest stream is assigned to the stream habitat only. A toad that inhabits a bog, and lays eggs in a pond (both in the coastal rain forest) is

assigned to the two finer habitat types—not the forest. Assignments to the larger-scale forest habitats are reserved for species that depend on the trees themselves for roosting, perching, nesting, or foraging (e.g., Bald Eagle, Brown Creeper, and Keen's Myotis). The assignments of key habitat for all SGCN are found in Appendix D. For mammals, the primary reference was MacDonald and Cook (2009). For birds, the primary reference was Armstrong (2015). Species experts reviewed Appendix D and recommended corrections or refinements.

What follows are general descriptions of each of the major habitats in Alaska, with specific consideration of their ecological role, their conservation status in the state, and some of the key SGCN associated with them.

Forest

There are approximately 120 million acres of forestland (land with >10% tree cover) in Alaska (Hutchison 1967). That area can be further classified depending on where it occurs in the state. The vast majority of forestland, about 107 million acres, occurs in Interior Alaska and is classified as "boreal forest." It overlaps closely with the central bioregion.

About 13 million acres of forest occurs along Alaska's southern coast, including the Kodiak Archipelago, Prince William Sound, and the islands and mainland of Southeast Alaska. This is classified as coastal temperate rain forest, and it overlaps closely with the southeast and southcentral bioregions. Although only 10% of the forested area of the state is coastal temperate rain forest, the majority of economic value from wood products is in this fraction.

Boreal Forest

The boreal zone is a broad circumpolar belt that spans up to 10 degrees of latitude in North America. The boreal forest of North America stretches southward from Alaska to the Rocky Mountains and eastward to the Atlantic Ocean. It occupies approximately 28% of the continental land area north of Mexico and more than 60% of the total area of the forests of Canada and Alaska (Johnson et al. 1995). Across its range, coniferous trees make up the primary component of the boreal forest. Dominant tree species vary regionally depending on local soil conditions and variations in microclimate. Broadleaved trees occur in pure stands or mixed with conifers. In Alaska, the boreal biome stretches from the Kenai Peninsula to the south slope of the Brooks Range (Viereck and Little 1972). A transition zone exists south of the Alaska Range in the region surrounding Cook Inlet and stretching northward into the Susitna River Valley.

Needleleaf, broadleaf, and mixed forest communities occur across a variety of sites in the boreal zone. Coniferous forests in the boreal ecoregion are dominated by spruce and occur over a variety of site conditions. White spruce occurs on warm, south-facing slopes on well-drained sites along rivers and hillsides where permafrost is absent, and at timberline where drainage is good. Dominant understory components in white spruce stands include shrubs such as resin birch, prickly rose, alder, willow, buffaloberry, highbush cranberry, and bearberry. Herbs such as twinflower; feather mosses, club lichens, and leaf lichens are widespread throughout the boreal forest.

Black spruce forests are found on floodplain terraces and flat to rolling uplands on well-drained to poorly drained soils. Tamarack may be associated with black spruce in wet bottomland areas. Low shrubs typically associated with black spruce include Labrador-tea, prickly rose, blueberry, and resin birch. The ground is usually covered with a continuous layer of mosses and lichens.

Deciduous forests of balsam poplar, cottonwood, or a mix of the two develop on floodplains of meandering rivers. These forest types often follow the establishment of alder and willow thickets and may be subsequently replaced by stands of white spruce. Understory shrubs associated with broadleaf forests include alder, willow, and prickly rose. Mixed forests are dominated by different combinations of spruce, birch, and aspen. Understory species include alder, bluejoint grass, bearberry, and Labrador-tea.

Interior bottomlands associated with the larger rivers in Central Alaska are typified by poorly drained, shallow soils, often over permafrost. Bottomland coniferous forests are dominated by white spruce, black spruce, or a combination of the two. Closed stands of white spruce occupy terrace locations with well-drained soils. Understory vegetation consists primarily of low and dwarf shrub, such as blueberry and dwarf birch, often accompanied by twinflower and horsetail. A well-developed layer of feathermoss is also common. Closed stands of black spruce occur on floodplains and are often associated with white spruce and paper birch on well-drained sites. On these sites, the tall shrub understory is a more important component of the habitat. Ericaceous shrubs commonly occur with sedges, bluejoint grass, mosses, and lichen.

Bottomland deciduous forests consist primarily of closed stands dominated by balsam poplar or quaking aspen with an understory of alder, willow, prickly rose, highbush cranberry, buffaloberry, and red-osier dogwood. An herbaceous layer consisting of northern bedstraw, dwarf dogwood, horsetail, and bluebell is typical. Mixed forests are predominantly made up of paper birch with spruce cohorts or white spruce with balsam poplar. Understory species are generally the same as those found with deciduous trees or in white spruce-dominated stands.

Ecological Role of Boreal Forest Habitats—The boreal forest region is a large and diverse patchwork of distinctive ecosystems and flora in which complex interrelationships between climate, solar radiation, surface water, slope, aspect, soil characteristics, permafrost, and disturbance regimes create patterns of vegetation across the landscape. As a result, the boreal forest includes a range of habitat types that vary from closed forest to open shrub and herbaceous communities that inhabit both uplands and wetlands.

Birds represent the largest class of vertebrates in the boreal forest. More than 80% of all terrestrial vertebrates associated with the western boreal region of Canada are birds (Niemi et al. 1998). Of the various species that rely on the boreal forest, approximately 20% are permanent residents; the others are migrants that spend the summer breeding season in the boreal forest (Smith 1993). During summer, most forest birds eat insects, particularly moth larvae. Research indicates that birds can reduce insect densities (Atlegrim 1989), especially when the insect populations are at low or levels (Torgerson et al. 1990).

For birds in the boreal region, there appears to be a close relationship between habitat diversity and species diversity (Kessel 1998). Kessel (1998) hypothesized the high occupancy and species richness found in deciduous forests was due to the high productivity of the floodplain ecosystems where these forests were found, along with the structural diversity within the forest that created many habitat niches. While boreal spruce forests tend to have lower bird densities and species richness than deciduous forests, they provide more stable habitat for resident species, such as the Boreal Chickadee. The greatest densities of permanent residents occur in boreal forests dominated by white spruce.

Many forest bird species, such as flycatchers, thrushes, and wood-warblers, use boreal forests for breeding and rearing young, but winter as far away as Central or South America. Many of the long-

distance migrants are particularly sensitive to fragmentation of breeding habitat (Smith 1993). Alaska's boreal forest is an important part of the breeding range of several species of boreal forest landbirds known to be declining in other portions of their North American range, including the Rusty Blackbird, the Boreal Chickadee, and the Olive-sided Flycatcher.

Boreal Forest Conservation Status—Approximately 37% of the total area in Alaska's boreal forest region lies within state or federal conservation units, including federal and state wildlife refuges, parks, national monuments, and other designations. These areas were designated by the state and federal governments to preserve unique or fragile ecosystems and historic sites and to protect essential fish and wildlife habitat. The remaining lands consist of other state lands, municipal or borough lands, Native allotment and corporation lands, and other private holdings.

Management goals and objectives for the conservation units reflect the importance of each area with regard to conserving essential fish and wildlife habitats, and as such, there are usually some restrictions on development within these areas. Generally, the laws and regulations, management plans, goals, and objectives written to guide the management of these areas recognize their importance as essential fish and wildlife habitat, and to protect important cultural and historic sites. As a result, development activities on some lands are often restricted or controlled to prevent changing the natural character of the lands and waters.

Overall, Alaska's boreal forest habitat is healthy. However, ongoing development (urbanization, agriculture, logging for lumber and wood energy) will likely have increasing impacts in this habitat type. Adverse impacts can be partially mitigated by maintaining corridors of forest habitat along streams and by identifying and conserving the most valuable forest areas for wildlife.

Wildfire plays a greater role than logging in shaping the extent and character of boreal forest habitat. Wildfires are expected to become even larger and more frequent as the climate continues to warm. ADF&G is currently working with Alaska Department of Natural Resources, Division of Forestry, to study ways in which logging might mimic large-scale natural disturbance of fire (Hunter 1993). For example, within a harvested area, retaining uncut islands of late-seral forest habitat could emulate the patchy burn patterns of typical wildfires, and be beneficial for wildlife species that prefer early successional habitats.

Coastal Temperate Forest

Coastal temperate rain forests are rare globally. They occur in only 7 places in the world, at higher latitudes where mountains meet the ocean. These areas have a maritime climate, with cool summers, warm winters, and abundant precipitation distributed throughout the year. Individual trees can live to be many centuries old, with trees of all ages interspersed in the stand. Essential features of "old growth" include a multilayered canopy, the presence of large, old trees, a well-developed understory, and dead and down trees on the forest floor.

The vast majority of Alaska's coastal temperate rain forests are in an old-growth condition. When old-growth forests are felled, either by clearcutting or by catastrophic winds, secondary succession begins, and a young, even-aged forest develops. These young forests are characterized by uniform trees with ages less than 150 years old, a single-layered canopy, and a sparse understory. It takes 200–300 years for young-growth stands to develop the compositional and structural characteristics of old growth.

Major habitat types in the coastal temperate rain forest are defined in terms of their relative mix of overstory tree species. The species mix, in turn, is a function of soil type and drainage, elevation, and latitude. For the coastal temperate rain forests of Alaska, the major forest types include western hemlock (46%), mixed hemlock/spruce (26%), Sitka spruce (17%), cedar (5%), and hardwood/deciduous (4%) (Hutchison 1967).

Western hemlock is ubiquitous throughout the Alexander Archipelago and predominates on well-drained, organic soils. There, individual trees may be more than 6 feet in diameter and over 500 years old. At higher elevations, or higher latitudes, western hemlock is replaced by the closely related mountain hemlock.

Sitka spruce occurs throughout the coastal temperate rain forest. On Kodiak and Afognak islands, the forests are nearly pure Sitka spruce stands. In Southeast Alaska, Sitka spruce trees occur most often in mixed stands with hemlock and cedar, but also occur in pure stands on some active alluvial and colluvial soils, including riparian areas, avalanche slopes, and uplifted beach zones. Sitka spruce are less shade tolerant than other species, and they disproportionately colonize new openings following wind-throw or clearcutting.

Western red cedar and Alaska yellow cedar represent a small but important component of the coastal temperate rain forest in Southeast Alaska. Yellow cedar occurs throughout the Alexander Archipelago and

The coastal temperate rain forest experiences almost no fire, and so trees live to very old age. Wind is the primary disturbance agent. Dominant trees are 200–900 years old. Photo by N. Bonzey.

Prince William Sound. Western red cedar is restricted to the southern half of the Alexander Archipelago. Both species are most abundant on poorly drained, acidic soils, where they are able to out-compete hemlock and spruce.

Ecological Role of Coastal Temperate Rain Forest Habitats—The absence of a dry season makes wildfire extremely rare, so individual trees can live to very old age. The primary agent of disturbance in this forest is wind, which typically topples 1–3 trees at a time, creating a constantly shifting fine-grained mosaic of small openings within the forest (Ott 1997). Over time, this gap-phase dynamic produces a forest with trees of many ages, a multilayered canopy, a diverse, abundant understory, and dead trees either standing (snags) or lying on the ground in various stages of decay (Capp et al. 1992). The variety of structural and compositional features makes old growth valuable as habitat for many wildlife species.

Old-growth forest provides habitat for many animals, including at least 53 species of mammals, 231 species of birds, and 5 species of amphibians and reptiles (MacDonald and Cook 1996). Because the coastal rain forest in southeast Alaska overlays an archipelago with hundreds of islands, endemism is high. Within Southeastern Alaska (Southeast), almost 20% of known mammal taxa (species and

The Chestnut-backed Chickadee is a denizen of the coastal rain forest. Photo by Andy Reago and Chrissy McClarren.

subspecies) have been described as endemic to the region (MacDonald and Cook 1996). Examples include the Prince of Wales flying squirrel, the Prince of Wales Spruce Grouse, and 5 subspecies of dusky shrew. Other species have evolved unique natural histories linked to old growth, such as the Marbled Murrelet, which is one of the few seabirds in the world to nest in trees. Because it prefers to nest in larger old-growth trees with moss platforms on wide limbs, the Marbled Murrelet is a sentinel species for the condition of old-growth forests in the region.

Bats in Alaska achieve their highest species diversity in the coastal rain forests of Southeast Alaska where they are resident year-round. The Keen's myotis is a coastal rain forest specialist that gleans insects within the forest; other bat species forage primarily over or near freshwater features that are under or adjacent to the protective cover of the forest canopy. Three species of bats have been documented roosting in trees in Southeast Alaska and the remaining species undoubtedly also use trees as day roosts. A radio telemetry study on Prince of Wales Island found that maternity colonies of Keen's myotis were located in relatively large-diameter cedar trees in areas with a higher proportion of old growth (Boland et al. 2009). The little brown myotis relies on forest features year-round, hibernating in rock scree on steep, forested hillsides, or under root wads of trees or stumps at lower elevations.

Other old-growth associated birds, including woodpeckers and owls, depend on large-diameter snags for excavating cavities for nesting and roosting, or in the case of the Rufous Hummingbird and American Dipper, build their nests from the mosses and lichens they find in old-growth forests. Other species depend on coastal forests because their primary food lives in the forest. Examples include the Northern Goshawk, which hunts beneath the overstory and captures a variety of old-growth associated birds and small mammals, or the Brown Creeper, which forages in the bark crevices of larger, old-growth trees.

Still other animals are dependent on the perpetually moist, humid environment of the rain forest, including species like the rough-skinned newt, the wood frog, and the long-toed salamander. The coastal, old-growth rain forest is an extraordinarily complex, stable habitat type. Over thousands of years, many wildlife species have evolved in special ways to exploit this forest for food, shelter, and security. The ecological web of interactions in the coastal rain forest is rich, and understanding of its complexities is only now starting to emerge through ongoing scientific study.

Coastal Temperate Rain Forest Conservation Status—Alaska contains the largest expanses of intact old-growth forest left in the world. About 3,000 square miles of this habitat (about 11%) has been logged (DellaSala 2011).

Some of the more intensively logged areas in Southeast Alaska include the northern half of Prince of Wales Island, northern Kuiu Island, Northeast Chichagof Island, North Baranof Island, Zarembo Island, Mitkof Island, Heceta Island, Tuxekan Island, and Long Island. Heavily logged areas overlap to a high degree with underlying calcium carbonate soils, or karst, which allows for good drainage and more productive tree growing conditions. There has been less logging in Southcentral Alaska, primarily because tree size and growth rates diminish with increasing latitude (Farr and Harris 1979).

More than 95% of the coastal temperate rain forest in Alaska lies within the Tongass and Chugach national forests—2 of the largest national forests in the U.S. These lands are managed for multiple uses, ranging from wilderness to intensive development. The allocation of federal and state lands to conservation or development status is governed by comprehensive land use plans, which are developed through a public process, and revised every 10–15 years.

Large Sitka spruce trees like these are rare in the old-growth forest of Southeast Alaska. Such stands have been disproportionately impacted by clearcutting. Photo by John W. Schoen.

Although a relatively small percentage of the forest area has been logged, much of the logging to date has been concentrated in the most productive stands with the largest trees. Not only are "big-tree" forests unique structurally and functionally (Kirchhoff and Schoen 1987), but they tend to occur in certain landscape positions that make them especially valuable to particular wildlife species. The disproportionate harvest of relatively rare, "big-tree" stands has been a primary conservation concern in Southeast Alaska for decades (Kiester and Eckhardt 1994; Albert and Schoen 2013). Maintaining sustainable and well-distributed populations of all fish and wildlife species should focus on preserving the natural diversity of forest conditions (species, structure, and landscape position) within this biome.

Shrub

Most shrub habitats in Alaska are interspersed within the mix of forest and tundra habitat types. This plan describes 2 types of shrub habitat: tall and low (e.g., dwarf). Ecological roles and conservation status of these habitats can be found in the respective Forest and Tundra Habitat sections of this chapter.

Tall And Low Shrub Habitats

Communities composed of tall shrub typically exist in areas of exposed alluvial soil, such as floodplains, streambanks, and lake margins, on burned or otherwise disturbed areas, and near timberline. Low shrub communities develop in moist areas and on slopes with northern aspects. The wettest sites support a mixture of tall shrub swamps, low shrub bogs, or shrub/graminoid communities.

Interior highlands consisting of rounded low mountains primarily sustain dwarf shrub vegetation and open spruce stands, with graminoid-herbaceous communities occurring in poorly drained areas. Open coniferous forests and woodlands typically dominated by white spruce with black spruce, birch, and aspen co-dominants are often found near timberline. These forest types contain an open shrub layer consisting of resin birch, alder, willow, prickly rose, buffaloberry, and other ericaceous shrubs. Ground cover generally consists of a layer of mosses and lichen similar to those found in conjunction with black spruce.

The area around Cook Inlet is a transition zone between the coastal rain forest and the central Alaska boreal region. Tall shrub communities dominated by alder and willow, either alone or in combination, form thickets on streambanks, floodplains, and drainage ways. Mesic graminoid herbaceous and low scrub graminoid communities occur across a range of moist to dry sites. Dry to mesic sites may be dominated by a combination of grasses, forbs such as monkshood and bluebell, and ericaceous shrubs.

Tall shrub communities are dominated by willows, including feltleaf willow, diamondleaf willow, and grayleaf willow. Also common are alders, such as American green alder and Sitka alder. A mix of ericaceous shrubs may also occur (for example, crowberry, narrow-leaf Labrador tea, mountain-cranberry, bog blueberry, and alpine bearberry, with dwarf arctic birch). A thick herbaceous layer is present in some areas, consisting of oxytrope, vetch, and bluejoint. Mosses may be abundant.

Ecological Role of Shrubs—Shrubs play an important ecological role in regions throughout the state. Shrubs are an important food source for browsing ungulates (e.g., moose, Sitka black-tailed deer, muskoxen) snowshoe and Alaska hares, lemmings, and ptarmigan. The fruits of shrubs, from salmonberries to blueberries, provide important foods for a host of birds and mammals. Shrubs provide perching and nesting habitat for many species of landbirds who forage for insects or seeds within the shrub layer. Willows (*Salix* spp.) are particularly valuable shrubs that colonize along streams, and help to stabilize stream banks. Shrubs contribute leaf litter to soils, increase nitrogen mineralization rates, and alter how snow is trapped and distributed in winter. Factors affecting shrub cover at high latitudes and at high elevations include warming temperatures, changes in snow cover, altered disturbance regimes as a result of permafrost thaw, tundra fires, and changes in herbivory intensity.

A Willow Ptarmigan in tall shrub habitat. The Willow Ptarmigan is Alaska's state bird. Photo by Tim Rains, NPS.

Conservation Status of Shrubs—Shrublands are expected to increase at the northern and upper elevational range edges with climate change. Comparisons of current-day with historical photos show evidence of a widespread increase in shrub abundance over more than 199 square miles of Arctic landscape during the last 50 years (Strum et al. 2001). Satellite observations from around the circumpolar Arctic, show increased productivity, measured as changes in 'greenness.' These changes

have coincided with a general rise in high-latitude air temperatures and have been partly attributed to increases in shrub cover. Shrub species in wet landscapes at mid-latitudes of the Arctic are the most sensitive to climate change (Meyers-Smith et al. 2015).

Tundra

Tundra refers to a cold-climate landscape that has ground vegetation but is devoid of trees. Alaska has 3 major types of tundra that can be generally described by their topographical and geographical locations: 1) arctic (high latitude) tundra, 2) alpine (high altitude) tundra, and 3) the maritime tundra present on Alaska's western and southwestern coast. The dominant plant species of tundra habitats are sedges, low and dwarf shrubs, and graminoids interspersed with forbs. In addition, there are mat- and cushion-forming plants and scattered bryophytes (nonvascular plants).

Alaska's tundra climates are characterized by a short growing season, long, cold, dark winters, and low precipitation with strong winds. Snow accumulation, where present, provides an insulating layer to the ground surface, benefiting plant and animal communities. Few plant species grow on the tundra and their growth is minimal, with most of the biomass concentrated in the root system. Due to the short growing season, plants often reproduce by division, in addition to seed production.

Treeless tundra habitat. Photo by Neal Herbert, NPS.

Arctic Tundra

Arctic tundra is generally distributed above the latitudinal tree line in Alaska, including the crest of the Brooks Range northward to the Arctic Ocean. Arctic tundra persists under cold air with low moisture-holding capacity, combined with minimal precipitation. The dominant vegetation type across the foothills and much of the coastal plain is tussock tundra, with willows in the small drainages, wet sedge tundra in old drained lakes, and *Dryas* tundra on drier ridges. Tussocks are formed of cottongrass and other sedges and forbs, with scattered dwarf shrubs. Prostrate woody shrubs, mosses, sedges, and lichen cover the mountainsides and valleys. The flat areas of the coastal plain are sporadically covered with small thaw lakes and ponds and rock polygons. Trees are generally unable to become established in arctic tundra habitats due to an underlying impermeable permafrost layer coupled with thin soils.

Arctic tundra plant communities found in mesic (moist) and hydric (wet) soil conditions include wet graminoid herbaceous types dominated by sedges or grasses. Areas of drier soils along the riverbanks, lakes, and coastal bluffs support dwarf shrub communities. Typical mesic sedge communities are dominated by the water sedge and tall cottongrass. Grass communities are dominated by tundra grass) and alpine foxtail, with the emergent pendent grass prevailing where surface water is 6 to 80 inches

Species of Conservation Need: Bristle-thighed Curlew, Numenius tahitiensis

The Bristle-thighed Curlew has one of the smallest populations of any shorebird species, numbering just 7,000 individuals. Its breeding grounds, discovered in 1948, are in 2 small, distinct areas of Alaska—one on the Nulato Hills (east of the Yukon Delta) and the second on the Seward Peninsula. It nests in maritime tundra near the coast. The bird winters exclusively on remote oceanic islands in the central and southern Pacific Ocean. It is the only shorebird species that becomes flightless during its molt, which greatly increases its vulnerability to predation by introduced cats, dogs, and pigs on these islands. Due to the small population and threats on their wintering grounds, the species is considered vulnerable to extinction by IUCN, and is listed as a species of high concern by the Alaska Shorebird Group and by the U.S. Shorebird Conservation Plan. Photo by Gregory Smith.

deep. In addition, mesic graminoid herbaceous communities dominated by tussock-forming sedges are widespread. Typical species include tussock cottongrass and Bigelow sedge.

Alpine Tundra

Alpine tundra occurs above tree line elevations in mountain ranges and exposed ridges in Alaska. At these higher elevations, the landscape is increasingly broken by rock outcroppings. Plant communities consist of prostrate, mat and cushion-forming species and intermittent shrubs. Barren and lichen-covered rocky areas are dominated by *Dryas* (mountain-avens) and mountain-heath communities. These plants are adapted to the scouring high winds and widely ranging temperatures of high-elevation alpine regions. Due to steep slopes and relatively thin soils at high elevations, areas of alpine tundra lack trees and may or may not have permafrost.

Alpine tundra transitions to subalpine forests or meadows and treeline habitats at lower elevations. In many areas, the subalpine region is a broad band where small islands of stunted trees are confined to sheltered sites. Subalpine plants represent the first distinctive type of vegetation below the alpine tundra. The transition to alpine tundra begins with communities dominated by shrubs, heaths and related families. Regeneration of alpine tundra plant species is often

The transition zone where tree growth stops and alpine vegetation begins. Photo by Frank Kovalchek.

Maritime tundra dominates the coastal areas of western Alaska, and provides important breeding habitat for many waterfowl and shorebirds. Photo by Andrea Pokrzywinski.

very slow following damage by fire or other disturbance.

Maritime Tundra

Maritime tundra is present along the coastal areas of southwestern Alaska and the Bering Sea islands. This tundra type is the product of the cool and damp climate generated by the cold waters of the Bering Sea. Seasonal weather patterns produce relatively milder winters, cooler summers and relatively high humidity. A gradual transition occurs from maritime to arctic tundra in the region of Kotzebue Sound, and a transition from maritime to alpine tundra occurs where mountains extend into the region. Uplands and mountain slopes support mosses, lichens, and prostrate alpine plants, while lower areas are covered with herbaceous forbs. The latitudinal location, combined with the maritime climate and increased precipitation, generally defines and distinguishes this tundra from arctic and alpine tundra types.

Maritime tundra is dominated by prostrate heath-scrub type communities interspersed with grass and forb meadows, with willows and alders present in the protected swales. Grass and forb meadows composed of mesic, graminoid communities are dominated by tussock-forming sedges in some areas, or by bluejoint, which forms meadows with codominant herbaceous species. Dwarf scrub communities of the maritime tundra are composed of low shrubs, grasses, and lichens. Tall scrub communities are dominated by willows.

Species of Conservation Need: Rock Sandpiper, Calidris ptilocnemis ptilocnemis

The Rock Sandpiper (Pribilof subspecies) breeds on 3 islands in the Bering Sea, and winters primarily along the shores of Cook Inlet in Southcentral Alaska. It is the northernmost wintering grounds of any North Pacific shorebird. It is able to survive the harsh winter conditions in Alaska by feeding on large, energy-rich Macoma clams that are found in the intertidal mudflats in Cook Inlet. The population, which numbers 20,000, is vulnerable to a potential oil spill from the many oil drilling platforms and pipelines in the Inlet. Photo by Dan Ruthrauff.

Ecological Role of Tundra Habitats—Alaska's tundra supports many avian migratory species during the spring, summer, fall, and winter seasons, providing important breeding, rearing, staging, refugia, and overwintering habitat. It is one of the most productive and abundant habitats for shorebirds in Alaska and supports a diversity of breeding species. The Buff-breasted Sandpiper nests on the tundra of the Arctic coastal plain, while the Rock Sandpiper nests in the heath of the maritime tundra (Bowman 2004). The Yellow-billed Loon is an arctic tundra breeder that overwinters in offshore and nearshore waters from Prince William Sound in Alaska, to Puget Sound, in Washington.

McKay's Bunting breeds on St. Matthew and Hall islands in the Bering Sea, and winters on the mainland in Western Alaska. It is an endemic species. Photo by Jim Dau, ADF&G.

The maritime tundra of the Yukon-Kuskokwim Delta of western Alaska is one of the nation's most important nesting areas for geese. Large numbers of ducks, Tundra Swans, and Sandhill Cranes also nest on the maritime tundra of western Alaska. The threatened Spectacled Eider breeds here. Most of the world's Bristle-thighed Curlews breed in western Alaska's hilly transitional zone between low-lying maritime and alpine tundra. McKay's Bunting is endemic to several Bering Sea Islands, where it breeds on the maritime tundra. This habitat is particularly important in sustaining existing healthy populations of this species.

Additionally, mammalian species, including muskox, caribou, foxes, wolves, bears, arctic ground squirrels, and many small rodents, are widespread across the arctic tundra. Nomadic caribou depend on tundra vegetation most of the year for survival, including during annual migrations to their calving grounds. Migratory species, such as jaegers, falcons and terns, also use this habitat. Five species of raptors that regularly breed in the arctic tundra region include the Peregrine Falcon, Gyrfalcon, Rough-legged Hawk, Short-eared Owl, and Snowy Owl. Raptors specialize in eating the lemmings, voles, and hares that in turn are adapted to eating the tundra vegetation. Rock Ptarmigan breed on the arctic coastal tundra. They make short migrations in winter to the foothills of the south slopes of the Brooks Range where willows, a primary food source, are more abundant (Johnson and Herter 1989). During spring, thousands of ptarmigan move north across the foothills to reach their breeding areas on the tundra, as does the Smith's Longspur.

Conservation Status of Tundra Habitats—Alaska's tundra habitat is increasingly susceptible to impacts from oil exploration and development, mining, transportation corridors, and associated human activities. This is particularly true in the Arctic North Slope region, where existing, proposed and active state and federal oil and gas leases continue to influence the Arctic ecosystems. Rules regarding tundra travel, development of pads, and restoration help to minimize and mitigate the effects of oil and gas exploration and development. Red Dog Mine, an active operation near the village of Kivalina, is currently the world's largest zinc mine.

Tundra habitats are likely to diminish in the future as climate change causes a northward and upward migration of shrub and forest habitat types (Sturm et al. 2001; Chapin et al. 2005). This expected diminishing trend makes their future status a priority concern in Alaska.

Wetlands

Wetlands along the Kobuk River. Photo by Neal Herbert, NPS.

Wetlands are communities characterized by poor soil drainage. They represent a transitional zone between aquatic and terrestrial habitats. Alaska's wetlands occupy 43.3% of the state's 403,247,700 acres. This contrasts with the Lower 48, where only 5.2% of the 1.9 billion acre land surface is wetland.[15] Wetland habitats in Alaska are numerous and complex. This plan highlights and provides simplified descriptions of 4 main types of wetlands found in Alaska: bog, grass wetland, sedge wetland, and marsh. Wetland habitats can be isolated, ephemeral, or located in riparian areas hydrologically connected to surface waters of rivers, streams, and lakes. Small wetlands, even those without visible surface connections, are joined to stream systems by groundwater, subsurface flows of water, and periodic surface flows, such as spring runoff. Significant wetlands also occur along the coastline and adjacent to river deltas, and within forests throughout the state.

Large areas of wetlands are abundant in the valleys and basins associated with Alaska river systems. Major river deltas also possess large wetland areas. One of the world's largest coastal deltas, the Yukon–Kuskokwim Delta, supports several wetland types. Other predominant wetland deltas of Alaska include the Colville River Delta on the Beaufort Sea coast, the Copper River Delta in Southcentral Alaska, and the Stikine River Delta in Southeast Alaska (Hall et al. 1994).

Bog

Most of Alaska's wetlands are bogs, covering approximately 110 million acres. Bog habitats feature non-flowing, stagnant water (perched water tables), and deep peat layers. Bogs have been recognized for their role in regulating the global climate by storing large amounts of carbon in their deep peat layers. Flora and fauna that live in bogs demonstrate many special adaptations to cope with the low nutrient levels, water-logged conditions, and acidic waters. Evergreens and shrubs are the most abundant woody plants found in bog habitats.

Muskeg bog in Southeast Alaska with characteristic poorly drained organic soils, sphagnum mounds, and stunted lodgepole pine. Photo by Stepheng3.

Bog habitats often support wetland tree species dominated by dwarf black spruce (less than 10 feet tall at maturity). Black spruce communities are common near tree line in the Central, Southcentral, and West biogeographic regions of Alaska. These cold, wet sites are just barely capable of supporting trees. Dwarf tamarack and birch may also occur. Dwarf tree cover is 25–60 % in these areas. In Southeast

[15] Society of Wetland Scientists, June 1998. Alaska's wetlands. 19th Annual Meeting.

Alaska, common bog tree species include lodgepole pine, yellow cedar, and mountain hemlock. Sitka spruce and western hemlock are the dominant bog tree species along the Gulf of Alaska coast.

Grass and Sedge Wetlands

Grass wetlands are dominated by water-tolerant grass species. Grasses may occur in clumps or tussocks and may be intermixed with sedges. The wetter sites generally are hummocky. Woody plants and lichens are absent. Aquatic mosses may occur seasonally. The soil substrate associated with grass wetlands is generally organic or mineral rich. In addition to providing important wildlife habitat, these wetlands serve as groundwater recharge areas, storing storm and floodwaters that help maintain minimum base flows critical for downstream aquatic resources.

Sedge-Wetland

Sedge wetland habitats are dominated by tall sedges, cotton grasses, rushes, or bulrushes and are typically inundated with water. Trees, shrubs, and lichens are absent, but aquatic mosses may be present. Sedges make up the largest genus of plants in Alaska and consist of erect, rooted, water-loving vegetation. The USDA-NRCS National Plants Database identifies 155 species, subspecies, and varieties of sedges in Alaska, of which 113 can be found in wetlands (Tande and Lipkin 2003).

Sedge wetlands occur in very wet areas of floodplains, slow-flowing margins of ponds, lakes, streams, and sloughs and in depressions of upland areas throughout Western, Central, Southcentral, and Southeast Alaska, generally in organic-rich substrate (Viereck et al. 1992).

Marsh

A marsh is an area of low-lying land that is flooded in wet seasons or at high tide, and typically remains water-logged at all times. There are 2 subtypes of marsh recognized: salt marsh and freshwater marsh.

Salt marshes are vegetated with sedges, and, in salt marsh areas, with goose-tongue and other salt-tolerant plants. The salt marsh ecosystem falls between the mean high watermark and the lower intertidal zone. Alaska has 345,000 acres of salt marsh wetlands and has 33,000 miles of coastline (Doyle 1998). Yet, salt marsh habitat in Alaska represents only two-tenths of 1% of the state's total wetlands, and only 4% of the total vegetated tidal marshes in the United States.

This meandering tidal stream and associated salt marsh are in Taku Inlet, Southeast Alaska. NOAA photo, ShoreZone program.

Salt marshes are typically located at river mouths; behind barrier islands, coves, and spits; and on tidal flats where low energy wave action and fine sediment deposits provide elevated land for marsh vegetation to establish. They are located at mid to upper intertidal elevations and characterized by salt-tolerant plant communities

such as certain types of sedges and grasses. Species composition and distribution patterns of salt marsh vegetation communities can vary distinctly based on differences in elevation, drainage, and soil type. Some of the nation's most extensive complexes of salt marsh habitat occur along the Alaska coast of the Beaufort Sea, Chukchi Sea, Bering Sea, and Gulf of Alaska.

Freshwater marshes are usually found in areas with low drainage that are subject to inundation and flooding. Freshwater marshes contain little or no peat. Low-growing plants like grasses and sedges are common, as are waterlilies and rushes. Species diversity in freshwater marshes is typically higher than for saltwater marshes.

Ecological Role of Wetlands—Wetlands are among the most productive habitats and are important in preserving the state's biological diversity. Alaska's wetland habitats are heavily used as summer staging and breeding grounds for migratory birds that use all 4 North American flyways to reach their wintering grounds. The expansive and varied wetland habitats of the Copper River Delta, for example, are of international importance as staging areas for millions of migrating shorebirds. Large wetland areas such as the Copper River Delta are extremely valuable because they provide large and intact complexes. The Lesser Yellowlegs and Solitary Sandpiper eat freshwater aquatic insects, such as diving beetles, dragonfly nymphs, and flies, as well as sand fleas and intertidal amphipods provided by salt marsh wetlands. Waterfowl and waterbirds are wetland-dependent, and many species of songbirds nest and feed in wetland habitats. Raptors and owls often frequent wetlands to forage. Three-spine and ninespine stickleback provide essential prey for piscivorous birds such as grebes. Fish use wetland habitat for spawning, rearing, and refugia. In turn, brown bears forage for returning salmon in these same locations. Amphibians breed in wetlands, and many spend their entire lives in wetlands.

The Olive-sided Flycatcher feeds almost exclusively on flying insects, especially bees, wasps, winged ants, aphids and beetles that are abundant in and over wetlands. Voles are year-round meadow residents that eat meadow grasses and seeds. They build distinctive runways crisscrossing through the area. They also dig underground tunnels, where they construct food and nesting chambers. During the winter in snow-covered areas, the voles make runways beneath the snow and feed on the snow-flattened grasses. Voles and other small rodents are the staple foods of weasels, martens, foxes, coyotes, all owls, most hawks, inland breeding gulls, and jaegers. Sooty Grouse forage in bogs for berries and insects. Wetland grasses and sedges provide habitat structure for production of invertebrates, crustaceans, and insect larvae that many species of animals depend on.

Salt marsh habitat provides marine, freshwater, and terrestrial species a host of resources that may vary with tidal stage. For some species, access to the salt marsh is essential to a life function, while other species use salt marshes more opportunistically. Salt marsh wetlands provide spawning and nursery habitat for many marine invertebrates and fishes, including forage fish species, such as stickleback, and commercially sought species, such as Dungeness crab and Pacific herring. Salt marsh zooplanktons, such as copepods, play an essential role in the food web conversion between phytoplankton and larger animals. Copepods feed on most phytoplankton species and occasionally on the juvenile stages of smaller copepods. Herring and smelt feed on copepods and amphipods provided by the salt marsh. Across the state, salt marshes provide resting habitat for geese, ducks, and shorebirds during migration. Raptors, such as the Merlin, search for small mammals seeking refuge in the salt marsh.

Although the salt marsh environment is harsh with regular fluctuations in salinity and water inundation, it provides a constant source of differing foods due to differential decomposition rates of resident plant

species. This is an important difference not afforded by habitats having more seasonal availability of resources. Plant and animal species' ecological interaction plays a vital role in the healthy function of all wetland habitats. For example, wetland fauna facilitate decomposition of organic matter and enhance nutrient regeneration; they also serve as food for a variety of higher trophic levels.

Conservation Status of Wetlands—Alaska's wetland habitat is generally healthy. Localized development will likely continue to result in habitat alteration. Opportunities should be sought to protect the most productive, important wetlands from development.

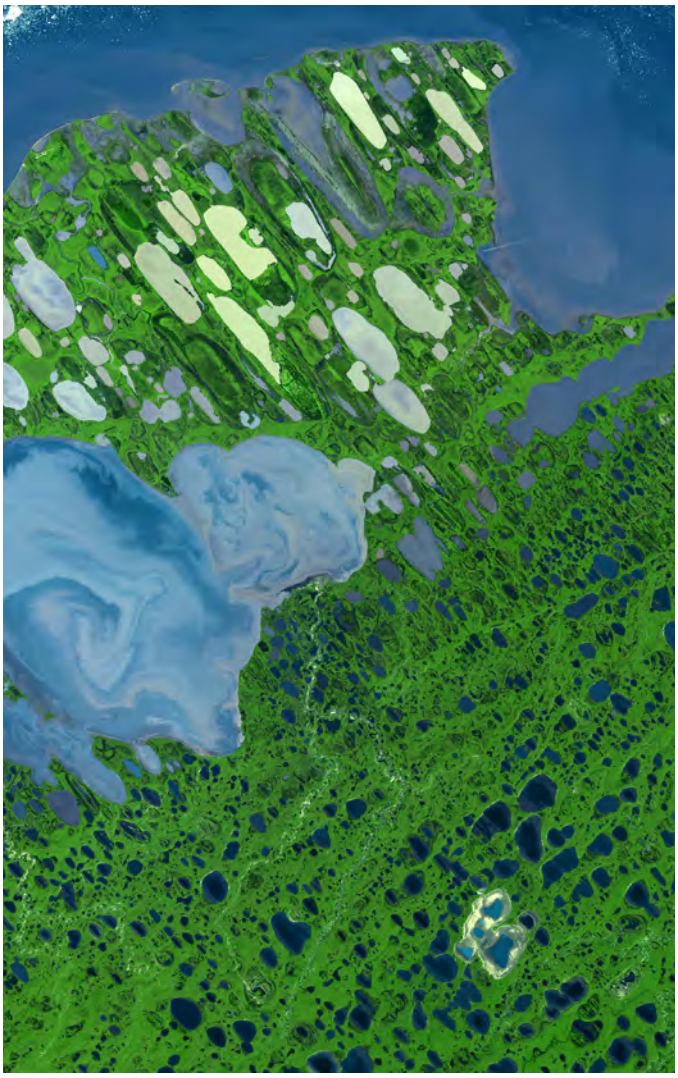
Threats to Alaska's wetlands include filling and dredging activities that fragment and block hydrologic processes and result in the elimination of and/or degradation of wetland habitat. These impacts are largely associated with transportation corridor construction, utility installation, natural resource extraction, and other development projects that result in wholesale wetland conversion. Much of the state's wetlands result from shallow water tables perched above permafrost. As climate change melts the permafrost, we expect many wetland areas to be drained, and plant succession to move the habitat type from wetlands towards shrubs and forest.

Freshwater

Alaska has more than 40% of the entire nation's surface water resources. Approximately three-fourths of all freshwater resources in Alaska are stored as glacial ice, covering about 5% of the state. Alaska has more than 3 million lakes greater than 5 acres (Harle and Estes 1993), over 12,000 rivers, thousands of streams and creeks, and an estimated 100,000 glaciers.

Alaska's freshwater ecosystems are found across the state from the temperate coastal rain forest of the Southeast region, to the boreal forest of Central Alaska, to the arctic tundra of the North Slope (Reynolds 1997). In terms of elevation, freshwater habitats are found from the highest alpine glacier and cirque lakes down to sea level, and flowing waters effectively connect the mountains to the sea.

Aquatic habitats are varied and complex and range from small, ephemeral streams to large, braided glacial systems that flow across entire regions of the state. The flow regimes of Alaska's rivers and lakes include those influenced by glacial melt, snowmelt, precipitation, and groundwater, including springs and upwelling areas. Headwater streams include pool, riffle, side channel, isolated pool and stream margin, and backwater habitats.



Wetlands on the North Slope, around Teshekpuk Lake. NASA photo.

Floodplain characteristics include main channels, side channels, oxbow lakes, backwater lakes, meanders, scroll depressions, and backwater wetlands habitats. Lake and pond habitats include typical shoreline, pelagic, and benthic areas. Still-water habitats range from tiny ponds to very large lakes. Also, the type and ratio of substrate materials offered by a waterway determine the habitat suitability for associated aquatic species.

Furthermore, riparian zones provide several functions directly related to aquatic habitats. They contribute large woody debris, provide leaf litter for primary consumer production, filter sediments and pollution, reduce wind, and regulate water temperature through shading and heat retention. They also provide streambank and floodplain integrity and stability via vegetative root systems. Although the functional boundary of a riparian area adjacent to a waterbody varies in relation to local flow regime, elevation, soils, and vegetation, the overall importance of riparian zones for fish and wildlife is undisputed.

Lakes and Ponds

Lake Iliamna is Alaska's largest lake, covering an area of approximately 1,000 square miles. It is 75 miles long and 20 miles wide and supports a unique population of harbor seals. Other lakes of size include Lake Clark and Becharof, Naknek, Ugashik, Teshekpuk, Tustumena, and Kenai lakes. The Wood–Tikchik Lakes system in Southwest Alaska consists of 13 lakes that range in length from 15 to 45 miles long.

Lake and pond habitats vary with substrate, bathymetry, and shoreline contour. Flow regimes and depth contours are also important influences on nutrient cycling, hydraulic retention time, and biological productivity in the relatively still waters of lakes and ponds. As with flowing waters, the origin of a lake basin determines its contour and morphometry.

Lakes form in glacier-dominated watersheds as a result of glacial advance and subsequent retreat. Most of the state's larger lakes, particularly those in Southwest and Southcentral Alaska, resulted from glaciation and are important to both resident and anadromous fish species for overwintering. Kenai Lake has glacial tributaries, while Iliamna Lake has clearwater tributaries. Both of these lakes are connected to rivers that support large and valuable runs of salmonids.

Oxbow lakes along the Kobuk River. Photo by Neal Herbert, NPS.

Many lakes in Alaska are not connected to a river or stream via an inlet or outlet. For example, lakes and ponds of thermokarst, fluvial, and volcanic origin generally lack connecting tributaries. Isolated or landlocked lakes can also be extremely shallow during the winter.

Although landlocked ponds and lakes may appear to lack connections to surface waters, many "isolated" waterbodies

are hydrologically connected to other lakes, wetlands, streams, or rivers by subsurface flows. For example, the state's Arctic region is dotted with shallow ponds and lakes that were created during deglaciation of the area. These ponds are hydrologically linked via the underlying permafrost.

Rivers and Streams

Alaska's largest rivers include the Yukon, Kuskokwim, Susitna, and Copper. The state's longest river is the Yukon. At over 2,000 miles long it is the third longest river in North America. It flows for 1,280 miles through Alaska and drains an area of 204,000 square miles. Alaska's rivers support many aquatic species including both anadromous and resident fish, and serve as corridors to the many smaller tributaries and waterways that support spawning, rearing, and overwintering habitats. These same tributaries provide protective vegetative cover, a significant source of detritus, and terrestrial wildlife riparian migration corridors.

The Kougarok River on the Seward Peninsula, Western Alaska. Photo by John Cloud, NOAA.

The type and ratio of substrate materials offered by a waterway determines the habitat suitability for associated aquatic species. Stream and riverbed substrates vary from large boulders to glacial silt or flour, clay, and mud. Large boulders provide resting areas for fish, while smaller cobbles and gravels allow for the required aeration and subsequent development of eggs buried in the streambed. Larger substrates provide greater surface area for aquatic invertebrate concentration and for the establishment of algae and mosses. Boulder and cobble bed streams are usually found in the upper portion of a watershed. These streams often have pockets of gravel and fine sediment in the pools, behind large rocks, and on the inside of bends and other areas of reduced velocity. Mud, silt, or clay substrates are often represented in shallower and slower waters, or at the terminus of a waterway.

Meandering waterways typically contain deeper areas of swift flow near the eroding outer edge of the meander, and areas of deposition and shallower water on the opposite bank. In broad valleys of major rivers, extensive meanders create oxbow lakes in abandoned channels. Braided channels are formed as a result of erosional and depositional processes, and are typical of large glacial rivers. Large woody debris is an important component of rivers and streams that helps to stabilize banks and substrate material, and provide cover from terrestrial predators. It also fosters formation of pool habitats and provides spawning bed integrity and habitat for aquatic invertebrates, elevating in-stream productivity.

Glacially influenced waterways are those where glacial input determines the chemical and physical characteristics of the water itself. Glaciers feed and influence nearly all major rivers in Alaska and provide the headwaters to some of the state's largest rivers, including the Copper, Susitna and Tanana.

Alaska has many rivers that are highly productive for salmon. Photo by Mr. Omykiss.

Glacial meltwater has high levels of nutrients that are highly bioavailable, and fuel high and sustained levels of primary productivity in some systems (Hood et al. 2015).

Alaska's glacially driven rivers exhibit high and variable rates of fluvial activity and channel adjustments from erosional and depositional processes (Wooster 2002). Rivers originating from glaciers tend to have high discharges, and generally have pronounced daily and seasonal stream flow fluctuations near the glacier and large year-to-year fluctuations in stream flow. Peak glacial river flows occur during the warmest months of the year, typically May through August. However, even during summer, water temperatures are measurably lower near a glacier than farther downstream. During the colder winter temperatures, when base flow is derived entirely from groundwater, glacial rivers generally run clear and low.

In contrast to glacial systems, clearwater rivers and streams exhibit low turbidity, high clarity and flow derived primarily from ground-water and precipitation. Clear waters maintain less dynamic annual flows than glacial waters. Clearwater systems have relatively narrower channel widths, stable well-defined beds and banks, relatively low sediment loads, and increased habitat complexity in the form of pools, riffles, and large woody debris. In clearwater streams, overwintering habitat can be reduced due to the smaller volume of water available in contrast to glacial river systems. Upwelling areas in groundwater-fed streams and perennial spring pools also provide some of the most important winter habitats for freshwater aquatic species in Alaska.

Ecological Role of Freshwater Habitats—Alaska's waterways, riparian zones, and their resources sustain large and diverse populations of fish and wildlife. For aquatic species, water provides migratory routes, spawning and rearing habitats, overwintering habitat, and refugia. Terrestrial wildlife also derive many benefits from freshwater aquatic habitats and riparian areas, including water itself, shelter, nesting and breeding areas, and important seasonal or daily transportation and migration corridors. Due to their relative isolation, lakes and ponds with no surface connection to another water body are more likely to contain unique biota due to temporal isolation.

The importance of freshwater aquatic species, such as fish, is apparent. Alaska's resident and anadromous fish use distinct microhabitats and often move between them with regular periodicity. This movement can occur seasonally, annually, or be associated with different life stages. For example, depending on species and life stage, fish use different habitats as juveniles (i.e., for rearing) than they do as adults for spawning (Schlosser 1991). Shifts in use can also be related to water temperature, water level, and

photoperiod. As temperatures decrease in the fall, for example, Alaska's freshwater fishes usually move from summer habitats to overwintering areas that offer different habitats.

The size and stability of bed material usually dictates the presence or absence of benthic invertebrate communities. For example, boulder, cobble, and gravel beds support a high diversity of benthic organisms. In streams, aquatic invertebrates drift downstream with the current. Most of these drifting organisms are immature aquatic stages of insects that later metamorphose into winged terrestrial adults, the main groups being mayflies, stoneflies, caddisflies, and midges. Immature mayflies spend from a few months to several years in streams before they metamorphose and emerge as terrestrial adult insects. During a brief few days the adults mate in swarms near the stream, lay eggs in the water, and die (Stolz and Schnell 1991).

South Fork of the Eagle River, near Anchorage. Photo by Frank Kovalchek.

Cobble and gravel substrate provides spawning habitat for fish species that construct redds and for broadcast spawners as well. Fish species foraging in cobble-boulder substrates either use isolated pockets of gravel for spawning, or they spawn in tributaries or reaches that have spawning gravels. Areas associated with upwelling of groundwater, and downwelling of surface flows, play critical roles in providing suitable spawning and overwintering habitat for most freshwater fish species.

Species of Conservation Need: Alaska Blackfish, Dallia pectoralis

These hardy little fish are only found in Alaska (central and western regions) and eastern Siberia. They are important prey for mink, otter, and loons, and are harvested as subsistence foods extensively on the Yukon-Kuskokwim Delta. They live in bogs, swamps, sloughs, and wetlands in summer, and migrate into deeper lakes in winter. They have a modified esophagus capable of gas absorption, and can tolerate extremely low oxygen levels by gulping air. They can also tolerate freezing water temperatures. They grow to around 6-7 inches by age 4, and live up to 8 years. Drying of wetlands may affect inland habitat, and coastal inundation by salt water storm surge may affect coastal lowland habitat. Photo by Ryan Ragan, ADF&G.

Upon their emergence from the gravel, juveniles may move into the boulder-cobble reaches to seek refuge. Large woody debris and boulders provide streambank structure that decreases sediment input to redds, and offer additional refugia for juveniles and smaller species.

Alaska blackfish prefer muddy substrates in quiet waters in densely vegetated areas of wetlands, ponds, rivers, and lakes. They are summer spawners whose eggs are demersal and stick to available vegetation. Blackfish have a unique modified esophagus capable of gas absorption, which allows them to breathe air. This ability enables them to live in small, stagnant tundra pools that are almost devoid of oxygen in summer and to survive in moist tundra mosses during extended dry periods.

Many avian species overwinter in other areas of the country or in other habitats within the state, yet spend their summers in ponds and lakes across Alaska. Loons, grebes, waterfowl, and shorebirds are all found throughout lake and pond habitats during the summer mating, nesting, and rearing season. Although loons spend their winters offshore, they spend summers inland in close proximity to the ponds and lakes where they nest and rear their young. In summer, waterbirds such as grebes prefer secluded habitats in ponds and lakes. During winter and on their migration journeys grebes prefer large lakes, coastal bays, and estuaries. Some gulls nest in the coniferous tree tops surrounding isolated ponds, eating insects and forage fish. Summer breeding areas for Aleutian Terns, however, include the matted dry grass near riverine habitat. Black Scoters and Surf Scoters nest in the riparian zone of lakes, ponds, or rivers in tundra or forests, while the White-winged Scoter prefers breeding grounds near streams and lakes.

Riparian vegetation also provides feeding, breeding, and nesting areas for all types of birds. Many of the nation's migratory birds depend on riparian areas of lakes, ponds, rivers, and streams to supply food resources such as insects, nuts, and berries, as well as protective sites and materials for nesting. Bird density, species richness, biodiversity, number of rare species, and number of breeding pairs are often elevated within riparian habitat.

Conservation Status of Freshwater Habitats—Alaska's freshwater habitat is generally healthy. Localized development impacts will likely continue to result in habitat alteration. Opportunities should be sought to alleviate negative impacts and maintain connectivity and quality habitat important to the sustainability of species. Threats to freshwater habitat include point and nonpoint source pollution, development and associated sediment erosion and removal of riparian vegetation, blockages, diversions, channelization, dams, unmonitored water withdrawals, natural resources extraction, mixing zones, invasive species, water withdrawals, and climate change.

Regulatory responsibilities over freshwaters in Alaska involve both state and federal agencies. The Alaska Department of Natural Resources (DNR) is the state agency responsible for water data collection and for planning and administering the appropriation of water. As the state's land manager, DNR holds land and water under the public trust doctrine and is responsible for maintaining these resources in an unimpaired state for the use of future generations. Alaska's laws guarantee the public's access to and use of state waters.

Marine

Marine habitats are differentiated based on depth and distance from shore. This plan identifies 4 marine habitat types: beaches/sea cliffs (including the intertidal zone), nearshore (from mean low tide to about 65 feet depth); the shelf (from 65 to 650 feet depth) and oceanic, which encompasses waters 650 feet or deeper.

Beaches and Sea Cliffs

Mudflats and beaches are intertidal unconsolidated substrate habitats ranging from sheltered tidal flats to steep cobble beaches exposed to pounding waves. Each type of substrate supports a distinct biological community, including many species of clams, polychaete worms, amphipods, and other invertebrates. Sand and gravel beaches host similar taxa (with gravel-inhabiting forms adapted to coarser substrate), as well as sand dollars and sand lance. Cobble beaches are subject to greater wave exposure, and fewer species are adapted to survive the stress of pounding waves and grinding substrate. However, when cobble provides a protective armor over a heterogeneous mixture of silt, sand, and other unconsolidated sediments, a rich infaunal community may live beneath it. Of the unconsolidated habitats, mudflats support the greatest species diversity and biomass, and cobble beaches support the least.[16]

Rocky substrate, moderate to strong wave and surf exposure, and a visible, vertical zonation pattern characterize rocky intertidal habitat. Colorful communities of invertebrates and algae grow in distinct horizontal bands dominated by algae, mussels, and barnacles. These species' physiological tolerance to desiccation and their competitive and predatory interactions with other species largely determine their vertical distribution. Although extensive research has been done on intertidal community structuring processes in temperate regions, including zonation patterns, disturbance processes, and adaptations of organisms, relatively little work has been done in subarctic regions. One difference between temperate and subarctic ecological processes is the pronounced seasonality of intertidal community composition and biomass. Dramatic seasonal changes, such as the cold winter air, shorter daylight, and long winters at or above 59 degrees north latitude (delineation of subarctic), all contribute to the distribution and composition of the intertidal communities. Low light conditions in winter sharply reduce algal growth, which is dependent on sunlight, nutrient availability, length and time of immersion, air temperature, and wave action. Stress from temperature changes causes high interannual variability in living biomass. The effects of these changes range from annual senescence of kelp and other macrophytes (many of which live throughout the year in temperate climates) to extreme intertidal mortality of flora and fauna.

Sea cliffs and mudflats in Kamishak Bay, Cook Inlet. NOAA photo, ShoreZone program.

Eelgrass bed in Prince William Sound. NOAA photo, ShoreZone program.

Eelgrass grows in beds (clusters) in low intertidal and shallow subtidal sandy mudflats. Like a coral reef or kelp forest, the physical structure of the eelgrass beds provides increased living substrate and cover for myriad invertebrates and fish. The

[16] Carroll, M. L. and R. C. Highsmith. 1994. Chemically-mediated recruitment of marine macrophyte. Benthic Ecology Meeting.

beds also generate food and nutrients for the soft bottom community through primary productivity and plant decay. Unlike kelp, eelgrass is a flowering, marine vascular plant. Although eelgrass blades die in the fall, the roots and rhizomes remain dormant through the winter. The perennial root and rhizome systems stabilize the fine substrate sediments, buffering the erosive forces of tidal flushing and seasonal storms (McConnaughey and McConnaughey 1985). This interannual stability allows eelgrass to come back in following years, providing a relatively consistent food source and substrate for the seasonal crop of epibiota. In Alaska, eelgrass beds are distributed along sheltered, shallow portions of the coastline, from Southeast Alaska to the Seward Peninsula. Izembek Lagoon is the site of one of the largest eelgrass beds in the world.

Alaska has more than 5 million acres of spectacular islands and sea cliffs, spreading along its coastline 44,000 miles, from the Alaska Panhandle in the southeast, around the Gulf of Alaska, across the Aleutian Islands, and north through the Bering Sea to above the Arctic Circle.

Nearshore

Nearshore habitat is the water column between the sea surface and seafloor in water depths up to 65 feet. It includes the subtidal area adjacent to the intertidal zone. Nearshore areas have greater variability in salinity, temperature, suspended sediment concentrations, and ice scouring than shelf or oceanic habitats. Wave energy is generally higher in the nearshore than in the deeper ocean because of breaking waves. Winds, freshwater input, ice current patterns, and tides drive seasonal cycles of mixing and turnover in the water column; the column may be strongly stratified during one season and strongly mixed during another, depending on environmental conditions. Freshwater from glacial rivers carries a heavy load of fine sediments that decreases light penetration and biological productivity in turbid areas. Where waters with contrasting density, salinity, and other characteristics meet, floating debris and kelp may mark a rip line. Such boundary areas often contain a greater abundance of fish, birds, and marine mammals.

A humpback whale swims along the shoreline in Prince William Sound feeding on herring and herring spawn. Photo by Rich Brenner, ADF&G.

Kelp forests growing in the nearshore habitat provide habitat structure, living substrate, cover, and microhabitats, as well as primary productivity. Some kelp species are perennials; however, many are annuals that die back during the dark, long winters. Although the extent of these forests varies from year to year, kelp contributes substantial primary productivity and habitat complexity to the marine ecosystem. The seasonal die-off contributes a strong pulse of detritus to the ecosystem during low-light winter months, supporting detritivores and upper trophic levels when primary productivity in the water column wanes. Eelgrass beds, which may also be considered part of the nearshore habitat, are discussed in the Intertidal description.

Shelf

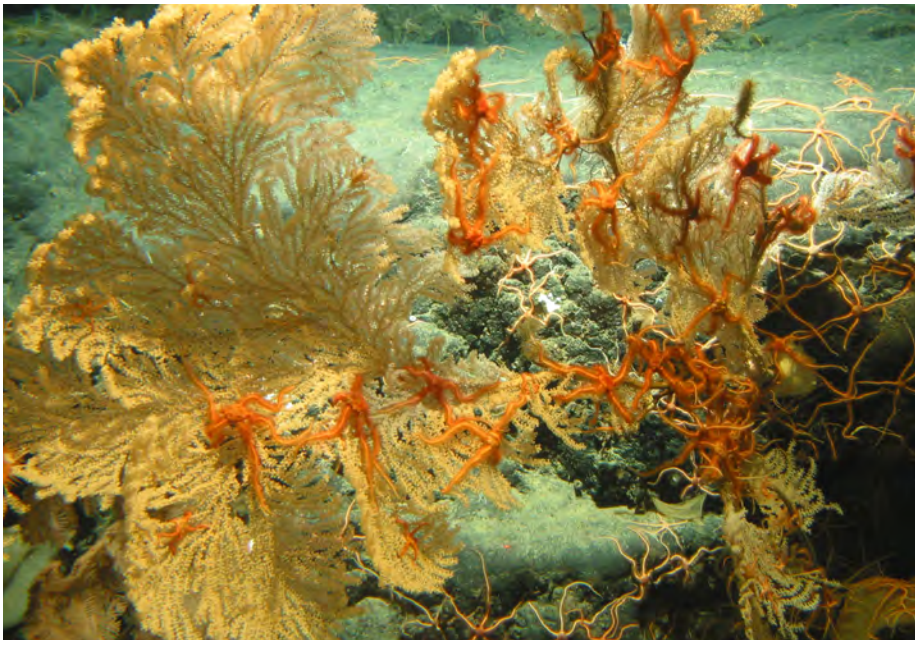
Shelf habitat refers to the continental shelf that lies at the edge of the continent; it includes waters greater than 65 feet but less than 650 feet deep. Continental shelves are nearly flat borders of varying widths that slope very gently toward the ocean basins. The width of the continental shelf varies. Shelf widths are typically greater in areas of passive continental margins, where there is little seismic or volcanic activity, because these areas are where continents are rifted apart, creating an ocean basin between them. Narrower continental shelves occur in areas of active continental margins, where plate convergence and subduction are occurring. Alaska has relatively narrow continental shelf habitat from Southeast to the southern boundary of the Aleutian Islands, and relatively wide continental shelf habitat in the Bering, Chukchi, and Beaufort seas.

Shelf habitats are characterized by high productivity that supports a wide range of animals. The habitat of the sublittoral zone environment can be soft-bottom (mud, sand, shell, gravel) shell debris or rocky. Benthic communities include infauna, which are organisms that live within sediments, and epifauna, which are organisms that live on sediments. In general, benthic mapping information for Alaska is very limited. Benthic habitats are diverse. However, typical benthic communities contain a diversity of deposit and suspension feeders, as well as predators and scavengers, but suspension feeders dominate. Prominent species include barnacles, king crab, bryozoan and other hydroids, shrimp, ascidians, anemones, sea pens, sea whips, brittle stars, sea cucumbers, sponges, gastropods, urchins, and shrimp. Soft-bottom communities recycle nutrients from the water column and rocky habitats.

Cold-water corals form important benthic habitat in the Gulf of Alaska and off the coast of the Aleutian Islands. These coral gardens include more than 100 species of coral and are comparable in size and structure to tropical coral reefs. The Aleutian Islands have the highest coral diversity of Alaska's waters. Some of these corals have a tree-like structure and can reach heights of 10 feet and widths of 23 feet.

Oceanic

Oceanic habitats begin at the abrupt change in slope that occurs at the boundary of the continental shelf on the ocean side. The steep slope extending to the ocean basin floor is called the continental slope. Oceanic habitats include several layers of water, each of which has distinct characteristics of salinity, temperature, and light intensity. The epipelagic zone, which extends between the surface and 650 feet depth, is the only area where food can be directly produced by photosynthesis in the open ocean. Below this, the source of food is primarily from



Corals are important benthic habitat in the Gulf of Alaska and Aleutian Islands. NOAA photo.

detritus falling from the epipelagic zone. Minor additional food sources include vertically migrating animals and chemosynthesis at hydrothermal vents. Alaska has vast oceanic habitats associated with its extensive coastline.

Unlike many other corals, deep-sea Alaska corals don't need light to grow. The corals acquire all the nutrients they need directly from the water column. These deep sea corals reefs are primarily composed of cold-water corals, black coral, gorgonian corals, stony corals, sea whips, sea pens, and sponges (Corallidae, Isididae, Paragorgiidae, Pennatulidae, Primnoidae; Antipathidae, Oculinidae, Caryophylliidae, Stylasteriidae).

Arctic cod concentrate along the ice edge where they are an important food for many seabirds and marine mammals. Photo by Shawn Harper, NOAA.

Ecological Role of Marine Habitat—The pelagic open water environment of nearshore, shelf, and oceanic habitats provides important nursery, feeding, and resting habitat for many seabirds, fishes, marine mammals, and of course, plankton. Phytoplankton are grazed upon by zooplankton, which in turn are consumed by carnivores and omnivores. Fish such as Pacific sand lance, capelin, eulachon, lantern fish, and Arctic cod are common. These fish are eaten by seabirds such as Red-legged Kittiwake, Black-legged Kittiwake, Marbled Murrelet, Kittlitz's Murrelet, Arctic Tern and Aleutian Tern. Some marine mammals (e.g., whales) feed directly on plankton, while others, such as seals and sea lions, feed on fish, and still others, like Pacific walrus, feed on benthic invertebrates.

The unique physical characteristics of polar marine environments have resulted in many species of fish, marine mammals, and birds sharing certain life-history characteristics. Many animals migrate seasonally, taking advantage of the highly productive short summer season and moving to other environments during the winter. Many polar marine animals are long-lived and have only 1–2 offspring per year. This

Species of Conservation Need: Red-legged Kittiwake, Rissa brevirostris

The Red-legged Kittiwake breeds on just 6 islands in the Bering Sea. A single colony, on St. George Island, contains about 80% of the world's population. The birds feed primarily on small fish species and invertebrates in the surface waters. The global population is relatively small and appears to be declining. The Alaska Seabird Conservation Plan lists it as highly imperiled. The IUCN lists it as vulnerable to extinction. Threats to this species include the possibility of an oil spill, especially were it to occur during the breeding season near St. George Island, and the possibility that predators, such as rats, might be accidentally introduced on breeding islands. Photo by Dick Daniels.

ensures that the species will persist during periods of low food supply, even if no offspring survive. Another common characteristic of Alaska marine animals is the capacity to store energy, commonly as fat, to survive periods when food is unavailable.

Extensive mudflats along Turnagain Arm. NOAA photo, ShoreZone program.

In benthic habitats, organic detritus from kelp and other macroalgae, dead animals, zooplankton, phytoplankton, and other sources of nutrients and carbon rain to the bottom. Contaminants in the water column also settle and accumulate in soft sediments; therefore, benthic communities are often used to the assess presence of pollution in the water column. As burrowing species churn the sediments, they incorporate nutrients into the sediments that feed deposit feeders. Bottom-dwelling fish, invertebrates, decomposers, and microbial life consume the contaminants and other organic materials, converting it to living biomass. These processes link the health and productivity of the soft and hard substrate communities with those communities living in the water column.

The deep-sea coral reefs near the Aleutians provide nurseries, places to feed, shelter from currents and predators, and spawning areas for fish and many other species of marine life. Sea stars, basket stars, polychaetes, snails, sponges, anemones, rockfish, shrimp, and crabs are known to inhabit Alaska's cold-water coral gardens.

Mudflats are an important stopover for migrating birds, such as Dunlin, which depend on ice-free foraging grounds during their spring migration. The sandpipers are among the millions of migrating shorebirds that focus on Baltic macoma, a small clam that can provide up to 30 percent of the birds' diet during migration (Senner and West 1978). Clams are also an important food source for waterfowl, which feed on the mudflats throughout the winter (Sanger 1983). Mudflats and beaches play an important, but poorly understood, role as nursery and spawning habitat for several commercially and recreationally important fish and invertebrates, including Pacific herring, Tanner crabs, and Dungeness crabs. Pacific herring spawn in the intertidal mudflats and in the mixed sand, gravel, and mud beaches. Sand and gravel beaches provide spawning habitat for capelin and sand lance, 2 primary food sources for seabirds.

The many sea cliffs in Alaska serve as protected habitat for nesting seabirds of low food availability. Abundant forage fish, such as those stated in the paragraph above, provide ample food supplies. About 50 million seabirds nest in more than 2,500 colonies on Alaska's coast each summer. This is 87% of all the seabirds in the United States. Most seabirds rest and sleep on the rolling waves, but some roost on land for a few hours a day. They gather their food from the sea either as individuals or in large feeding flocks. Many bird species, such as Red-legged Kittiwakes, nest only in Alaska and nearby Siberia. The Pribilof Islands provide breeding habitat for virtually all of the world's 210,000 Red-legged Kittiwakes.

Conservation Status of Marine Habitats—Alaska's marine waters and associated habitats are generally healthy. Localized development will likely continue to result in habitat alteration. Opportunities should

be sought to alleviate negative impacts and provide suitable areas of quality habitat important to the sustainability of species.

The extensive and seamless nature of marine ecosystems puts them at risk for water pollution, which can travel far from its original source, making it difficult to regulate. Pollution from the oil industry is a major concern in Alaska marine waters, especially since the oil tanker Exxon Valdez spilled 11 million gallons of oil (in 1989), causing extensive damage to marine habitats and animals in the Gulf of Alaska. Other threats to marine waters from oil exploration include the disposal of toxic drilling muds, and noise pollution.

Juneau is the third largest city in Alaska. Tour ships bring more than 1 million visitors to Juneau each year, with up to 5 cruise ships visiting per day. Photo by David D.

Increases in marine water transport activities related to recreational, commercial, and industrial uses place additional stress on the health of Alaska's marine waters. The growing presence of large cruise ships, bulk cargo ships, and oil carriers to Alaska's developing port facilities poses concerns related to the proper disposal of solid waste and gray water. Gray and black water disposal from recreational boating activities into marine waters goes essentially unregulated.

Proliferation of invasive species is also a significant concern relating to Alaska's marine environment. Several species, including Atlantic salmon, Chinese mitten crab, and the European green crab have been identified as real or potential threats to Alaska ecosystems in Alaska's *Aquatic Nuisance Plan.*

Furthermore, climate change will bring greater levels of coastal shipping to and through the Arctic in coming decades, increasing the likelihood of such problems as invasive species and spills. Biological regime shifts leading to ecological shifts as a result of a warming climate are increasingly being documented for marine species, from phytoplankton to marine mammals (Mantua and Hare 2003).

Other conservation concerns for Alaska's marine environment include adverse impacts from fishing techniques, in particular on-bottom trawling (NRC 2002). Some marine habitats under federal jurisdiction are protected by Marine Protected Areas (MPAs). MPAs are year-round closures designated to enhance conservation of marine or cultural resources.

The Alaska Maritime National Wildlife Refuge (AMNWR) encompasses many of Alaska's coastal islands, headlands and reefs. Almost all of the Aleutian Islands are included in the refuge, and many areas are also included in the Aleutian Islands Wilderness. Additionally, the Aleutian Islands are a Biosphere Reserve—an international recognition given by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Despite the protected status of the land, many of the animal species that live on the islands are threatened by potential or actual threats to the surrounding marine environment on which they are intrinsically dependent. The conservation problem of most concern is the decline in almost all species of fish-eating seabirds in the Aleutians. Mortality and population declines of many fish-eating seabird populations have been linked to trophic changes in the Bering Sea ecosystem due to commercial harvests of fish and whales over the last 4 decades, according to a study by the National Research Council (1996). Other threats to Alaska coastal islands and cliff habitats include

habitat degradation and conversion from cattle and reindeer introduced for ranching; and predation on seabird colonies by foxes, also introduced for ranching. AMNWR engages in continuing efforts to eradicate rats, which are introduced predators of seabird colonies. Pollutants, associated primarily with military development, are locally acute. Given the great importance of the marine environment to so many species, and number of threats, conservation of these habitats is a high priority

Sea Ice

Sea ice in the Arctic environment consists of both "fast ice" and "pack ice."

Fast Ice

Shorefast ice forms in place and is attached "fast" to the coastline or to large floes or pressure ridges that are grounded. Fast ice forms annually and may contain icebergs and floes of older pack ice. It can extend for a few yards from a shore, ice front, shoal, or grounded iceberg, or may extend for a hundred miles or more from such attachment points, depending on water depth. Fast ice is generated in the shallow coastal waters of the northern Bering, Chukchi and Beaufort Seas. Its formation depends on a combination of air and water temperatures and wind direction over the continental shelf. Sea ice is dynamic and variable with many cracks or openings.

Pack Ice

Pack ice is not anchored to land and moves with the ocean's currents and winds. It forms annually and can include old sea ice, as well as ice that has formed elsewhere and has floated with the winds and currents. Under present climatic conditions, pack ice persists in the Arctic Ocean all year. It is extremely heavy and has the effect of dampening sea swells. The rolling motion of the sea can be considerably moderated by a relatively narrow band of pack ice only 325 feet wide. The result is that where pack ice persists in reasonable quantity, the sea calms sufficiently for low temperatures to freeze it more easily than moving water. The edge of this loose moving ice, called the fringe, is subject to dispersal by wind and currents and is broken by the vertical motion of swells from the open sea. Generally, multiyear pack ice in the Arctic has a 3- to 5-year "life" expectancy.

Due to its movements with ocean currents and wind, pack ice is not continuous; instead pond-like open water refuges called polynyas and long, linear cracks called leads are created. Polynyas are created where winds and currents combine to produce open areas where there is no ice, or comparatively thin ice, during the winter. Some reoccur year after year in the same places, although the exact boundaries vary annually with prevailing environmental conditions. Extensive polynyas are found in the Bering Sea. Other open areas, such as leads, are created when weak ice is broken by wind stress, initially forming a crack, and then widened by the wind or currents. The maximum southerly extent of the ice pack occurs in April, typically extending no farther south than the Pribilof Islands in the Bering Sea. By September, the ice reaches its maximum northward retreat in the Arctic Ocean (Gibson and Shullinger 1998).

Ecological Role of Sea Ice Habitats—Nine species of mammals are strongly and positively linked with the occurrence of sea ice in Western and Northern Alaska. These are the arctic fox; polar bear; beluga and bowhead whales; the Pacific walrus; and the bearded, ringed, spotted, and ribbon seals (Burns et al. 1990). Each species of marine mammal requires a certain type of sea ice for resting, molting, socializing, breeding, rearing, migration, and access to prey.

Predator-prey interactions within this marine ecosystem are dictated by spatial and temporal availability of sea ice. Marine mammals such as the polar bear depend almost entirely on sea ice for their habitat.

Among the ice-associated seals, ringed seals occur in all habitats offered by sea ice, but are the only seal to inhabit the stable land-fast ice along Alaska's northern shorelines. They make and maintain breathing holes through ice that may be 6 feet thick, and the pups are born in snow caves or lairs excavated in snowdrifts on the ice. Ringed seals do not dive to great depths and make particular use of ice over shallow waters by preying on Arctic cod during their nearshore migration. Bearded seals typically occur in all but the shore-fast ice, while ribbon seals and spotted seals are generally found only in the ice front from February to late April. Although some spotted seals occur on the ice fringe, as well as deep into the pack ice, they are not typically found in open seas or consolidated ice in the early spring (Trukhin and Kosygin 1988). Spotted seals take advantage of shorefast ice only when the ice front (10- to 20-yard rectangular floes with brash ice or open water between) has dispersed in late spring–early summer or in fall before the ice front forms. Polar bears use the sea ice as a platform from which to hunt ringed and bearded seals. They wait for seals to return to air holes, capturing and pulling them through the ice hole as they come up for air. Alternatively, polar bears will slowly stalk and catch seals as they rest on the ice surface. Without sufficient ice, bears may become stranded onshore, unable to access and successfully hunt their usual prey.

Ice floes provide important resting and pupping habitat for harbor seals. National Park Service photo.

Pacific walrus calves are usually born on the pack ice in late April–early June. The calf subsists solely on milk for the first 6 months or so, before beginning to eat solid foods. Nursing takes place primarily in the water, but also sometimes on land or ice. Sea ice allows seals and walruses to rest near food resources: It provides spacious habitat, is remote from shore-based predators, is relatively sanitary, and may offer shelter from the wind. The ice edge is also important habitat for birds and marine mammals that are less ice-adapted and cannot feed within the more continuous fast ice zone. These animals are often found feeding and resting in leads and divergence zones near the ice edge.

Quality and quantity of the ice is an important variable in local habitat selection of ice-dependent species. Seasonal environmental change dictates larger scale changes in species abundance and distribution patterns. For example, migrations of subarctic seabirds (e.g., Thick-billed Murres), water birds, fish, and marine mammals follow the retreating ice northward. The reproductive success and spatial distribution of ice-dependent species also vary between warm and cool environmental conditions. For example, seals and walruses haul out on sea ice to sleep and bear young. Walruses mainly occupy a narrow band of the

ice edge in the Chukchi Sea in summer and open water and polynyas throughout the range of sea ice in the Bering Sea in winter and spring.

Leads and polynyas provide migration routes from summer feeding grounds to wintering areas. Whales, walruses, and certain seals depend on polynyas for winter survival. During this time their presence in other areas of the Arctic is restricted for lack of places to breathe due to thick ice cover on the sea. The survival of animals overwintering in polynyas depends on the water remaining open, in order to minimize energy used to maintain breathing holes. Migratory sea ducks such as the federally listed Spectacled Eiders move far offshore to waters during the months of October through March, where they sometimes gather in dense flocks in polynyas located amid nearly continuous sea ice. Sea ice plays a major role in the distribution and migration patterns of Ivory Gulls (Spencer et al. 2014). Ross's Gulls are adapted to feeding on invertebrates at the ice edge.

The presence and condition of sea ice plays a broader and more complex role in the Arctic ecosystem than simply providing a platform and transportation routes. During the winter, tiny marine ice algae populate the lower surface of the sea ice. Ice algae are thickest where openings or thinner ice allow more light penetration. By spring, the algae form a thin, dense layer. The algae are the food for an under-ice community of diverse biota. Crustaceans and other small sea life feed on these plants, and are in turn, food for fish. Arctic cod are a staple food source for other fish, birds, seals, and beluga whales. Fish species such as herring, capelin, eelpout, sand lance, and pollock, as well as octopus and shrimp, are significant prey species of arctic seals (Quakenbush 1988), and other marine mammals. As spring approaches, most of the plankton sinks to the sea bottom and supports important benthic communities, including clams, amphipods, worms, snails, sea cucumbers and mollusks, including crab (Gibson and Shullinger 1998). In turn, these bottom-dwelling populations support large marine mammals, such as walruses and bearded seals.

Two walruses resting on an ice floe in the Chukchi Sea. Photo by Justin Crawford, ADF&G.

Effects of diminished sea ice include potential changes in the timing, migration routes, and numbers of marine mammals. A change in the status, health, or accessibility of marine mammal populations will affect the human coastal and island communities' subsistence activities, economics, and cultural traditions.

Conservation Status of Sea Ice Habitats—Alaska's sea ice habitat is diminishing in annual depth and extent. The 4 years with the smallest area of Arctic sea ice on record occurred in 2012, 2007, 2011 and 2015 (lowest to fourth lowest).[17] Localized development will likely continue to result in habitat alteration. Opportunities should be sought that alleviate negative impacts and maintain connectivity, as well as suitable areas of quality habitat important to the sustainability of species.

[17] Howard, E. Arctic sea ice shrinks to fourth lowest extent on record. The Guardian. 16 September 2015. http://www.theguardian.com/environment/2015/sep/16/arctic-sea-ice-shrinks-to-fourth-lowest-extent-on-record. (Accessed 19 September 2015).

Currently, arctic sea ice habitats are impacted by climate change, offshore oil and gas development activities, and pollution and contaminant transport. Each of these conservation concerns has associated transboundary, regional and international implications that harbor significant threat to arctic marine and coastal ecosystems in Alaska. Of great concern for arctic habitats are the ecological implications of reductions in sea ice extent and duration.

International efforts to protect the Arctic and its biota are occurring under the auspices of the Arctic Council, an intergovernmental forum for addressing common concerns and challenges faced by the Arctic states of Canada, Denmark, Finland, Iceland, Norway and the Russian Federation, Sweden, and the U.S. Two Arctic Council programs, in particular, focus on the needs of arctic marine species; these are the Program for Conservation of Arctic Flora and Fauna (CAFF), which promotes conservation of biodiversity and the sustainable use of living resources, and the Program for the Protection of the Arctic Marine Environment (PAME). PAME addresses policy and nonemergency pollution prevention and control measures related to the protection of the arctic marine environment from land and sea-based activities, including marine shipping, offshore oil and gas development, land-based activities, and ocean disposal. Established in 1993, the PAME program works closely with CAFF scientists and also with representatives of 3 other Arctic Council programs: Sustainable Development Working Group (SDWG), which explores the economic, social, and cultural aspects of sustainable development; Arctic Monitoring Assessment Program (AMAP), which identifies pollution risks and their impact on arctic ecosystems and assesses the effectiveness of international agreements on pollution control; and Emergency, Prevention, Preparedness and Response (EPPR), concerned with sharing information and methods for spill prevention and control.

All offshore oil and gas developments require a means of bringing hydrocarbons to the international market. With one exception this requires onshore infrastructure. The exception is offshore oil transfer, which is the single biggest source of oil pollution in the Arctic (Smith 2004).

Sea ice in the Arctic is diminishing as the climate warms. Photo by Patrick Kelley, USCG.

To date, fast ice has provided a useful platform on which to construct temporary roads and conduct onshore exploratory seismic and drilling operations. Fast ice used for seismic exploration may impact denning polar bears that construct dens where sufficient snow accumulation provides cover. Additionally, seismic exploration has been documented to alter bowhead whale migration routes, as well as to displace ringed seals (Richardson et al. 1999; Harwood et al. 2010).

Alaska's arctic waters have experienced an increase in use by maritime traffic in recent years, and this trend will likely continue. Based on current activity levels of oil exploration, production, and transportation, Cook Inlet and the Beaufort Sea are the state's areas of highest concern regarding protection from oil spills. Unfortunately, there continues to be no significantly effective method for containing and cleaning up fuel spills that may occur in icy waters (DF Dickins Associates Ltd. 2004). Booms and skimmers are ineffective in broken ice and unusable in

closed ice conditions. This is particularly troubling because contaminants remain toxic longer and are more difficult to clean up once trapped in ice. They also take longer to break down in the Arctic's colder temperature regime. An additional concern is that fuel spills concentrate in open waters in the sea ice and in breathing holes where animals surface and congregate.

Currently, 30 miles of Arctic Ocean coastline is federally designated as wilderness. This area is known as the Arctic National Wildlife Refuge. It is here, on the coastline of this refuge, that more polar bears den than along any other stretch of Alaska's coast. Other important polar bear denning habitat occurs within the National Petroleum Reserve–Alaska.

Other

Rocks and Caves

Karst landscape is an area of underlying limestone (carbonate bedrock) in which erosion and dissolution by groundwater/chemical weathering has produced fissures, sinkholes, underground streams, and caverns. The high soil acidity and damp conditions of temperate rain forests and muskeg are ideal for creating interconnected dissolved features in alkaline calcium carbonate bedrock. This network of caves and tunnels is a distinct habitat type located underground but connected, in varying degrees, to the overlying landscape through sinkholes, cave entrances, and subsurface hydrology.

In Alaska, karst landscape is primarily located in the Alexander Archipelago, which includes Prince of Wales, Dall, Coronation, Sumez, Heceta, Baker, Kosciusko, Kuiu, Long, Etolin, Revillagigedo, Kupreanof, and Chichagof islands (Baichtal 1995). The mainland near Haines, Haines State Forest in Southern Chilkat Valley (Streveler and Brakel 1993), and the Wrangell–St. Elias Mountains also contain areas of karst. Outside of Southeast Alaska, the only other karst landscapes overlain by temperate rain forest are located in Chile and Tasmania. Other karst areas in Alaska include the Lime Hills on the west side of Cook Inlet, the Jade Mountains in northwest Brooks Range (sinkholes, springs, and underground streams) and the White Mountains in Central (Interior) Alaska. The karst cave systems in Southeast Alaska are the most extensively studied; very little is known about the extent and ecology of Alaska's northern and western karst areas. The following habitat descriptions address karst cave conditions in Southeast, in the coastal areas of Canada, or generalized cave conditions.

Within the karst cave system are several zones of differential habitat use and characteristics. The "entrance zone" is located immediately around the cave or tunnel opening and is the most influenced by surface conditions. The "twilight zone" extends from the entrance to mid-depth and is best characterized by decreasing light levels and connectivity to the exterior. The final zone is the "deep cave" area, which is almost entirely isolated from exterior conditions. Within and between these zones are a range of characteristics that affect species distribution: light level; temperature; the range of temperature variation; air flow patterns; cavern size; the cave's depth below land surface and elevation relative to sea level; humidity; substrate type; connectivity to surface water/flow levels; level of human disturbance; turbidity, pH, and conductivity of water; nutrient input to the system; and thickness of epikarst (Aley and Aley 1997). The one factor that influences all of these habitat characteristics is the degree of connectivity between the surface and subsurface. In a karst cave system, the speed and magnitude of transfers between surface and subsurface are controlled by sinkholes and hydrologic flows.

Nutrient input to cave systems depends on surface organics being transported through connections from the surface. These nutrient sources may take the form of debris falling into sinkholes or being

This sea cave is part of a columnar basalt formation. Some sea caves are used by nesting seabirds. Photo by Steve Hillebrand, USFWS.

washed into cave systems by sinking streams (streams descending through the cave system).

Karst cave inhabitants can be obligate, opportunistic, or accidental. Accidental inhabitants are those organisms introduced into the systems through sinkholes or flushed in by water flow. While accidental species rarely survive, they present an important influx of nutrients to the system. Opportunistic use is generally limited to terrestrial or littoral openings, but this use does represent a wide range of taxonomic groups. Obligate cave inhabitants consist of troglobite (terrestrial cave dwellers) and stygobite (aquatic cave dwellers) invertebrates.

The entrance zone is characterized by lower light levels and higher relative humidity than exterior conditions, and more dramatic temperature variations and higher nutrient availability than interior areas of caves. Davis et al. (2000) defined the entrance zone as 0–33 feet from the entrance of the caves, but actual entrance zone parameters may exist in varying locations depending on cave entrance size.

The "twilight zone" extends from the entrance to mid-depth; it has sheltering characteristics but is not completely isolated from the surface. Most invertebrates found in caves reside in the twilight zone. Few true obligate troglobites occur here, but there is large potential for finding as yet undescribed and unidentified species. Other species may have certain portions of their life cycle that necessitate different zones of the caves.

The deep-cave zone is a very stable, insulated habitat, but this stability is a function of a very narrow range of habitat conditions. Deep cave invertebrates (hypogean invertebrates) are highly specialized to cave conditions, with extremely limited tolerance for light, humidity, temperature, and pH variations, but with the ability to exploit low nutrient and oxygen levels. The interior of a deep cave generally has little organic debris, no light, temperatures slightly above freezing, high humidity (100%), a pH near neutral (a consequence of the buffering effects of the dissolved calcium carbonate), and a very limited input of new species, predators, or competitors.

In addition to Karst Caves, the coastline of Alaska often features sea caves. A sea cave, or littoral cave, is a type of cave formed primarily by erosion. Sea caves are especially common on the Aleutian Islands where the steep cliffs are exposed to wave action. If the interiors of the caves have ledges, they are often used by seabirds for nesting.

Ecological Role of Rocks and Caves—The connectivity between karst systems and the overlying landscape also benefits the overlying forest. In Southeast Alaska, karst areas are better drained and have less acidic soil, promoting growth of larger trees than in nonkarst areas. Dissolved fissures in the bedrock allow deep root growth, making large trees more windfirm. The underground portions of streams can provide buffers for water pH, water temperature, and flood discharges.

Habitat functions of the entrance zone include denning by black and brown bears, river otters, wolves and mustelids, although there is uncertainty about the extent of this use (Streveler and Brakel 1993). Sitka black-tailed deer use the thermal buffering effects of air currents at cave entrances in both summer and winter (Baichtal and Swanston 1996). This effect has been called "cave breath" and may allow some species or individuals to live at the temperature limits of their distribution. Both songbirds and seabirds use openings for nesting and feeding depending on proximity to shore (Baichtal 1995).

Protection of the karst landscape is important to preserve the state's species biodiversity. The narrow range of interior conditions supports communities of species that are specifically adapted to unique environmental conditions. In addition, these environmental conditions generally occur in isolated pockets that preclude migration of individuals between habitat patches. As a result, obligate cave fauna, especially deep-cave inhabitants, have population characteristics of a species highly susceptible to rapid evolutionary change via endemism.

Aquatic habitats associated with karst landscapes are more productive than nonkarst aquatic habitats. Streams flowing through karst areas support larger coho salmon fry and parr than Southeast streams without karst. Higher alkalinities of karst streams are positively correlated with higher fish densities (Bryant et al. 1998).

Conservation Status of Rocks and Caves—Alaska's karst cave habitat is generally healthy. Localized development will likely continue to result in habitat alteration. Opportunities should be sought to alleviate negative impacts and maintain connectivity, as well as maintains suitable areas of quality habitat important to the sustainability of species.

The conservation of both karst cave habitats and associated species communities is complicated by the limited knowledge of the cave ecology in Alaska. Many unknown or poorly understood variables could impact species survival. Some of these variables include identifying links to the overlying landscape and connections to groundwater and surface water systems. Hydrologic systems expand the area of impact and effects far beyond the physical limits of a cave. Road development, land clearing, timber harvest, and mining activities all have the potential to alter subsurface water and nutrient flows. Timber harvest and related road construction in the vicinity of caves increase runoff and sedimentation, which may flood, scour, or fill previously stable cave environments. Debris accumulates and blocks cave entrances and exits through practices of disposing of slash and rerouting of surface flows into sinkhole ponds or dry sinkhole pits.

The protection of a karst cave is very much dependent on the ownership of the overlying land. On state and private lands there is minimal to no protection. The State of Alaska Division of Forestry will protect karst formations that affect water quality as per the Alaska Forest Resources and Practices Act and Regulations. If significant recreational activity or important fish or wildlife habitat is found to be dependent on a karst resource, it will be taken into account during the development and implementation of the Forest Land Use Plan (FLUP) process for a proposed timber sale (Division of Forestry, Coastal Region). In 1992 the state legislature attempted but failed to pass an Alaska State Cave Protection Act.

There is a higher level of protection for caves on federally owned lands due to the Federal Cave Resources Protection Act of 1988. This act applies to listed "significant caves" on federal lands. The significance is determined by criteria established by the Secretary of the Interior or his/her delegates. In Alaska, a large amount of the karst landscape is located on federal lands: Portions of the White Mountains are

under BLM management; many of the caves in the Alexander Archipelago are in the Tongass National Forest; karst landscape is located in Wrangell–St. Elias National Park and Glacier Bay National Park; and the Lime Hills and the Jade Mountains are both located on a mixture of federally owned and Native owned or selected lands.

The 1997 Tongass Forest Plan Cave Standards and Guidelines (USFS 1997) implemented a karst resources management plan that included developing an inventory of caves and hydrologic systems and protecting and maintaining significant caves and cave resources to the extent feasible. These guidelines fulfill responsibilities under the Federal Cave Resources Protection Act. The Forest Service in the Ketchikan area has developed a cooperative effort with the Alaska Cavers Association to inventory and document caves. The Thorne Bay Ranger District has developed trails and viewing platforms and tours for 2 of the larger caves in Southeast. Even within the Tongass National Forest, different land designations (monuments, wilderness areas, etc.) may affect the degree of cave protection.

Cultivated-Developed Land and Artificial Structures

These habitat types are lands that have been permanently changed by human activities through digging, clearing, paving, or building. It includes agricultural land, airport runways, lands developed for housing and retail. It includes farm, office and industrial buildings, factories, hatcheries and refineries. It includes communication towers and lines, and above-ground pipelines. Most developed habitats and artificial structures are detrimental to wildlife. For example, millions of birds every year are killed by collisions with window glass and communication towers (Veltri and Klem 2005). Developed habitats rarely provide the food, or shelter, that animals find in natural habitats. There are some cases, however, where structures provide some benefit to wildlife. In tundra habitats, structures provide elevated sites for perching and for building nests. Ravens and raptors are well known to exploit power poles, abandoned dredges, and buildings in the arctic for nesting. As avian predators benefit, the birds and mammals they prey on may decline, at least locally. Similarly, landfills associated with developments often subsidize some bird species like gulls, sustaining them at higher than normal levels. Again, depredation by gulls on the eggs and young of nesting shorebirds, and other waterbirds, becomes a localized problem (Weiser 2010).

Artificial structures, like this gold dredge on the Fortymile River, provide nesting and roosting sites for birds of prey and can serve as hibernacula for bats. Photo by Craig McCaa, BLM.

Threats to Wildlife

The Cook Inlet population of beluga whale (340 whales, as of 2014) is listed as Endangered. One of the threats to this population is from strandings. This image, taken in 1999, shows a group of Cook Inlet beluga whales stranded in Turnagain Arm. At least 8 whales died in this stranding. Photo by John W. Schoen.

What follows is a systematic assessment of threats that could potentially affect wildlife populations in Alaska at regional or statewide scales. Threat categories follow Salafsky et al. (2008).

Residential and Commercial Development

Housing

Because the human population in Alaska is small, the development of housing for both the existing and anticipated future population is unlikely to be a significant threat to wildlife at the statewide level, unless population growth is far greater than in the past. Housing developments may entail the draining and filling of wetlands, diversion of small water bodies or streams, or development of high-value riverfront, lakefront, and oceanfront properties that disproportionately impact high-value wildlife habitat. Housing development may also lead to point-source pollution associated with failed septic systems, or in some areas of Alaska, be associated with lack of functional sewer or septic systems (e.g., sewage lagoons; see also Pollution section).

Houses and shops crowd the waterfront in downtown Ketchikan, Alaska. Photo by Wendy Cutler.

Commercial and Industrial

Most of the industrial development anticipated in Alaska is related to natural resource extraction, and is covered under other sections of this document. Because of the high costs associated with shipping, labor, and energy in the state, substantial new manufacturing development is unlikely. The population of the state is growing, however, and there have been increases in commercial

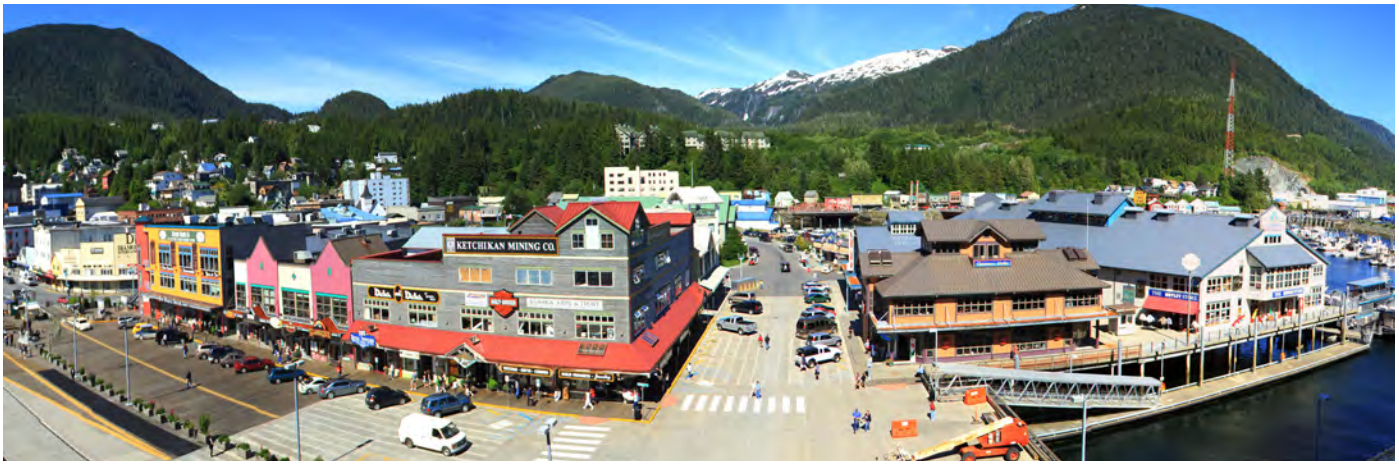
Tram over Juneau. Photo by Sonny Sideup.

retail and office development, primarily in the 4 largest population centers (Anchorage, Wasilla, Fairbanks, and Juneau). Most of this commercial development has occurred on (or adjacent to) land already modified by people. As with housing, the extent of habitat affected by commercial development is small in relation to the size of the state, and is unlikely to affect viability at the species level.

Tourism and Recreation

Approximately 1.6 million tourists visit Alaska each year (McDowell Group 2015). This number has decreased slightly (by about 150,000) since 2008, probably due to the nationwide economic downturn. Approximately 57% of all tourists who visit Alaska each year do so with the cruise ship industry. While there has been some direct development related to this sector, the most likely threats to wildlife from the cruise ship industry are related to water pollution and disturbance, which are addressed in other sections of this document. Direct development resulting from tourism has mostly involved hotel, restaurant, and other tourism-related infrastructure, and has mostly occurred in population centers and nearby areas that are already developed. Commercial tourism activities, including sport fishing, river rafting, kayaking, and flightseeing are regulated by permit on most public land units in the state (see also Human Disturbance section).

Recreational uses, including nonguided hiking, kayaking, river rafting, sport-fishing and wildlife watching are less strictly regulated (except in parks, where backcountry permits are often required) and have effects that are classified under disturbance. The infrastructure associated with recreational activities (e.g., viewing platforms and trails at wildlife viewing sites on national forest lands, like Anan Wildlife Observatory and Mendenhall Glacier Visitor Center, and state lands like Potter Marsh and Creamer's Field) are modest in extent, and are unlikely to have significant effects on wildlife habitat or species viability. Open top pipes associated with recreational and other facilities (i.e., outhouse vent pipes) are an additional threat to birds that investigate the hole and become trapped within the pipe or in the holding tank below.



View from the balcony of a cruise ship docked in Ketchikan, in Southeast Alaska. Photo by Jim Nista.

Agriculture and Aquaculture

Crop Production

Only a very small percentage (approximately 0.02%) of all land in Alaska is used for crop production,[18] an amount that decreased slightly between 2000 and 2010.[19] Most development of land for agriculture took place between 1920 and 1980. Climate change could increase the suitability of some lands in the state for agriculture, which could lead to more natural habitat being altered. Because of transportation constraints, however, almost all current crop land is located in the Matanuska–Susitna Valley or the upper Tanana Valley, and these transportation constraints would be likely to limit any expansion of crop production elsewhere in the state. Because of the small amount of habitat affected and low prospects for expansion, threats to wildlife populations from crop production are considered low through the next decade.

The Mendenhall Glacier Visitor Center was built in 1962. Since then the face of the glacier has retreated more than 1.5 miles, and vegetation has grown up around the center. Photo by Reways92.

Timber and Pulp Production

This threat refers to plantation forestry (e.g., palm oil plantations, Christmas tree farms) and not to logging of original forests. There is little of this in Alaska, though second growth stands following clearcutting of old growth could be considered a type of plantation forestry. Threats related to commercial logging of natural forests are covered under the subsection on Biological Resource Use.

Livestock Production

Livestock production in Alaska is currently limited in scope, involving less than 14,000 total animals, most of which are dairy and beef cattle.[20] These animals primarily occupy land that is included in the previous section on crop production, and also occur primarily in developed areas of the state within the Railbelt. Other threats to wildlife related to livestock production in the state include the possibility of disease transmission from domestic animals (Cleaveland et al. 2001). These pathogens could possibly affect populations such as moose, caribou, sheep, and bears (Zarnke 1983), as well as many avian species which could be affected by pathogens from domestic birds. Of significant concern, however, are livestock that

There are very few ranches raising cattle in Alaska. This one is near Fairbanks, in the interior of Alaska. Photo by L. T. Hunter.

[18] Alaska Agricultural Statistics. 2010. Prepared by Alaska Field Office, National Agricultural Statistics Service, U.S. Dept. of Agriculture. PO BOX 799, Palmer, AK 99654. http://www.nass.usda.gov/Statistics_by_State/Alaska/Publications/Annual_Statistical_Bulletin/annual2010.pdf (Accessed July 2015).

[19] Ibid.

[20] Ibid.

are abandoned and become feral, as on Chirikof Island in the Aleutians, or livestock that are allowed to roam off lease on sensitive wetland habitats, as on Kodiak Island. In addition to potentially transmitting pathogens to native species, livestock grazing brings significant change to the vegetation by foraging and trampling. Although livestock production is not a significant problem statewide, it can be an acute problem for endemic species on islands.

Aquaculture

Globally, aquaculture supplies more than 50% of all seafood produced for human consumption, and that percentage is expected to continue to rise.[21] Aquaculture can involve either farms (for finfish or shellfish) or hatcheries (for finfish). Finfish farming involves rearing fish in pens or raceways until they reach harvestable size. There is no finfish farming allowed in Alaska, but the practice is common in China (Feng et al. 2004), Korea, Chile, Norway, Japan, and British Columbia, and those products compete with Alaska's wild-reared salmon on global markets. Hatcheries, in contrast, rear salmonids from eggs to juvenile stage and then release them into the ocean. They feed in the ocean for 1 to 4 years, depending on the species, before returning to the hatchery site where they are harvested. They may also be harvested in some fisheries long before they arrive at the hatchery site (called nonterminal fisheries).

Hatcheries have been very successful, and have increased output exponentially in recent years. Hatcheries on both sides of the Pacific contribute more than 5 billion salmon to the ocean every year, 90% of which are pink and chum salmon (Krikelas and Ford 2014). Today, there are 2 times as many salmon in the Pacific Ocean as there were 50 years ago. Alaska, alone, contributes 850 million hatchery pink salmon to the Pacific each year.[22] In 2010, one third of all salmon caught commercially in the state originated from 5 hatcheries in the Prince William Sound/Copper River region.[23]

Shellfish mariculture is allowed in Alaska, with associated permitting and regulation (Hilborn and Eggers 2000). Shellfish mariculture can include farming of native species, such as littleneck clams and

Species of Conservation Need: Steelhead, Oncorhynchus mykiss

Steelhead are found in streams and rivers draining all throughout the Gulf of Alaska, from Southeast to Kodiak and the Alaska Peninsula. All steelhead begin life as rainbow trout in a freshwater stream. After 2–3 years, a portion of each year's cohort of trout migrates to marine waters to feed, becoming steelhead. Steelhead return to fresh water after 1–3 years to spawn, and may spawn 2–3 more times after that, returning to the ocean after each spawning cycle. They can reach sizes of up to 30 inches or more. Little is known about their ocean migrations, except that they have been recaptured in open ocean fisheries as far east as past the end of the Aleutian Chain. These fish are dependent on spawning and rearing habitat that is usually in the headwaters of drainages. Populations are small, discrete, and not well studied. Sport and subsistence harvests of these fish are therefore conservative. Photo by Ken Marsh.

[21] National Oceanic and Atmospheric Administration, National Marine Fisheries Service. Aquaculture FAQ. http://www.nmfs.noaa.gov/aquaculture/faqs/faq_aq_101.html (Accessed July 2015).

[22] Yale Environment 360. November 2010. Hatch-22: The Problem with The Pacific Salmon Resurgence. http://e360.yale.edu/feature/hatch-22_the_problem_with_the_pacific_salmon_resurgence/2335/ (Accessed July 2015).

[23] Ibid.

mussels, or farming of Pacific Oysters, which are not native to Alaska. Oysters grow well in Alaska's waters, but do not successfully reproduce here due to cold water temperatures (Pauley et al. 1988).

Threats to wildlife populations from aquaculture are most likely related to disease or invasive species introduction in shellfish (McLaughlin et al. 2005), or genetic effects from hybridization with wild stocks from straying of hatchery-origin salmon (Waples 1991). An outstanding research question is whether or not increased competition for food both between wild and hatchery juvenile fish, and among top predators in marine waters is affected by abundance of hatchery-produced salmon (Ruggerone et al. 2003, 2012). Hatchery production of salmon in Alaska is regulated under a permitting system to minimize problems associated with disease, genetic factors, straying rates, and mixed-stock management.

Unregulated hatchery production from other Pacific Rim nations, primarily Russia, China, Japan, and South Korea has increased substantially in the past 4 decades and may be of concern.[24] Atlantic salmon are extensively farmed in British Columbia and Washington state, and during the last 20 years, hundreds of thousands of Atlantic salmon have escaped from these operations; today, Atlantic salmon are regularly reported in Alaska waters (Quinn 1993).[25] As with hatchery fish, farmed Atlantic salmon pose some threat of disease introduction (McVicar 1997), the possibility of hybridization (McGinnity et al. 2003) or the establishment of spawning populations that might outcompete and displace native salmon and steelhead (Volpe et al. 2001).

Washing down a latern net full of oysters at an oyster farm in Sea Otter Sound, Southeast Alaska. Photo ADF&G.

The William Jack Hernandez Sport Fish hatchery can produce 6 million fish per year, and is the largest indoor fish hatchery in North America. Photo by Ken Graham.

[24] Wild Salmon Center, 721 NW 9th Ave, Suite 300. Portland, OR 97209. 503-222-1804. State of the Salmon: Salmon Hatcheries. http://www.stateofthesalmon.org/hatcheries/ (Accessed July 2015).

[25] Alaska Department of Fish and Game. Invasive Species — Atlantic Salmon (Salmo salar) http://www.adfg.alaska.gov/index.cfm?adfg=invasiveprofiles.atlanticsalmon_resources. (Accessed July 2015)

The trans-Alaska pipeline carries oil 800 miles from Prudhoe Bay to the Valdez terminal, in Prince William Sound. Portions of the pipeline are elevated, and refrigerated, to prevent thawing the underlying permafrost. Photo by Luca Galuzzi.

Energy, Production, and Mining

Alaska's economy is highly dependent on natural resource extraction, particularly of oil and natural gas. While the total number of jobs from this sector is a small percentage of all jobs in Alaska, income from this sector to state government accounts for more than 90% of all revenues,[26] and state government spending and employment has been a large driver of the state's economy.

Oil and Gas Production

Threats to wildlife populations in Alaska from oil and gas development are related primarily to the direct effects of exploration and extraction and effects related to transportation of the resource. Direct effects include the loss of habitat and the disturbance from water withdrawals, construction and operation of drill pads, roads, processing facilities, and employee housing, including associated ongoing air, water, and noise pollution. Effects from transportation include loss of habitat from pipeline, pump station, and terminal development, as well as the effect of oil spills.

Until very recently, oil and gas development in Alaska has mostly involved extracting oil from conventional reservoirs. If future development involves a significant amount of extraction of unconventional sources of oil (shale gas, coal-bed methane, and methane hydrates) threats to wildlife from oil and gas development may increase. These increased threats are likely to be related to the intensity of drilling, transportation, and development infrastructure used. The cost for initiating development of unconventional oil resources on the North Slope is expensive given the remoteness, lack of infrastructure, and significant costs associated with each well, so this type of development may not occur for some

Species of Conservation Need: Killer Whale, Orcinus orca

Killer whales are the most widely distributed marine mammal in the world, but reach highest densities in colder waters. In Alaska, the killer whale is found in the Gulf of Alaska and the Bering Sea. The Northeastern Pacific Population, from California to Alaska, is estimated to be 2,500 individuals. There are 3 ecotypes recognized, depending on their morphology, ecology, and behavior. Resident whales occur in large pods and feed primarily on salmon, especially Chinook salmon. Transient whales travel more widely, in smaller groups, and feed exclusively on marine mammals. Offshore whales range far from coastal waters and appear to feed on fish and possibly sharks. The population in Prince William Sound declined by half following the Exxon Valdez oil spill in 1989 and is considered a depleted stock. Threats today are contaminants, depletion of prey, ship strikes, and oil spills. Photo by Robert Pittman, NOAA.

[26] Alaska Department of Revenue, Tax Division. 2014 Annual Report. http://www.tax.alaska.gov/programs/documentviewer/viewer.aspx?1139r (Accessed July 2015)

time. Technologies such as hydraulic fracturing of existing wells and directional drilling can reduce the impacts of development and exploration.

Perhaps the most significant threats to wildlife populations from both existing and future oil and gas extraction are the effects of possible oil spills, both small and large. Localized effects from small spills are generally limited to the direct damage to habitat and wildlife in the immediate area of the spill, and generally represent a very small effect in relation to all wildlife and habitats in the state. Effects from spills, even relatively small ones, become more dispersed and more significant when those spills occur into or near marine or freshwater, because spilled oil is much more difficult to control and recover in those situations. Of particular concern would be any oil spill occurring in arctic waters where there is sea ice (Cox and Schultz 1981).

Effects on wildlife from oil spills in the marine environment include the deaths of seabirds, marine mammals, fish, and marine invertebrates. The mortality can be widespread and have population level effects, depending on the size of the spill (Peterson 2001), and the location. An oil spill affecting coastal staging areas, such as Izembek Lagoon or the Copper River Delta, could expose millions of birds to harm. Long-term effects have been shown to decrease reproductive success in seabirds for up to 10 years after a spill event (Barros et al. 2014). Indirect effects of oil and gas production include inflated predator numbers (gulls, ravens, foxes), associated with camps and infrastructure, that have been found to depress nesting success in the surrounding area (Liebezeit et al. 2009).

Although the rate of expansion of oil and gas development in the state has slowed recently, it is likely that new exploration and development will continue into the future. Overall, the total amount of habitat directly affected by these activities is small, but the effect of linear infrastructure (roads and pipelines) extends beyond the actual footprint of the development, providing barriers to movement or general displacement. The most significant threat, however, is the threat of an oil spill, especially in places where oil is difficult to contain and remove (e.g., sea ice) and in locations that are critical to large numbers of animals (e.g., staging areas, important migration points such as Unimak Pass and Bering Strait)

A still-active mining claim within the historic Independence Mine properties in Alaska. Photo by Switchbladesista.

Mineral Production

Threats from current and future mineral development in Alaska can be divided into near-term direct effects and longer-term indirect effects. Near-term direct effects are primarily related to loss of habitat. These come from open pit or placer mining, with associated tailings disposal, and water withdrawal and impoundment; construction of infrastructure for processing and transporting ore and ore concentrates; and ongoing effects of operation of mines, processing facilities, housing, and related infrastructure. These activities can completely eliminate habitat in the mine's footprint, but the overall percentage of all wildlife habitats affected statewide is generally small, and unlikely to result in population level effects on wildlife. The exception is where the activities occur on or very near specific critical habitats of at-risk species.

Longer-term indirect effects include the effects of water withdrawals on both surface and groundwater, the effects on watersheds of landscape alteration, and the effects on surface and groundwater

quality from mine drainage. Mineral extraction and coal mining typically require the use and eventual disposal of significant amounts of water. Withdrawals of freshwater from rivers and streams can lead to reduced depths and flows (Bjerklie and LaPerriere 1985) and increased water temperatures, all of which can have negative effects on the fish and wildlife that depend on that water. Disposal of water used in leaching or other ore reduction operations generally requires treatment, which requires impoundment facilities, which alter habitats, affecting wildlife. Wet impoundments may also leak, or fail, over time, sometimes catastrophically, with associated impacts on wildlife (Davies 2002).

Landscape-scale watershed alterations from large-scale mineral development affect water quality and hydrology in ways that are generally detrimental to fish and wildlife. These effects include increased erosion and sediment transport, along with a decrease in hydrological buffering which leads to high flows for short periods of time followed by longer periods of decreased flows. These effects reduce the quality of habitat for aquatic organisms.

The extraction of metals from ore-bearing rock often results in the exposure of metal sulfides to oxygen and water. With water, tailings and exposed mine areas form sulfuric acid runoff which often contains high levels of metals. Acid mine drainage has long been recognized as extremely detrimental to wildlife (Hofert 1947). This runoff can be highly toxic to aquatic organisms in general (Koryak et al. 1972; Jennings et al 2008), both in freshwater and marine environments (Grout and Levings 2001). A primary reason these threats are of significant concern is the persistence of such runoff over time and the difficulty and often prohibitive costs of mitigation,[27] which have led to abandoned sites continuing to have negative effects on wildlife decades after mine operations have ceased and mining companies have gone out of business.[28]

Renewable Energy Production

Except for possible large hydropower development (covered in the section on Natural System Modification), threats to wildlife from renewable energy production in Alaska are relatively minor, and are primarily related to wind turbines and possible tidal systems for electrical generation. Wind generation results in a small direct loss of birds (< 0.01 % of annual avian mortality from anthropogenic sources, Erickson et al. 2005) The amount of wind generation in Alaska is extremely small in relation to the landscape, and this effect is unlikely to lead to conservation concerns for any bird species; however, in certain locations these systems could pose localized threats to concentrations of birds. Potential

Wind turbines atop Pillar Mountain, Kodiak Island, operated by Kodiak Electric Association. Photo by James Brooks, USCG.

[27] United States Geologic Survey. Environmental Health - Toxic Substances. Watershed Contamination from Hard Rock Mining,. http://toxics.usgs.gov/regional/mining/index.html (Accessed July 2015).

[28] Ibid.

effects on wildlife from any future tidal energy development are very difficult to predict, but would likely involve disruptions in migration patterns of marine fishes and mammals, as well as marine traffic. These could have potentially significant adverse effects on marine mammals if sited in places where large numbers pass annually (e.g., Bering Strait, Unimak Pass).

Transportation and Service Corridors

Roads and Railroads

Roads are known to have significant negative effects on wildlife (Spellerberg 1998). The existing road system in the state is very small relative to the size of the state, comprising less than 1,100 miles of highways and about 3,500 miles of arterial and major collector roadways.[29] Most of these arterial and collector roadways are in urbanized areas, and almost all roads occur within a narrow north–south corridor running from the Kenai Peninsula to Prudhoe Bay. An exception is the relatively high density of roads on islands in Southeast Alaska associated with the logging industry.

A number of new major roads have been proposed in the state over the past 40 years, including roads connecting Juneau with Haines and connecting the Dalton Highway to Nome. These roads have faced a number of obstacles, primarily the prohibitive cost of constructing them, and appear unlikely to be built during the next decade. There is one main rail system in the state, and it has only one main line, running 470 miles from Seward to Fairbanks.

Threats to wildlife from roads and the railroad include blocking migration corridors, both terrestrial and aquatic including salmon spawning, direct losses from vehicle–animal collisions, disruption of local hydrology from solid fill, trapping and hunting loss, displacement (Thurber et al. 1994), introduction of invasive plant species, herbicide use for right of way maintenance, and disruptions from roadway noise, air pollution, and dust, as well as spills of oil and other hazardous substances. Threats to wildlife from the railroad are less than for a similar length of highway because traffic is relatively infrequent. However, because of the volume of product carried, potential threats from spills may be higher.

The 414 mile-long Dalton Highway parallels the trans-Alaska pipeline, from Fairbanks to Prudhoe Bay, and is one of the most isolated highways in the world. The road carries 160 trucks per day in summer and 250 per day in winter. Photo by Matt Verso.

Roads lead to increased human activity and development spurred by new means of access. These effects can range from increased hunting and fishing pressure, and increased disturbance from recreational activity, to effects from major

[29] Alaska Department of Transportation and Public Facilities. Certified Public Road Mileage in Centerline Miles. http://www.dot.alaska.gov/stwdplng/transdata/pub/2013cprmFinal.pdf (Accessed July 2015).

Caribou on the Parks Highway. Photo by J.K. Brooks.

resource extraction activities made feasible by roads. An example of this is logging-related road construction on islands in Southeast Alaska. Not only is valuable old-growth habitat lost to logging, but the increased access for trappers and hunters can lead to high harvest. Although legal take can be regulated, illegal take cannot; and illegal take may approach legal take in magnitude (Person and Russell 2008). Education, outreach, and road management are key to managing wildlife in multiple-use forest settings.

Utility and Service Lines

As with the scope of most transportation development in Alaska, the total area affected by utility and service lines in the state is quite small, and is mostly contained within a fairly narrow north–south corridor where other development and transportation infrastructure in the state is centered. Threats to wildlife from utility lines in Alaska primarily involve direct loss of birds from power transmission lines (Bevanger 1998). Towers associated with utility lines provide artificial structures for nesting and perching by raptors and ravens. An artificial increase in predators can depress nesting success of shorebirds and waterfowl along these corridors.

Pipelines can affect wildlife movement (Murphy and Curatolo 1987), and spills of oil or liquefied natural gas from pipeline failure could be significant, depending on spill size, location, and time of year. From 1995 to 2005, just over one half million gallons of product were spilled from 732 pipeline incidents, and of this, 285,000 gallons were from a single incident of vandalism to the

More than half of the Alaska pipeline is elevated above ground to allow wildlife passage beneath, and to prevent permafrost thawing. The pipe supports in some sections are refrigerated to prevent conduction of heat into the ground. Photo by Derek Ramsey.

trans-Alaska pipeline.[30] Threats to wildlife from pipeline spills are often restricted to the direct damage to habitat and wildlife in the area affected by the spilled product, and do not involve landscape scale effects. However, when a spill of significant size occurs near or into a water body, particularly flowing water, it can be difficult to control the spread of the spilled product. This can have widely dispersed effects on wildlife, particularly invertebrate (Miller et al. 1986), fish (Moles et al. 1979), and other aquatic species that depend on that system.

Shipping

Threats to wildlife from shipping in Alaska are primarily related to marine shipping (Humphries and Huettmann 2014), although there is also substantial shipping by barge that occurs on the Yukon, Tanana, Noatak, Kobuk, Nushagak, Kvichak, and Kuskokwim river systems. Effects on wildlife from shipping include disturbance from engine or sonar noise, direct loss from collisions and propeller strikes, introductions of invasive species, and probably most important, effects from oil spills. There were 15 major spills of crude or fuel oil into coastal marine waters in Alaska between 1976 and 2004,[31] and hundreds of smaller spills. Between 1995 and 2005, a total of 1,799 spills involving vessels released more than a half million gallons of spilled substance, primarily noncrude oil (diesel or bunker oil).[32] More than half of this amount was from a single vessel accident, when the MV *Selendang Ayu* ran aground on Unalaska Island, spilling 335,732 gallons of fuel.[33]

Most of the goods used in Alaska are shipped from the Lower 48 states by barges as shown here, moving through the Inside Passage of Southeast Alaska. Photo by Jim Nista.

Bulk carrier Selendang Ayu aground on Unalaska Island. Although carrying a cargo of soybeans, the ship spilled approximately 350,000 gallons of fuel oil and diesel oil. NOAA photo.

[30] Alaska Department of Environmental Conservation, 2007. 10-Year Statewide Summary, Oil and Hazardous Substance Spill Data. http://dec.alaska.gov/spar/perp/docs/10year_rpt/10YR_Core_web.pdf (Accessed July 2015).

[31] Alaska Department of Environmental Conservation, Division of Spill Prevention and Response. Major Oil Spills to Coastal Waters. https://dec.alaska.gov/spar/perp/bigspills.htm (Accessed July 2015).

[32] Ibid.

[33] Ibid.

In many cases, marine shipping accidents in Alaska waters occur in extremely remote locations, making cleanup and mitigating effects on wildlife extremely difficult. Although the reduction in sea ice in the Arctic may result in an increase in shipping traffic, this increase is expected to be relatively small during the next 10 years.[34] The risk of an extremely large marine oil spill has been reduced somewhat by the use of double-hulled tankers, but oils spills in ice would be challenging to clean up, and be quite damaging to most marine wildlife (see Pollution section).

Flight Paths and Military Training

There are a number of commonly used civilian flight paths over Alaska, including those used by in-state traffic, as well as those used by air traffic between Asia and North America. Due to the small population of the state, the overall amount of in-state civil air traffic is relatively low. Effects on wildlife of air traffic are primarily related to noise and air pollution generated during low elevation flight during take-off and landing. These effects are restricted to the areas near major airports. While there are localized effects on wildlife of flight paths and civil aircraft activity, these effects are unlikely to have population-level effects on wildlife.

A large expanse of land, sea, and airspace in Alaska is designated as military training area, including 65,000 square miles of airspace, 2,500 square miles of land space, and 42,000 square miles of ocean surface.[35] These areas are used for various kinds of military training, including live-fire exercises by both ground and air-based forces. Threats to wildlife from military training activity include direct losses of wildlife and habitat from munitions training and aircraft and vehicle collisions, increased air and water pollution from munitions and transportation (Racine et al. 1992), and behavioral effects related to noise pollution, particularly from low-level training exercises (Kaseloo 2005). These kinds of activities could have negative effects on a wide array of wildlife species and their habitats. While the total amount of land, water, and air space designated for military training is large, for most of the area, the overall percentage of time that activity is taking place, particularly at significant scale, is quite low.[36] Military training activities are also subject to large number of federal laws that control, minimize, and mitigate effects on wildlife.[37] Despite the large amount of area designated for military training in the state, these activities are unlikely to have population or landscape-level effects on wildlife.

Biological Resource Use

Hunting and Trapping

A large proportion of Alaska residents hunt and trap wildlife in Alaska, resulting in an estimated annual harvest of 22 million pounds of nonfish wildlife.[38] These activities have a direct effect on wildlife populations, resulting in the harvest of many thousands of animals each year,[39] especially deer, moose, caribou, bears, seals, walrus, upland game birds, and many species of waterfowl. When roads increase access to areas, combined threats from hunting and roads can have a cumulative effect on local wildlife populations. Harvests are managed to maintain healthy populations of the species. While

[34] Maritime Infrastructure: Key Issues Related to Commercial Activity in the U.S. Arctic over the Next Decade. GAO-14-299: Published: Mar 19, 2014. Publicly Released: April 18, 2014. http://gao.gov/products/GAO-14-299?source=ra (Accessed July 2015).http://gao.gov/products/GAO-14-299?source=ra (Accessed July 2015).

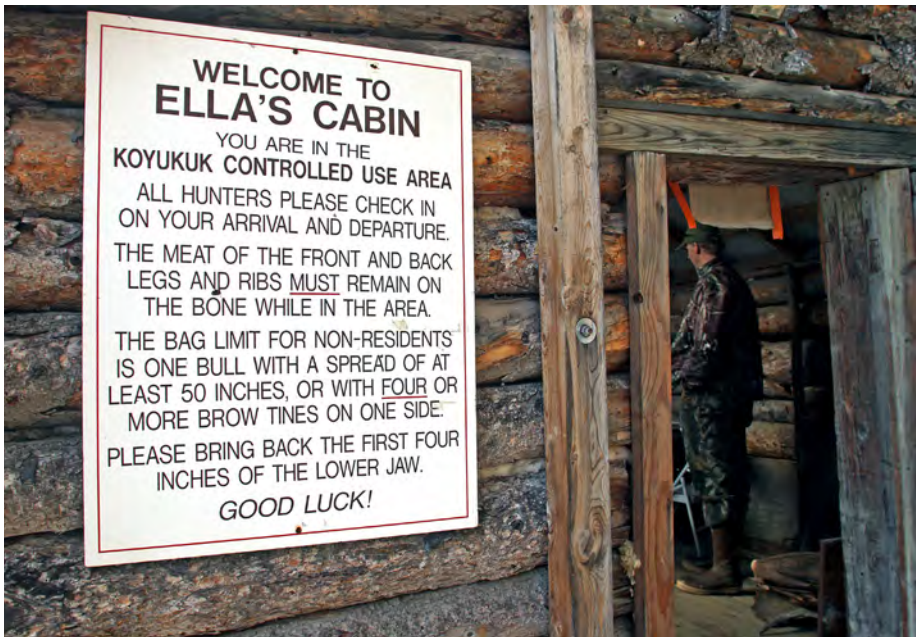
[35] Joint Pacific Alaska Range Complex, Frequently Asked Questions. http://www.jber.af.mil/shared/media/document/AFD-120214-039.pdf (Accessed July 2015).

[36] Joint Pacific Alaska Range Complex. U.S. Department of Defense. http://www.jber.af.mil/jparc.asp (Accessed July 2015).

[37] Ibid.

[38] Subsistence in Alaska: A year 2012 update. http://www.adfg.alaska.gov/static-f/home/subsistence/pdfs/subsistence_update_2012.pdf (Accessed 1 September 2015).

[39] ADF&G. Alaska's Game Species. http://www.adfg.alaska.gov/index.cfm?adfg=hunting.species (Accessed 1 September 2015).



Hunter checkstation on the Koyukuk River. Photo by Ken Marsh.

these harvests reduce the size of the populations of the targeted species, they are managed by both the state and federal governments under sustained yield principles. Alaska's state constitution includes a clause requiring management and utilization of natural resources under the sustained yield principle.[40]

Populations and harvests are monitored by game management area, and seasons and bag limits are adjusted annually as needed to protect population numbers. Because of the cultural importance in the state of these animals and the opportunity to harvest them, management is generally conservative. Therefore, hunting is unlikely to have population-level effects on most hunted species beyond the sustainable harvests Alaska has successfully managed for more than a half-century, since statehood in 1959.

Fishing

Large harvests of fish occur in Alaska in commercial, subsistence, sport, and personal use fisheries throughout the state. By far the largest of these harvests are from commercial fisheries. Commercial fishing in Alaska waters is managed by the State of Alaska on all inland waters and within the 3-mile limit in marine waters. Most commercial fisheries in marine waters outside the 3-mile limit, and all halibut fisheries, are managed by the federal government. State-managed commercial fisheries harvested more than 93 million pounds of shellfish in 2010, 230 million pounds of salmon during 2014,[41] and have averaged more than 80 million pounds of herring annually over the past 20 years.[42] In 2014, harvest in federally-managed commercial fisheries was about 660 million pounds[43] in the Gulf of Alaska and about 4.2 billion pounds in the Bering Sea/Aleutian Islands area.[44] State-managed subsistence fisheries harvest an estimated 28 million pounds of all species of fish annually,[45] and sport angler harvests averaged an estimated 2.9 million fish annually between 2004 and 2013.[46]

[40] The Constitution of the State of Alaska, Article 8—Natural Resources. http://ltgov.alaska.gov/Mallott/services/alaska-constitution/article-viii-96A0natural-resources.html (Accessed 19 September 2015).

[41] ADF&G. Alaska Commercial Salmon Harvests and Exvessel Values. http://www.adfg.alaska.gov/index.cfm?adfg=CommercialByFisherySalmon.exvesselquery (Accessed 1 September 2015).

[42] ADF&G. Commercial Herring Catch, Effort and Value. http://www.adfg.alaska.gov/index.cfm?adfg=commercialbyfisheryherring.herringcatch (Accessed 1 September 2015).

[43] National Marine Fisheries Service, Alaska Region, Sustainable Fisheries Catch Accounting. Gulf of Alaska Catch Report. http://alaskafisheries.noaa.gov/2014/car110_goa.pdf (Accessed 1 September 2015).

[44] National Marine Fisheries Service, Alaska Region, Sustainable Fisheries Catch Accounting. Bering Sea Aleutian Islands Catch Report. http://alaskafisheries.noaa.gov/2014/car110_bsai_with_cdq.pdf (Accessed 1 September 2015).

[45] ADF&G. Subsistence in Alaska: A year 2012 update. http://www.adfg.alaska.gov/static-f/home/subsistence/pdfs/subsistence_update_2012.pdf (Accessed 1 September 2015).

[46] ADF&G. Alaska Sport Fishing Survey database [Internet]. 1996– . Anchorage, AK: Alaska Department of Fish and Game, Division of Sport Fish (Accessed 1 September 2015). Available from: http://www.adfg.alaska.gov/sf/sportfishingsurvey/." (Accessed 1 September 2015).

For the most part, commercial fisheries that occur in state-managed waters primarily target salmon (mostly sockeye, chum, and pink), groundfish, herring, and crab (king, Dungeness, and Tanner), although there are fisheries targeting many other species of finfish and shellfish. State-managed subsistence and sport fisheries also primarily target sockeye, Chinook, coho, and chum salmon, but many species of shellfish and resident freshwater species of finfish are also harvested. Federally-managed marine fisheries primarily target pollock, Pacific cod, other groundfish species, and Pacific halibut.

This purse seigner is pulling in a heavy net of mostly hatchery pink and chum salmon. Photo by Geron Bruce, ADF&G.

All of these fisheries are managed under transparent systems of regulatory control, and are managed under sustained-yield principles.[47,48] The stocks that are subject to state-managed fisheries are monitored annually for escapement (salmon) or stock abundance (herring and shellfish), and harvests are monitored and controlled through fishery management plans that dictate management actions that restrict gear types, time, and areas in which fishing is allowed. Federally-managed marine fisheries are also managed for sustained yield, and the National Marine Fisheries Service conducts stock assessments annually to determine levels of total allowable catch. Both of these systems of management are designed to prevent overfishing. Biological and environmental variability can result in population declines. When these events have occurred, management regimes have adjusted by limiting harvests or closing entire fisheries.

Geoduck clams are patchily distributed in Southeast Alaska--the northern limit of their range. They are targeted by sport, subsistence, and commercial dive fisheries. Individual clams can live to be over 100 years old, and their recruitment is sporadic and very low, making this species susceptible to overharvest. Photo by Lorraine Vercessi, ADF&G.

Globally, slightly more than half of the fishery stocks are fully exploited (meaning no room for expansion). Worldwide, 28% of stocks are overexploited, 3% are depleted, and 1% are recovering from depletion. However, fisheries in Alaska are recognized world wide for sustainable management practices, and no Alaska stocks of fish are experiencing overfishing levels.

The most likely effects of fishing-related mortality on wildlife are related to bycatch (Lewison et al. 2004). Bycatch can include nontarget species, such as crab, octopus, halibut, salmon, and squid. Bycatch also causes direct mortality through the unintended capture of marine mammals,[49] seabirds, and corals, in fishing gear (Melvin and Parrish 2001; Lewison et al. 2004). All of these

[47] 5 AAC 39.222 in Chapter 5 of the Alaska Administrative Code, LexisNexis.

[48] Magnuson-Stevens Fishery Conservation and Management Act, Public Law 94-265, As amended by the Magnuson-Stevens Fishery Conservation and Management Reauthorization Act (P.L. 109-479).

[49] National Marine Fisheries Service. Marine mammal bycatch in U.S. commercial fisheries: Observations, extrapolations, and management. http://fish.washington.edu/classes/fish513a/pdfs/Week8Angliss.pdf (Accessed July 2015).

Herring from acoustic trawl. Researchers sort herring gathered in an acoustic trawl survey in Lynn Canal, Alaska. Photo by David Csepp, NOAA/NMFS.

bycatch issues are considered by the Alaska Department of Fish and Game, the North Pacific Fishery Management Council, and the National Marine Fisheries Service in setting seasons and limits. A number of regulatory measures have been implemented to address these concerns, including the identification and limitations on fishing in Marine Protected Areas, development of bycatch avoidance technologies and techniques, and the establishment of areas closed to bottom-contact fishing. While these efforts reduce impacts, the effect of bycatch on vulnerable populations can be significant.

Logging

Timber harvesting for commercial purposes occurs in 2 major forests of the state: the interior boreal forest and the coastal forests (Hutchison 1967). The bulk of the harvest has come from Southeast Alaska, where timber resources are superior. The coastal forests are also characterized as predominantly "old-growth" forest, where stands contain all-aged trees (some hundreds of years old), with multiple canopy layers, a patchy, heterogeneous quality, and a diverse, abundant understory. The dominant commercial tree species are western hemlock (56% of sawlog volume), Sitka spruce (38%) and red and yellow cedar (4%) (Hutchison 1967). The dominant harvest method used has been clearcut logging, in which trees of all ages in a stand are cut simultaneously. This allows maximum sunlight to reach the ground, which can benefit understory growth, and is more economical than selective logging. Clearcutting also results in a single-aged stand of replacement trees, which left untreated, will close over and shade out the understory in 15–35 years.

The largest timber harvests occurred in the 1940–2000 period, peaking in 1990 when more than 1 billion board feet were logged on National Forest and Native-owned private lands combined (Brackley

Species of Conservation Need: Yelloweye Rockfish, Sebastes ruberrimus

Yelloweye rockfish are found in the nearshore areas of Southeast Alaska, the Gulf of Alaska, and along the Aleutian Chain. They prefer rocky outcrops or underwater boulder fields, and stay near the bottom. Adults are often solitary and inhabit steep rocky areas that have nooks and crannies that provide shelter. They are slow growing and can live to well over a century old. A female may produce between 1.2 and 2.7 million young in a year. While stocks of yelloweye rockfish are considered healthy, careful management is necessary to sustain these populations. These fish are mostly captured as incidental catch in commercial longline and halibut sport fisheries. Because these fish can't vent their swim bladder, they often suffer an everted swim bladder when brought to the surface, which is usually fatal. ADF&G has engaged in an outreach program to educate sport anglers on the need to use deepwater release devices, which have been shown to significantly increase catch and release survival. ADF&G photo.

Logging in Southeast Alaska is typically by the clearcut method which removes all of the trees at once, and creates an even-aged stand in place of the original old-growth stand. Photo by John W. Schoen.

et al. 2009). High operating costs, declining markets, increased regulations, litigation, and public pressure to protect remaining old-growth habitat has led to much reduced sale offerings and harvest amounts in recent years. For the period 2002–2012 timber harvest on federal lands in Southeast Alaska averaged 37.5 million board feet (MMBF) per year. Over that same period on Native-owned lands in Southeast Alaska, it averaged 114.5 MMBF per year (Zhou 2013). On state-owned lands, it averaged 13.0 MMBF per year in Southeast Alaska (ADNR 2013).

On the Tongass National Forest, there is a plan to help maintain a long-term timber industry in the region by transitioning from old-growth logging to second-growth logging over the next 20–30 years. Whether this is economically feasible given the current struggles of the timber industry remains an open question.

Logging on National Forest lands occurs under a multiple use mandate that zones different forest areas for different uses, ranging from wilderness values to commodity values (timber and mineral production). The public is invited to comment on and influence these plans on National Forest lands. Logging is planned in ways that attempt to meet the needs of industry while protecting important wildlife resources. For example, providing no-cut buffers along salmon-bearing streams, estuaries, and the coastline helps to meet the important needs of wildlife, recreational users, and the tourism industry in watersheds where road building and logging are allowed.

On state and private lands, logging is regulated under the Alaska Forest Resources and Practices Act (FRPA). The act and related best management practices, govern timber harvesting, reforestation, and road design, construction, maintenance, and closure.

Clearcut logging in Southeast Alaska has left the largest development footprint in the state apart from urban areas, with approximately 400,000 acres of old-growth forest logged on public lands,[50] and over 200,000 acres logged on private lands,[51] Although only 11.9% of productive old-growth forests have been logged regionwide, large-tree stands have been reduced by at least 28.1%, karst forests by 37%, and landscapes with the highest volume of old growth by 66.5% (Albert and Schoen 2013).

Most of the past logging occurred on highly productive sites, at lower elevations, in riparian areas, and nearer the coastline (Albert and Schoen 2013). These impacted sites traditionally had the highest fish and wildlife values, and so logging has had impacts disproportionate to the area logged. Scientists predict that on some islands, like Prince of Wales Island, loss of rare forest types may place local viability of species dependent on old growth at risk of extirpation (Albert and Schoen 2013). Most of the listing petitions for terrestrial taxa in Alaska, including the Queen Charlotte Goshawk, Prince of Wales flying

[50] Alaska Forest Association. 111 Stedman Street, Suite 200 | Ketchikan, AK 99901. Alaska Forest Facts. http://akforest.org/facts.htm (Accessed July 2015).

[51] Sealaska Corporation. http://www.sealaska.com/home-lands/land-legislation/myths-facts/clear-cutting (Accessed July 2015).

squirrel, and Alexander Archipelago wolf, have asserted that logging-related habitat loss is affecting these species.[52]

Logging in the boreal forest is more focused on 1) the more productive stands of white spruce for lumber found in both upland and riparian settings, and 2) hardwood for fuel, found in upland settings. White spruce accounts for 57% of interior forest, followed by paper birch (23%), aspen (11%), and balsam poplar and cottonwood (9%) (Hutchison 1967). Riparian forests are relatively important wildlife habitat, and the effects of their loss or conversion on wildlife are not well understood.

Harvesting Wood Biomass for Energy—Biomass energy may be produced by combustion of fish oil, solid waste, or wood to generate heat and power. It is gaining interest, and some application, especially in rural areas of Alaska where the cost of petroleum-based fuels is very high. There are 10 facilities in Alaska currently using biomass for fuel, 14 under construction, and 24 undergoing feasibility studies.[53]

The most common and plentiful biomass fuel is wood. It is used in the form of cordwood, wood chips, or wood pellets/briquettes. This material can come from residual sawmill waste, from slash (limbs and tops) left on the ground during standard logging or thinning operations, or from timber sales specifically for whole trees that will be chipped. When wood waste is used at mills, there is no additive threat to wildlife or wildlife habitat. Where the harvest focuses on larger trees or on fast-growing deciduous species such as willow, aspen, alder and poplar, this logging activity does change the structure and habitat value of these stands for wildlife. These changes may be positive or negative, depending on the wildlife species considered. Thus, biomass harvesting in Alaska has the potential to impact boreal forests in Central Alaska.

Willows that grow naturally have been proposed as a source of biomass fuel. National Park Service photo.

Human Intrusion and Disturbance

Recreational Activities

Alaska is a state known for its abundant opportunities for recreational activities, and both residents and many of the approximately 1.6 million tourists who visit Alaska each year take advantage of them (McDowell Group 2015). These opportunities include consumptive activities such as fishing and

[52] The petitions for Prince of Wales Flying Squirrel and Queen Charlotte Goshawk have been found not warranted. The decision on the wolf is under review by the USFWS.

[53] Alaska Energy Authority. Biomass in Alaska. http://alaskarenewableenergy.org/wp-content/uploads/2009/11/REAP_biomass-Presentation_March-2012.pdf (Accessed July 2015).

hunting, as well as many nonconsumptive activities like backpacking, hiking, wildlife viewing, biking, camping, snow machining, jet skiing, and boating. Threats to wildlife in the state from hunting and fishing are addressed in the section on Biological Resource Use. Threats to wildlife from nonconsumptive recreational activities, particularly motorized transportation to access recreation, are most likely to involve displacement behavior (e.g., avoidance of noise and humans), damage to habitats from vehicles (e.g., riverbank erosion from wakes, surface damage from off-road vehicle traffic), and increased risk of wildfire danger from human-caused ignition.

Most recreational activity that occurs in Alaska outside of human population centers generally happens at a low level of intensity; that is, only a small number of people are participating in any given area at one time. In addition, because the transportation infrastructure in the state is confined to the limited road system, the barriers to access most of the wildlife habitat in the state are so great that much of it is unavailable to recreationists. Because of these factors, recreational activities are unlikely to have population-level effects on wildlife. Exceptions to this include popular river corridors, some accessible ocean shoreline, areas near population centers, and popular fish and wildlife viewing areas where human activity can be very concentrated, and can affect riparian and shoreline habitats important to some bird and aquatic species.

Switchbacks on the way to Crow Pass. Alpine environments can show the effects of heavy recreational use, as evidence by these switchbacks on the hike to Crow Pass. This trail is also part of the 23-mile Crow Pass running race. Photo by Frank Kovalchek.

Military Exercises

Two major military exercises are conducted every year in Alaska, involving thousands of personnel, and hundreds of vehicles, aircraft, and facilities.[54] There is also ongoing military training that occurs on a much smaller scale. These activities result in temporary increases in aircraft overflights (sometimes at low elevation), vehicle traffic, and live fire exercises in the training areas utilized. All of these activities are likely to have some effect on wildlife populations. The primary effects of these activities would be the direct loss of wildlife and habitat from live ordinance use and disturbance behavior from aircraft, ordinance use, and vehicle and human activity. While these effects could be significant in some areas, the total amount of land area designated for military maneuvers in the state is less than 0.001 percent of all land in the state,[55] and these activities are unlikely to have population level effects on wildlife.

[54] Joint Pacific Alaska Range Complex. U.S. Department of Defense. http://www.jber.af.mil/jparc.asp (Accessed July 2015).
[55] Ibid.

Natural System Modification

Fire and Fire Suppression

Wildfire plays an important role in the life history of many species of wildlife in Alaska. Wildfires can reduce wildlife populations through the immediate loss of animals and the short-term loss of suitable habitat over large areas. Wildfire is also an important part of natural systems that maintains biological diversity (Smith et al. 2000); overall, the natural cycle of habitat change caused by wildfire generally leads to more productive and diverse landscapes. As climate change brings more frequent and severe fires to Alaska, scientists expect to see a net increase in deciduous forests (e.g., alder, willow, aspen, birch), and a decrease in conifer forests (e.g., black spruce; Johnstone et al. 2010). Climate change could also lead to a shift from forest cover to shrublands and grasslands in some regions in response to shorter fire cycles and spring fires. Both of these types of landscape-scale habitat changes would lead to changes in the distributions of various species of wildlife, with some species' ranges contracting and some expanding. Fire regimes in treeless arctic tundra are less well understood, and there is some evidence that high-intensity tundra fires may lead to permanent changes in vegetation (Racine et al. 2004), which could have significant effects on wildlife. Alaska has seen some major wildfire seasons over the past 20 years, including 2004, when 6.7 million acres burned.[56] Both the size and frequency of tundra fires have increased in Alaska in the recent past (Rocha et al. 2012).

Paratroopers from Fort Richardson descend over Donnelly drop zone. Photo by Marlene S. Berry, U.S. Army.

Wildfire and the changes to habitats it causes can affect a diverse range of wildlife, both positively and negatively. Vegetation change caused by tundra fires could reduce the availability of the preferred feed of caribou, but may increase habitat suitability for other species such as moose and ground squirrels. Because of the large percentage of Alaska that is undeveloped and inaccessible, recent fire management planning has designated most of the state as falling in "limited protection zones."[57] This means that many fires that were suppressed in the past will now be allowed to burn. Overall, this should have a positive effect on wildlife populations. With the possible exception of severe widespread tundra fires, wildfires in Alaska are unlikely to have negative population-level effects on wildlife.

[56] U.S. Department of Interior, National Incident Command Center. http://www.predictiveservices.nifc.gov/intelligence/2004_statssumm/incident_support.pdf (Accessed July 2015).

[57] U.S. BLM. Alaska Interagency Wildfire Management Plan. 2012. http://fire.ak.blm.gov/content/planning/aiwfmp_2010.pdf (Accessed July 2015).

Dams, and Water Management and Use

Alaska is in the fortunate position of having relatively few water impoundments, and much of the state has abundant surface and groundwater availability. There are about 167 named dams in the state. Most of these dams are relatively small, and were built for small hydropower operations, for municipal water storage for small communities, and for treatment of water at mining operations. Threats to wildlife from possible future dams and from water withdrawals are most likely to come from any future major hydroelectric dam or from dams or water withdrawals associated with large-scale mineral and oil and gas development. Dams and water withdrawals have the potential to de-water stream channels downstream of the dam or withdrawal, resulting in reduced flows and increased water temperature, and create fish migration barriers. These threats are most likely to affect fish, other aquatic organisms, and waterfowl, as well as downstream wetland or estuarine habitats. Another concern is the potential failure of containment dams holding effluents from mineral processing. These kinds of effluent can directly kill fish and other aquatic organisms, and can alter habitat through sedimentation and channel modification.

Kanuti River and burned area. Photo by Steve Hillebrand, USFWS.

There are currently a number of regulatory protections for wildlife in Alaska related to water impoundments and withdrawals. The Anadromous Fish Act (AS 16.05.871- .901)) contains protections for any stream that is habitat for anadromous fish. Also, a large percentage of Alaska is designated as federal parks, monuments, and wildlife refuges; and waters of these lands are unlikely to see development involving dams or water withdrawals. Although preliminary environmental work has been undertaken (twice in the last 35 years) for the development of a hydroelectric dam on the Susitna River, the cost of development is likely to prevent that project from moving forward in the next decade, given the current fiscal environment in the state. Because of the size and inaccessibility of most of Alaska and existing regulatory protections, dams and water use are unlikely to have significant population-level effects.

The Salmon Creek dam, built in Juneau in 1914, was the first variable radius arch dam in the world. The reservoir continues to provide drinking water and power for the city of Juneau. Photo by Nvvchar.

Invasive and Other Problematic Species

Invasive Species

For the purposes of this plan, invasive species is defined using the language of Executive Order 13112: "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Alaska currently has few invasive animal species that have spread and multiplied to the point of causing major ecological effects.[58] The most serious effects of invasive species, so far, have been felt on individual Aleutian Islands where the establishment of exotic foxes, rats, and mice have wreaked havoc with some bird populations, and pushed some, like the Aleutian Canada Goose, to near extinction. Successful eradication of foxes on most islands (Petersen et al. 2015), and rats on some others (Buckelew et al. 2011), has restored the natural fauna on most of those islands today.

While the state's physical environment prevents many potential invasive species from becoming established, the low level of biodiversity also increases the risk that establishment of an invasive species population could lead to the decline of a native species. Warming, drying, and potential landscape-scale changes caused by climate change could lead to habitats becoming suitable for many plant and animal species, allowing populations to become established. These new species are likely to have negative effects on wildlife in the state, both through predation and competition for resources, and also as potential vectors for animal and plant pathogens that are not currently found in the state. Increases in human development, particularly new roads and other transportation improvements, are also likely to hasten the spread and establishment of invasive species, both those that are already found in the state and new species moving north.

Currently the invasive species most likely to threaten aquatic wildlife in the state are probably some marine colonial tunicates and some plant species (*Elodea* spp.), especially surface aquatics that are likely to be spread by floatplane traffic among lakes, or through flowing waters by downstream transport of plant fragments. All of these organisms can spread rapidly and outcompete native plants, altering the habitat and reducing the available forage species of wildlife. Elodea can completely fill slow-moving river channels, slowing current and increasing water temperatures, and could pose a threat to a number of fish species and other aquatic organisms.

Arctic foxes were introduced to some of the Aleutian Islands where they are an invasive species. This image is of the Pribilof arctic fox, a subspecies native to the Pribilof Islands. Photo by Kelly Nesvacil, ADF&G.

A number of invasive terrestrial plants could outcompete willow and native grasses which serve as browse and provide bird habitat. Some of these invasive species could have significant economic effects, ranging from population declines of economically important native species due to competition from invasive species to transportation and infrastructure problems from marine fouling organisms. Because invasive species can have significant impacts on native wildlife species, are currently not widespread,

[58] ADF&G Invasive Species Overview. http://www.adfg.alaska.gov/index.cfm?adfg=invasive.main (Accessed July 2015).

and can be controlled with diligent efforts, we consider the control of invasive species a high priority. Table 3 provides a list of the animal and plant invasive species that currently pose the greatest threats to wildlife in the state.

Most invasive species have limited distributions in the state, primarily associated with human population centers, and it is unclear how quickly they are spreading. Although natural spread does not appear to be occurring very quickly, anthropogenic spreading can accelerate the rate of spread of these species to remote areas. There are currently a number of laws and regulations in the state aimed at preventing the introduction of potential invasive species, and both the state and federal governments and nongovernmental organizations (NGOs) have engaged in public education efforts regarding the dangers of introducing nonnative species.

Problematic Native Species

Hatchery-reared salmon, particularly pink and chum salmon, can contribute to high population levels that result in direct competition with other species for forage fish (see aquaculture threat). Northern pike,

Table 3. Species that are considered a threat to wildlife and their habitats in Alaska as invasive species (human-facilitated).

INVASIVE ANIMAL SPECIES	INVASIVE PLANT SPECIES
Paralithodes brevipes, Hansaki king crab	*Fallopia xbohemica*, bohemian knotweed
Eriocheir sinensis, Chinese mitten crab	*Fallopia japonica*, Japanese knotweed
Carcinus maenas, European green crab	*Fallopia sachalinensis*, giant knotweed
Potamopyrgus antipodarum, New Zealand mud snails	*Phalaris arundinacea*, reed canarygrass
Didemnum vexillu, tunicate	*Elodea Canadensis*, Canadian waterweed
Botrylloides schlosseri, tunicate	*Hieracium aurantiacum*, orange hawkweed
Botrylloides violaceus, tunicate	*Hieracium caespitosum*, meadow hawkweed
Salmo salar, Atlantic salmon	*Cirsium arvense*, Canada thistle
Esox Lucius, northern pike (native in some regions)	*Prunus padus*, European bird cherry (Mayday tree)
Psuedacris regilla, Pacific chorus frog	*Vicia cracca*, bird vetch
Rana aurora, red-legged Frog	*Melilotus albus*, white sweet clover
Alectoris chukkar, Chukar	*Lythrum salicaria*, purple loosestrife
Colinus virginianus, Bobwhite Quail	*Centaurea stoebe*, spotted knapweed
Phasianus colchicas, Ring-necked Pheasant	*Alliaria petiolate*, garlic mustard
Passer domesticus, House Sparrow	
Sturnus vulgaris vulgaris, European Starling	
Streptopelia decaocto, Eurasian Collared Dove	
Mus musculus, house mouse	
Rattus norvegicus, Norway rat	
Rattus Rattus, roof or ship rat	
Oryctolagus cuniculus, European rabbit	
Procyon lotor, raccoon	
Arion ater, European black slug	

Sources: ADF&G Invasive Species Program and the AKEPIC Data Portal, Alaska Natural Heritage Program.

Northern Pike are native to some lakes in Alaska, and have been introduced in others. They are aggressive predators on native trout and salmonids. Photo by Luc Viatour.

which are native to much of northern Alaska, can become problematic when they are transplanted to other waterbodies (Sepulveda et al. 2013). Mink were transplanted to some islands in the early twentieth century for ranching, and these populations can have significant effects on native seabirds.[59] Northern sea otters have increased in some areas to very high levels, resulting in depletion of shellfish and urchin populations (Carswell et al. 2014). Desirable game species, such as mountain goat and deer, have been transplanted in Alaska to islands outside their native range, and have thrived (Paul 2009). To the extent these animals compete with, or prey upon, native wildlife, they pose a possible conflict (Martin et al. 2011; Lewis and Klein 1992). Experience proves there is little ability (or desire) to eliminate transplanted game species once they are successfully established.

Pollution

Overall, the amount of human-caused pollution that enters Alaska's waters and air from in-state sources is small relative to the size of the state. Because of the largely undeveloped nature of the state, pollution threats are low except in connection with localized development (e.g., mines, household sewage). These are not expected to broadly threaten species viability.

Household Sewage and Urban Waste Water

Most household and other urban waste water in the state is collected and treated in sewage treatment plants before being discharged into rivers or directly into the ocean, except in sparsely populated and small villages of rural areas. While there are some risks to wildlife associated with levels of metals and chemicals that are not completely removed by the treatment process, the total amount of this kind of pollution (and the area it may affect) in relation to the amount of wildlife habitat in the state makes it very unlikely that these factors would have population-level effects on wildlife. Effluent from large cruise ships has been considered a problem to nearshore ecosystems, and regulations now require cruise ships in Alaska waters to maintain approved wastewater treatment systems, and limit where discharges can occur. These effluents are generally regulated under the requirements of the federal Clean Water Act, and require permitting and monitoring for compliance.

Industrial and Military Effluents

Alaska has little manufacturing industry at present (4% of state GDP), but there are ongoing efforts to grow this in the future. Alaska has several oil refineries, a number of fish processing plants, and one fertilizer plant (not currently operating). The U.S. Department of Defense has approximately 700 formerly used defense sites in Alaska, all of which are polluted with a variety of toxic contaminants.[60] There are 2 large and 2 smaller military bases in the state. All of these industrial and active military

[59] Environmental assessment draft potential recovery of pigeon guillemot populations Naked Island group, Prince William Sound. Chugach National Forest, Alaska. http://www.fws.gov/alaska/pdf/pigeon_guillemot_recovery_ea_072013.pdf (Accessed July 2015).

[60] Alaska Community Action on Toxics. 2003. Environmental Justice and Military Superfund Sites in Alaska. http://www.akaction.org/wp-content/uploads/2013/06/EJ_AK_Military_Superfund_Sites_2003.pdf (Accessed July 2015).

sites contribute some discharges of water pollution, but all are also under the same regulations and permitting requirements as sewage treatment plants.

The source of pollution most likely to pose a threat to wildlife populations is large-scale mineral development. Although there are regulations in place to limit discharges of pollution, those restrictions may be intentionally or unintentionally violated.[61]

Agricultural and Forestry Effluents

Because there is so little agricultural land in the state, and most of that land is not intensively fertilized, there is very little risk that agricultural effluents will cause any population-level effects on wildlife. Effluents from the forest products industry in the state currently include increases in natural runoff from clearcutting and sedimentation due to landslides (which is exacerbated by logging on steep slopes). Sedimentation from road building and logging-related operations is monitored and regulated by the Alaska Department of Natural Resources under the Alaska Forest Resource Protection Act (FRPA). There are no longer any pulp mills operating in the state.

Garbage and Solid Waste

Garbage in unsecured containers and in landfills is a major attractant to wildlife, such as bears (Peirce and Van Daele 2006). This can result in nuisance and safety issues for people in rural and urban communities (Peine 2001), as well as provide a nutritional subsidy to avian and mammalian predators, potentially skewing the population balance among some species (Ripple et al. 2014).

Solid waste in the state is mostly contained in landfill operations in major population centers. Over the past several decades, most of these operations have been upgraded to meet modern standards, with lined pits and effluent recovery systems. Solid waste systems in rural areas of the state are more likely to pose some threat to wildlife because they tend to be simple landfill operations. These sites can attract and support unnaturally high levels of avian and mammalian predators (e.g., ravens, gulls, and foxes) which can result in excessive depredation of nests and young in the nearby vicinity (Weiser 2010). While solid waste treatment and storage do result in some wildlife impacts, it is not likely to affect species viability at a large scale.

This Laysan Albatross chick has died from ingesting plastic garbage picked up while foraging. Photo by Claire Fackler, NOAA.

[61] U.S. Department of Justice. Justice News. March 4, 2015. Mining Official Pleads Guilty in Alaska to Making Illegal Discharges from the Platinum Creek Mine and for Making False Statements to Federal Officials. http://www.justice.gov/opa/pr/mining-official-pleads-guilty-alaska-making-illegal-discharges-platinum-creek-mine-and-making (Accessed July 2015).

The improper disposal of garbage at sea, including discarded fishing gear, has resulted in significant accumulations on beaches (Hess et al. 1999) and in open-ocean gyres. This can result in entanglements and ingestion, with associated harmful effect on seabirds and marine mammals (Manville 1989; Raum-Suryan et al. 2009).

Airborne Pollutants

In-state air pollution in Alaska is also concentrated around urban population centers, and primarily arises from vehicle exhaust and heating of buildings (particularly with wood). Air pollution is also present in the state from global sources such as transportation and coal-fired electrical generation. Threats to wildlife from air pollution in the state are probably primarily related to pollutants such as heavy metals and persistent organic pollutants, mostly because those substances bioaccumulate, as evidenced in Alaska birds (Evers et al. 2014; Kaler et al. 2014), whales, (Hoguet et al. 2013), fish (Kenney et al. 2014) and wolves (McGrew et al. 2014).

Geologic Events

Threats to wildlife populations in Alaska from geologic events, while highly unpredictable, have the potential to be significant. The state is located in the most tectonically active region in the country, with a significant portion of its coastline lying at the intersection of two major tectonic plates. Alaska's mainland is on the very eastern edge of the North American tectonic plate, and the northern edge of the Pacific Plate is moving eastward and colliding with the mainland. These conditions have led to a high frequency of earthquake activity in the state, including a 9.2 magnitude quake in 1964 that resulted in significant loss of coastal habitat in some areas. The zone between the 2 tectonic plates is also responsible for the more than 50 volcanoes that mostly lie in an arc from the southwestern edge of the Alaska Range out the Aleutian Island chain.

Threats to wildlife from geologic events in Alaska are primarily related to the possible effects of earthquake-induced tsunami damage to coastal habitats, coastal wetland habitat loss from earthquake induced uplift or subsidence, and the potential for widespread ash fall from a major volcanic eruption. Earthquake-induced breaches of mining ponds, holding facilities, or similar infrastructure could also threaten wildlife and habitats. Tsunami damage to coastal habitats could result in direct loss of nearshore marine life and temporary loss of habitat from wave action damage. As a result of the 1964 Alaska earthquake, approximately 70,000 square miles of land subsided over 3 feet, and some areas uplifted as much as 10 feet. Most of this land was in coastal areas. Shallow, nearshore marine habitats such as estuaries and lagoons are extremely productive and are important habitat for seabirds and a number of juvenile fish and shellfish, including salmon and some forage fish species.

A major volcanic eruption would likely cause some direct loss of wildlife and habitat in the immediate area of the volcano, but more dispersed and potentially more serious effects could result from widespread ash fall. Geologic evidence of ash fall events from prehistoric volcanic eruptions has shown areas affected as much as several hundred miles from the ash source.[62] Volcanic ash can be harmful to wildlife health, causing direct mortality from inhalation, increasing sedimentation and radical change of the pH of waterbodies, and the death of vegetation that wildlife depends on. These effects can last for significant amounts of time, possibly multiple generations for wildlife populations.

[62] U.S. Geological Survey, Fact Sheet 027-00 Online Version 1.0. Volcanic ash fall, a hard rain of abrasive particles. http://pubs.usgs.gov/fs/fs027-00/ (Accessed 1 September 2015).

Climate Change

New lava dome at summit of Mt. Redoubt following 2009 eruption. Photo by Cyrus Read, Alaska Volcano Observatory/USGS.

Most of the threats to wildlife populations in Alaska that are expected to arise from the changing climate will result from projected landscape-scale changes in habitats. Some of these habitat changes and accompanying trophic disruptions are predicted to result in extinctions or local extirpations of significant numbers of species (Maclean and Wilson 2011). These potential habitat changes would also lead to significant changes in the ranges of many species. Many of the drivers of change to habitats are themselves interrelated. For example, multiple factors affect freshwater availability and temperature, and these factors tend to be self-reinforcing: warming leads to decreased water availability, which leads to warmer water, which leads to higher evaporation rates, which leads to further decreases in water availability. Permafrost melting is strongly related to freshwater availability, which is closely related to vegetation change. Because of how strongly these factors are related and interact, the discussion of the individual elements below includes unavoidable repetition. In the interest of brevity, these discussions are not exhaustive, and focus on the most likely and most disruptive effects of climate change.

Sea Ice Decline

Over the past few decades, the rate of warming in the Arctic has been over twice the rate at lower latitudes (Kaufman et al. 2009; Melillo et al. 2014). This warming has been accompanied by a rapid loss in sea ice (AMAP 2012; Vihma 2014). Sea ice decline is of particular concern because its effects are likely to create positive feedback, or conditions that result in further sea ice decline. It is important to acknowledge that there is a significant range of outcomes in the many models that climate scientists have developed

As ice cover declines in the arctic, the darker water absorbs more heat from the sun and accelerates ice melting. Photo by Christopher Michel.

The Kittlitz's Murrelet is a seabird that commonly associates with glaciers during the breeding season. It nests on recently deglaciated rock and feeds in the waters of glacially-carved fjords. Photo by John W. Schoen.

regarding the rate at which sea ice will decline, but all models predict increased sea ice loss over time (Vihma 2014).

There are a number of potential effects on wildlife and their habitats caused by sea ice decline. These include direct effects such as the loss of denning, hunting, and haulout habitat for marine mammals, which is likely to have negative effects on polar bears, walrus, and ice seals (Laidre et al. 2015). Another likely direct effect is changes in Arctic Ocean currents, which play a significant role in the migration of juvenile Arctic cisco (Zimmerman et al. 2013) and adult Dolly Varden, and also influence permafrost melting (Fritz et al. 2015), and nearshore salinity and temperature—all influencing productivity and the distribution of marine life. Increases in coastal erosion are likely to negatively impact coastal habitats such as lagoon, estuary, and salt marshes, which are important habitat for many migratory birds and fishes and the trophic systems they depend on.

A likely indirect ecosystem-level effect is related to changes in productivity in the Chukchi and Bering seas due to warmer water and more light penetration. Changes in productivity may include increased algal production, changes in ocean current, temperature, and wind patterns, and changes in phytoplankton and zooplankton community structure. These effects are very difficult to predict, but could result in significant changes in trophic dynamics and in the community structure of secondary producers and consumers, including forage fish assemblages and commercially exploited species such as walleye pollock.[63] A number of important seabird, fish, and marine mammal species are upper trophic level predators in these systems, and are likely to be species that show the effects of these ecosystem-level changes (Moore et al. 2014).

Polar bears are among the ice-associated species expected to decline as warming temperatures diminish sea ice extent in the Arctic. Photo by Justin Crawford, ADF&G.

An additional effect of sea ice decline is the likely increase in marine traffic in the Beaufort and Chukchi seas, which will increase the likelihood of direct disturbances to marine wildlife from noise, and will increase both air and water pollution. In addition to increases in transportation activity, the decrease in the extent and duration of sea ice cover is likely to increase the likelihood of offshore oil and gas development, which has its own set of potential effects, including increased noise and the possibility of oil spills.

[63] NOAA Fisheries-Alaska Fisheries Science Center. What is the impact of the Ecosystem on fishery resources in the Bering Sea? http://www.beringclimate.noaa.gov/essays_livingston.html (Accessed 1 September 2015).

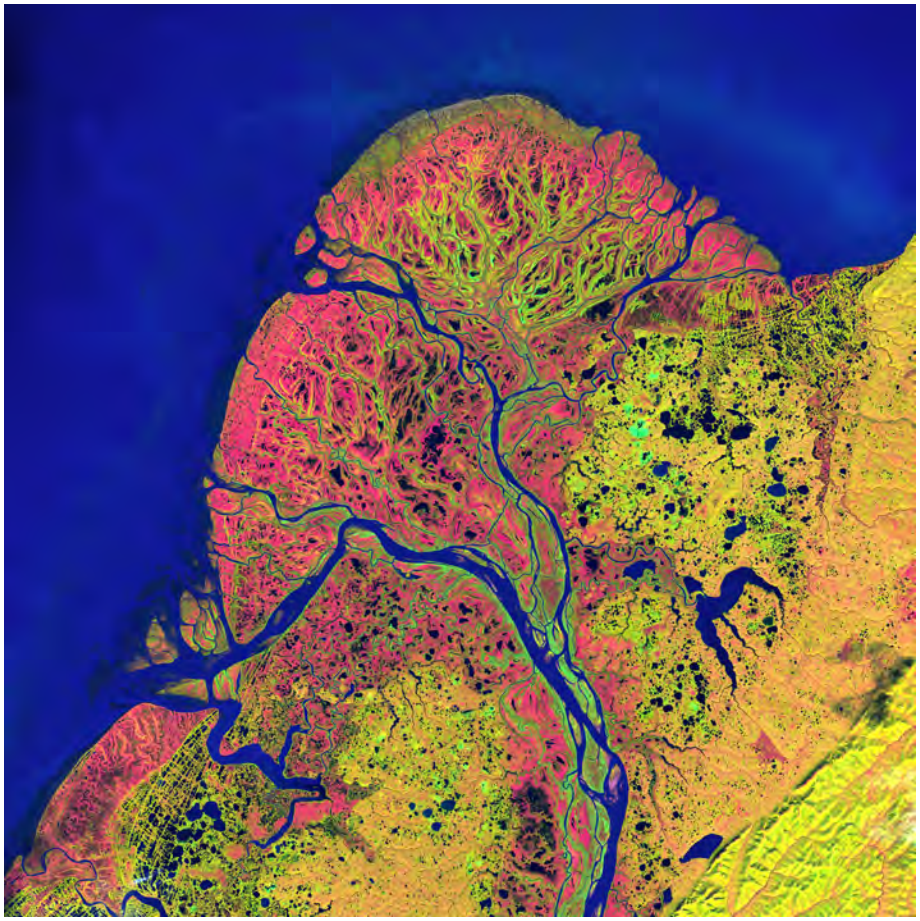
Sea Level Rise

Sea level is projected to rise between 1.5 to 5 feet by the end of the current century.[64] The effects on wildlife populations and their habitats are primarily related to habitat loss from coastal inundation, increases in the extent and effects of storm surge, and the alteration of critical habitats such as estuaries, eelgrass beds, salt marshes, and coastal lagoons. Much of the most productive and important habitat for waterfowl in Alaska is in extremely low-lying areas such as the Yukon–Kuskokwim Delta and the coastal plain of the North Slope. These areas could experience significant saltwater intrusion, leading to loss of nesting habitat and significant changes in food webs that support waterfowl and other wildlife.

Estuaries and eel grass beds are critical habitat for a number of marine and anadromous fishes, and increased sedimentation and increased salinity could alter the vegetation and trophic systems. This is of particular concern because these nearshore habitats play a critical role in the juvenile development of many marine and anadromous fish species. In some coastal areas of Alaska, where deglaciation is actively occurring, sea level rise may be counteracted by isostatic rebound. The effects of sea level rise on some migratory species may be felt most acutely on more southern shoreline habitats used as stopover feeding or staging in migration.

Ocean Acidification

Of all the threats to wildlife related to climate change, ocean acidification has both the potential for some of the most widespread and disruptive ecological effects, and is of such a complex nature that those effects are the hardest to predict or to mitigate. Ocean water in Alaska is more susceptible to the acidification effects of increased atmospheric carbon dioxide (CO_2) because of its colder temperatures (Steinacher et al. 2009). Some of the most abundant and productive species of marine plankton and benthic arthropods in the marine waters of Alaska form shells using carbonate minerals, and ocean acidification already has reached threshold levels that negatively affect these organisms (Mathis et al. 2011; Fabry et al. 2008). This group of



An image from space of the low-lying Yukon River Delta, showing its many water features. NASA photo, Goddard Space Flight Center.

[64] UNEP, IPCC. Climate change 2013: the physical science basis. Chapter 13, Sea level change. https://www.ipcc.ch/pdf/unfccc/cop19/3_gregory13sbsta.pdf (Accessed 1 September 2015).

animals is a critical component of the marine trophic systems that produce much of the forage fish which seabirds, marine mammals, and many species of commercially harvested fish rely on (Fabry et al. 2009). Acidification appears to have negative metabolic effects on many marine organisms beyond those related to forming calciferous shells, so the impacts of ocean acidification on marine food webs may be far more pronounced than previously thought. The potential trophic cascades that could result from the loss of populations of primary consumers (zooplankton spp.) could have profound effects on almost all wildlife that are secondary consumers, from sea birds to many species of fish to marine mammals.

Freshwater Availability and Temperature

Many models predict that one major effect of climate change will be changes in precipitation patterns, with water availability overall projected to decrease due to increased evaporation and runoff, especially in the Interior and Arctic regions of Alaska.[65] The timing, duration, and temperatures of runoff in many river systems in Alaska is moderated throughout the summer by the melting of water stored in glaciers and permanent ice fields, which are losing mass every year. Even relatively minor decreases in water availability could lead to the loss of migration routes for fish to spawning and overwintering habitats, and/or loss in the quantity of those spawning and overwintering habitats, up to and including complete loss of those habitats.

The Koyukok River winds its way through Kanuti National Wildlife Refuge. Photo by Bill Raften, USFWS.

As temperatures rise in general, and if precipitation amounts decrease and contributions to riverine systems from snowmelt and ice fields and glaciers decrease, riverine water temperatures will rise as well. Most salmonids are cold water adapted, and have upper limits on what is considered their survivable temperature range, and the effects of climate warming is likely to increase water temperatures beyond those limits, leading to adverse health effects. A number of fish diseases, particularly those involving fungal infections, are known to be exacerbated by warm water temperatures. There is already anecdotal evidence of these types of fungal outbreaks in salmon returning to the Kobuk River and in Dolly Varden in the Noatak River.

Most glaciers in Alaska are wasting and retreating, including this hanging glacier in Endicott Arm, Southeast Alaska. Photo by Amy Carroll, ADF&G.

Freshwater inputs to the marine environment from many large river systems in southern Alaska are strongly influenced by glacier and ice field melt. These influences have significant effects on nutrient input, temperatures, salinity,

[65] 2014 National Climate Assessment. U.S. Global Change Research Program. Climate change impacts in the United States. http://nca2014.globalchange.gov (Accessed July 2015).

and currents in the nearshore marine environment, particularly in fjord and estuarine environments (O'Neel et al. 2015). These ice fields and glaciers are rapidly losing mass, and warmer temperatures are resulting in less precipitation falling as snow, also leading to less water storage potential. The current increases in freshwater runoff and the eventual decreases are likely to result in significant changes to the chemistry and physical properties of habitats that are extremely productive and serve as rearing areas for many fish species, as well as feeding areas for seabirds, whales, and marine mammals (O'Neel et al. 2015).

Along with factors that result in less water on land, increased temperatures also are likely to contribute to significant drying of the landscape in Alaska. There is already evidence of lakes and wetlands shrinking throughout the state (Klein et al. 2005; Riordan et al. 2006; Rover et al. 2012). Diminished water in these habitats leads to increases in summer temperatures, leading to further drying. The reduction in the quantity and quality of freshwater habitats is of particular concern since these support so many fish and waterfowl.

Permafrost Melting

Increasing mean temperatures and increases in the seasonal duration of above-freezing temperatures are expected to result in increased seasonal depth of thaw throughout Alaska. This will affect soil chemistry and overall productivity in general, but the most disruptive effects are likely to occur in the approximately 80% of the state that is underlain by continuous or discontinuous permafrost. Continuous permafrost appears to have warmed in northern Alaska by as much as 3 degrees Centigrade (3.6 degrees Fahrenheit) over the past 40 years, even at depths of over 70 feet (Osterkamp and Romanovsky 1999).

This increased depth of thaw has the potential for significant disruptive landscape-scale effects on wildlife habitats. In areas with ice-rich permafrost, the combination of thawing and poor drainage can result in ground surface subsidence and soil oversaturation, causing tree mortality and widespread vegetation change (Jorgenson et al. 2001).

Black-legged Kittiwake in meltwater pool on Arctic Sea ice. Photo by Christopher Michel.

In areas of dry permafrost, thawing will lead to increased drainage and decreases in available moisture, which can also lead to wide-scale vegetation change (Hinzman et al. 2003). Permafrost melting can also change surface hydrology, leading to drying of ponds and wetlands (Yoshikawa and Hinzman 2003). In flowing-water environments, permafrost melting results in stream bank destabilization, increased sedimentation, and

decreased water quality, which can affect spawning success of fish and productivity of aquatic macro invertebrates, which are the primary food source for many fish species.

A thermo-karst melt pond created when an adjacent road accelerated the melting of permafrost. Photo by John Cloud, NOAA.

Another likely significant effect of permafrost thawing relates to the freeing of carbon currently sequestered in frozen soils, which could result in a positive feedback cycle. Increased depth of thaw and increased soil temperatures will lead to increased microbial activity, which will cause increased release of currently sequestered CO_2 into the atmosphere, as well as increased releases of methane (CH_4) from anaerobic decomposition. Both of these gases are further contributors to climate change when released.

Vegetation Change

The suitability of terrestrial wildlife habitats for species assemblages is driven primarily by the vegetation types that dominate those habitats. Vegetation is at least partially controlled by factors such as soil moisture and temperature. Warming is expected to result in longer growing seasons, reduced freshwater availability (in the Arctic), reduced permafrost, and dryer, warmer soils (Hollister et al. 2005, Calef et al. 2005). While effects on individual species or communities may not be apparent in the short-term, long-term changes such as change from sedge tundra to shrub dominated tundra will obviously affect wildlife that depends on those habitats. These changes will result in habitat loss or gain for a significant number of species in Arctic, Northwest, and Interior Alaska (Marcot et al. 2015). Global vegetation models predict that boreal forests are particularly sensitive to a biome shift during the twenty-first century. This shift would manifest itself at the biome's margins, with evergreen forest expanding into current tundra while being replaced by grasslands or temperate forest at the biome's southern edge (Beck et al. 2011).

Mismatched Phenology

The growth, survival, and reproductive success of most species in Alaska, both migratory and year-round residents, are highly dependent on synchronous timing of migratory or reproductive events (such as spawning, hatching, calving, and fledging) with the phenology of physical (e.g., timing of runoff, accumulation of degree-days) or biological (emergence of prey species) events. In general, species have evolved specific life history attributes, and populations are strongly affected by disruptions in the timing of these events. Climate change is already leading to changes in the phenology of many of these kinds of events, leading to a "mismatch" between species behavior and the events that behavior is based upon (Brook et al. 2015). While many species may readily adapt to the changes in timing of events important

to their life history, the heterogeneity and inconsistency of event timing that is exacerbated by climate change could result in significant population fluctuations of a large number of susceptible species.

Change can affect ability of young to find food. Can you locate the 5 ptarmigan chicks surrounding the hen in this image? Photo by Paxson Woelber.

Conservation Actions

A researcher holds an olive-sided flycatcher—a species in decline across North America. Photo by Julie Hagelin, ADF&G.

Conservation actions are the activities available to improve the conservation status of wildlife in Alaska and minimize the chances of future listings. These actions can take many forms, from filling critical information gaps, to controlling threats, to captive breeding efforts (Salafsky et al. 2008). In this chapter we outline types of conservation actions that are being or might be applied in Alaska.

Data Acquisition

Good data are essential for conservation. For many of Alaska's SGCN, basic information is lacking on population size, population trend, habitat relationships, and movements within and between seasons. Having that information is often a prerequisite to making an informed assessment of a species' conservation status, prescribing effective conservation actions, and deciding on permits and other resource development matters. To obtain trend information, long-term monitoring and data collection efforts are often necessary. Alaska has and will continue to make important data gathering key among its conservation actions. Important actions on data needs include the following:

- Determine distribution in Alaska, and habitat associations of SGCN.
- Determine population trends and abundance of SGCN.
- Estimate survivorship by age class, and causes of mortality for SGCN.
- Map long-distance migratory movements and habitat use by SGCN.
- Determine sustainable exploitation rates for harvested SGCN.
- Identify important spawning and rearing habitats for aquatic SGCN.
- Determine and monitor the effects of large-scale releases of hatchery fish on other marine SGCN.
- Determine how key habitats are likely to change in the future due to climate change, and model effects on SGCN.
- Determine how habitat changes due to logging will affect SGCN, and what mitigation measures could reduce adverse impacts.

ADF&G biologist measuring the beak of a Black Oystercatcher. Photo by Francis Bruhwiler.

Land and Water Protection

This category includes actions to identify, establish, or expand parks and other legally protected areas, and to protect habitat resources important to wildlife.

Species of Conservation Need: Pinto abalone, Haliotis kamtschatkana

Pinto abalones are found in kelp beds and rocky areas of the northeast Pacific Ocean south of Salisbury Sound in Southeast Alaska. They are primarily in shallower waters to 40 feet, but may occur as deep as 330 feet. They are herbivorous. Alaska Natives use abalone flesh as a subsistence food, and the mother-of-pearl shells as a trade item. The pinto abalone has a distinctive delicate flavor. Commercial harvest of pinto abalone began in the 1960s. The fishery in Alaska peaked at 379,000 pounds in 1979–1980, and declined sharply to 14,000 pounds in 1995. The fishery closed in 1996 and has not reopened. The Pinto Abalone is listed as endangered by IUCN, and is an ESA species of concern. Threats include illegal harvest and predation by recovering sea otter populations. Photo by Scott Walker, ADF&G.

Legally Protected Lands

In Alaska, a high percentage of the landscape is already in a protected status as park land or wildlife refuge. Alaska holds 70% of all national park lands in America, 80% of wildlife refuge acreage, and 53% of designated wilderness in the nation. State and federal lands account for 87.5% of all lands in Alaska. In addition to Federal lands, Alaska has 3.3 million acres of state park land, in 8 state parks, administered by the Alaska Department of Natural Resources. The state also has 3.2 million acres of special wildlife conservation areas (12 game refuges, 17 critical habitat areas, and 3 wildlife sanctuaries) which are managed by the Alaska Department of Fish and Game.[66]

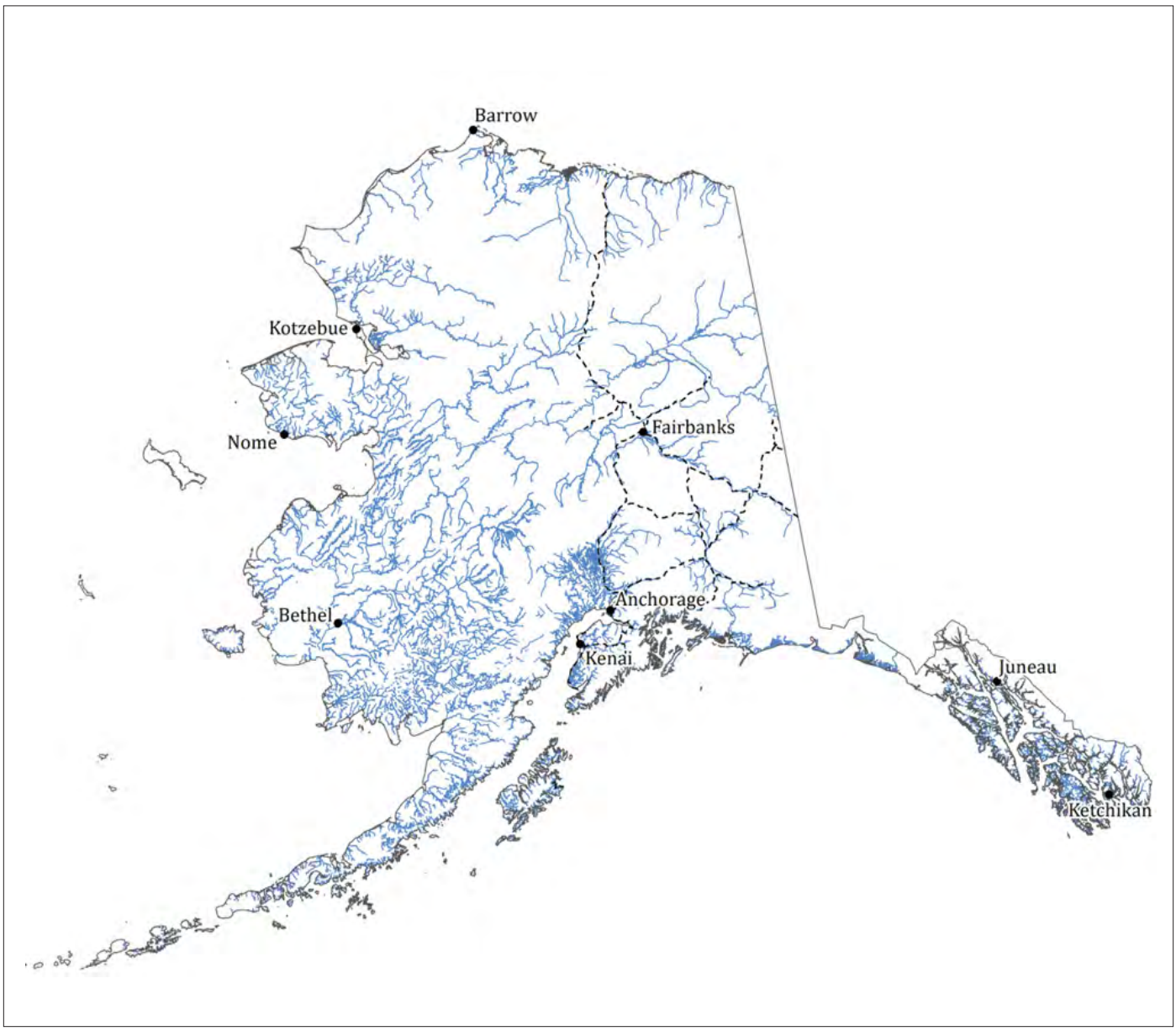


Figure 3. Extent of flowing waters covered by the habitat protections provided by Title 16 of Alaska Statutes, requiring permitting for any development activities affecting these waters.

[66] ADF&G. Refuges, Sanctuaries, Critical Habitat Areas and Wildlife Refuges. http://www.adfg.alaska.gov/index.cfm?adfg=conservationareas.locator (Accessed 28 July 2015).

Protecting Habitat Resources

Under Title 16 of Alaska Statutes, waters identified as important for the spawning, rearing, and migration of anadromous species of fish are protected under a permitting system that attempts to eliminate, minimize, or mitigate any negative effects of development or resource extraction that occur in such waters. The department maintains and continually updates a Catalog of Anadromous Waters[67] that identifies where such permitting is required. These catalogued waters represent the majority of the state's large rivers and streams (Figure 3).

In addition to the protections to anadromous streams provided by Title 16, the Alaska Department of Fish and Game also maintains a program to secure instream flow reservations on waters identified as important to wildlife. These reservations may limit the amount of water available for mining, agriculture, hydroelectric power, or other uses. Both of these programs are essential aspects of habitat protection in state, and will continue to be supported by Alaska's participation in the State Wildlife Grant program.

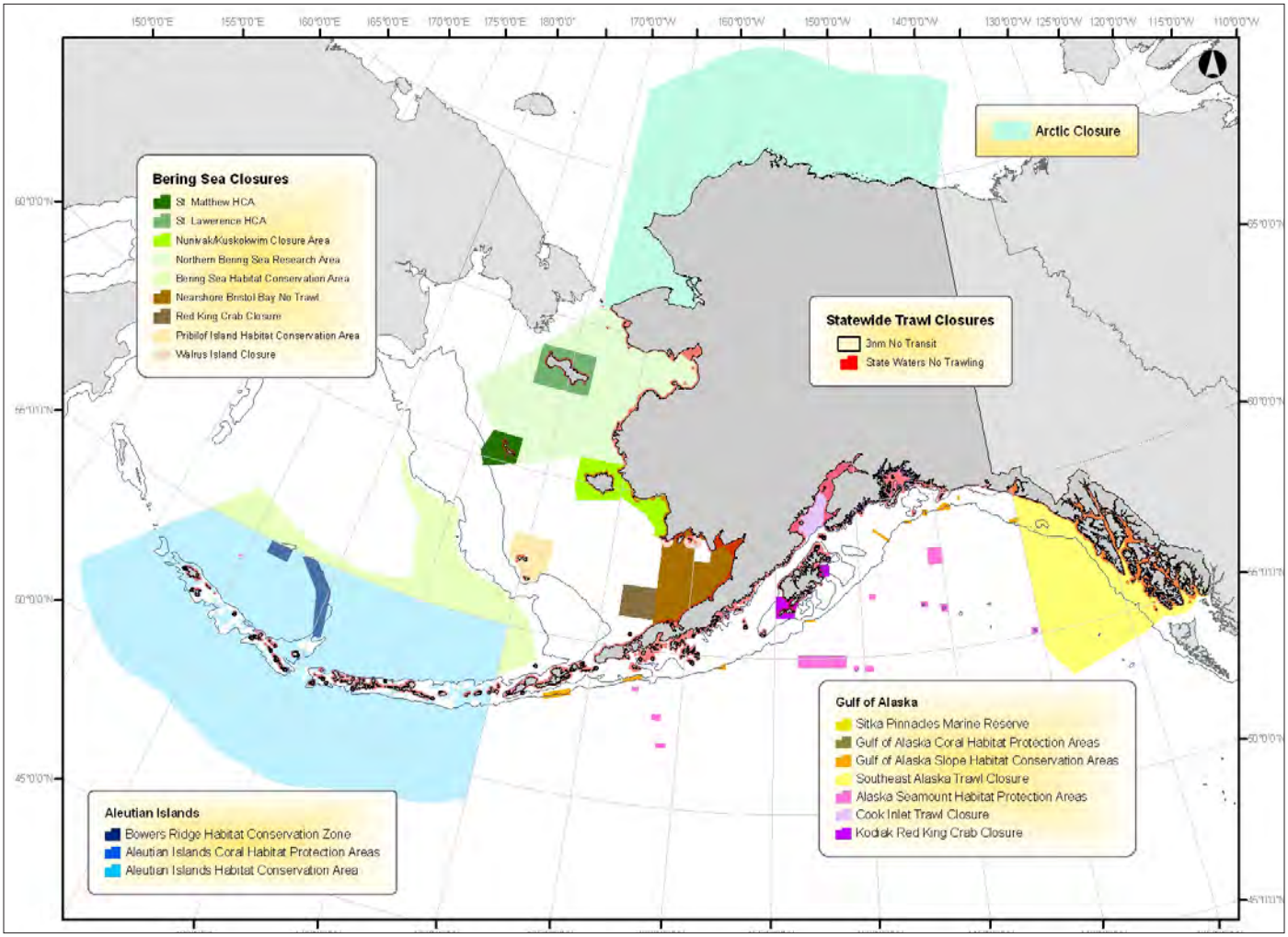


Figure 4. Marine Protected Areas in Alaska. Map by North Pacific Fishery Management Council.

[67] ADF&G. Anadromous Waters Catalog. https://www.adfg.alaska.gov/sf/SARR/AWC/ (Accessed 28 July 2015).

Various nongovernmental organizations (NGOs) are engaged in ongoing efforts to elevate the protective status of public lands in Alaska, including to establish the coastal plain of the Arctic National Wildlife Refuge as Congressionally designated Wilderness,[68] and to provide permanent protection for special wildlife areas on the National Petroleum Reserve–Alaska (NPRA).[69] These conservation units, combined, represent a large percentage of the Arctic ecoregion in Alaska. The areas identified for heightened protection include breeding grounds for millions of waterfowl, shorebirds, and big game species (caribou, muskoxen, bears). They also represent important tundra habitats that are expected to shrink as the climate warms, and trees and shrubs encroach from the south. Species that would benefit from stronger habitat protection in these areas include those SGCN that use arctic tundra or wetlands habitats in the North bioregion (see Appendices B and D).

There are also efforts by nongovernmental conservation organizations, and some commercial fishermen, to strengthen land protections on the Tongass National Forest, in Southeast Alaska. Their efforts are aimed at persuading Congress to provide permanent protection to 77 highest-value salmon and trout watersheds (1.9 million acres) on the Tongass.[70] This action would not only protect salmon and other aquatic SGCN from potentially harmful effects of clearcut logging, but would provide added security for all terrestrial SGCN that depend heavily on old-growth coastal forest habitats, including such high priority SGCN as the Marbled Murrelet, Queen Charlotte Goshawk, and the Alexander Archipelago wolf.

In 2002, the Alaska Department of Fish and Game convened a task force to develop a process by which marine protected areas (MPAs) could be nominated to the Alaska Board of Fisheries (ADF&G 2002). The department recognizes their utility as a useful tool for conservation, in combination with other fishery management measures. The current extent of marine habitat protections is fairly extensive (Figure 4). Additional marine habitat areas of potential concern (and thus likely candidates for protection) have been identified by the North Pacific Fishery Management Council.[71]

Marine biodiversity is correlated with structural habitat diversity. When the sea floor is characterized by boulders, corals, anemones, kelp, and other living organisms, it is susceptible to damage from fishing gear, particularly bottom trawls. Regulations prohibiting groundfish trawling and scallop dredging have been implemented to protect areas where this habitat type is known to occur. These marine protected areas comprise a relatively large portion of the continental shelf, and in many respects, serve as marine reserves.

Audubon Alaska (a nongovernmental conservation organization) has identified a series of globally Important Bird Areas (IBAs) in the pelagic waters of the Bering Sea and Gulf of Alaska that encompass about 38% of all pelagic seabirds in Alaska waters (23 million birds) within only 6% of the marine surface area. These data provide additional support for future designation of MPAs, with specific orientation towards conservation of seabirds. SGCN that could benefit from MPAs include all species that occur in the marine ecoregions (Appendix B) and use nearshore, shelf, and offshore habitats (Appendix

[68] Podesta, J. and M. Boots. 2015. President Obama Calls on Congress to Protect Arctic Refuge as Wilderness. The White House. 25 January 2015. https://www.whitehouse.gov/blog/2015/01/25/president-obama-calls-congress-protect-arctic-refuge-wilderness

[69] The Conservation Alliance. 2013. Interior Department Protects Special Areas within National Petroleum Reserve–Alaska. 21 February 2013. http://www.conservationalliance.com/interior-department-protects-special-areas-within-national-petroleum-reserve-alaska/

[70] Trout Unlimited. The Tongass 77: Protecting Southeast Alaska's Best Salmon Watersheds [brochure]. http://www.americansalmonforest.org/uploads/3/9/0/1/39018435/thetongass77p.final4.14v2.pdf

[71] North Pacific Fisheries Management Council. Habitat Areas of Particular Concern—HAPC. http://www.npfmc.org/habitat-protections/habitat-areas-of-particular-concern-hapc/ (Accessed July 2015).

D). Benefits would accrue to many high priority SGCN, including salmon, Arctic cod, Steller sea lion, northern sea otter, whales, walrus, Short-tailed Albatross, Red-legged Kittiwake, and Spectacled Eider.

Although it is clear that land and water protection is an appropriate and effective tool for conserving Alaska's wildlife, the department's work in this area will be limited mostly to enforcing regulatory measures on existing conservation units in Alaska. Where nongovernmental organizations or other agencies propose new land and water protections, the department will evaluate those proposals as is appropriate to its mission and authority and may make recommendations to accept, strengthen, modify, or reject them.

Land and Water Management

This conservation action is directed at conserving or restoring sites, habitats, and the wider environment. It includes management of currently protected areas for conservation, eradicating and controlling invasive species, and enhancing degraded habitats and restoring ecosystem function (Salafsky et al. 2008). In Alaska, addressing the habitat effects of climate change will be important, especially in those habitats most sensitive to such change, including sea ice, tundra, and coastal wetlands. Though climate change is a global problem requiring a global solution, in some instances, resistance, resilience, and transformation-oriented land and water management strategies could lessen the impact of climate change on some vulnerable habitats or species (Adger et al. 2007).

Stream Management and Restoration

Restoration of stream habitats degraded due to early logging practices on the Tongass National Forest is a priority. A number of restoration projects aimed at reintroducing large woody debris (logs) to recreate pools in streams, stabilize stream banks, and moderate stream flow have been completed or are underway. These actions can have significant and long-lasting benefits for salmon, trout, aquatic invertebrates, especially, as well as the many wildlife species that depend directly or indirectly on salmon, from bears (Hilderbrand et al. 1999) to songbirds. The Alaska Department of Fish and Game also has statutory authority under Title 16 for fish (riparian) habitat and fish passage programs to protect and improve the value of these ecosystems for fish. Both the State of Alaska and the U.S. Fish and Wildlife Service have begun efforts to eradicate Elodea from several water bodies in the state.

In addition to agency work on stream management and restoration, Alaska has 4 Fish Habitat Partnerships that share a mission of protecting, restoring, and enhancing Alaska's fish and aquatic communities through fish habitat conservation. These 4 partnerships operate in Southeast Alaska, Southcentral Alaska (2), and Southwest Alaska. Voluntary, locally-driven, and nonregulatory, these partnerships help identify and fund local projects and leverage the resources and expertise of member organizations to benefit Alaska's native fishes and their habitat. Activities involve assessing, mapping, and prioritizing fish habitat needs in the regions, and developing partnerships with agencies, NGOs, and individuals to accomplish needed important habitat restoration and protection. Given the economic and recreational value of the fisheries resource in the state, and the strong public support it engenders, continued support of these restoration and management efforts is a priority in this plan.

Wetlands Management and Restoration

It is important to enforce existing laws that protect wetlands from development. Expansion of the Alaska wetlands inventory by the USFWS,[72] including data on location and type of wetlands, water

[72] Alaska National Wetlands Inventory, U.S. Fish and Wildlife Service. http://www.fws.gov/alaska/fisheries/nwi/ (accessed 15 September 2015).

Species of Conservation Need: Queen Charlotte Goshawk, Accipiter gentilis laingi

Queen Charlotte Goshawk, *Accipiter gentilis laingi.* This subspecies of the Northern Goshawk is found across the Alexander Archipelago in Southeast Alaska down to Vancouver Island and coastal Canada. Studies by ADF&G and the Forest Service indicate that this secretive bird has large home ranges/ low densities compared with other goshawks. It is associated with old growth forest in some locales, but it also nests in older second growth (e.g., >70 - 90 years). It preys on grouse, medium-sized birds (thurshes, robins), waterfowl, and red squirrels. It was subject to various ESA petitions and lawsuits associated with forest management and timber harvest. The scientific findings of the research led to conservation measures in the multiple-use Tongass Land Management Plan and a not warranted finding in the U.S. Photo by Craig Flatten, ADF&G.

characteristics (quantity and quality), and habitat suitability for associated wildlife, would be valuable. With that inventory completed, improved management, conservation, and restoration of these important habitats will be possible. Much of the water provided to wetlands does not come from large water bodies such as streams, rivers, or lakes, but rather small seeps, sheet flow, springs, and rivulets. These should also be identified, mapped, and acknowledged in management of our water resources.

Forest Habitat Management and Restoration

Terrestrial restoration projects include silvicultural thinning to open up densely stocked second-growth stands that develop 20–40 years after clearcutting (Hanley et al. 2013). Although this restoration activity has limited benefits to songbirds (Matsuoka et al. 2012), there is evidence it benefits small mammal populations, and may benefit the Queen Charlotte Goshawk.[73] Other forest management prescriptions designed to benefit old-growth-dependent species include retention of snags and mature trees within cutting units, establishment of natural old-growth buffers along shorelines and riparian areas, and establishment of old-growth reserves of specific size, spacing, and composition to sustain viable, well-distributed wildlife populations.[74]

Recent management direction on the Tongass National Forest is aimed at reducing the harvest of old-growth forest.[75] This policy is supported by professional wildlife and ecological societies,[76] as well as more than 200 individual scientists. The Forest Service has proposed that rather than end old-growth logging immediately, it prefers a phased approach over the next 15–30 years, where old-growth harvest would gradually be replaced by young-growth harvest (i.e., a second entry into previously logged stands). The department supports the Forest Service's planned management transition out of old-growth logging. Beneficiaries of this conservation action include many SGCN that inhabit the coastal

[73] USDA Forest Service, Alaska Region, Issue paper, April 2011. Wildlife Thinning—Science and Adaptive Management on the Tongass National Forest http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5299759.pdf (Accessed 12 September 2015).

[74] USDA Forest Service, Alaska Region. Appendix D. Old-growth Habitat Conservation Strategy, Wildlife Standards and Guidelines and Wildlife Viability http://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb5422739.pdf (Accessed 12 September 2015).

[75] U.S. Department of Agriculture, Office of the Secretary, Washington DC. July 2, 2013. Secretary's Memorandum 1044-009 Addressing Sustainable Forestry in Southeast Alaska http://www.ocio.usda.gov/sites/default/files/docs/2012/Addressing%20Sustainable%20Forestry%20in%20Southeast%20Alaska.pdf (Accessed 19 September 2015).

[76] Letter to USDA Secretary Vilsack from 7 professional Societies, dated 20 January 2015 regarding Old-growth Logging Transition on the Tongass National Forest. http://www.esa.org/esa/documents/2015/01/tongass-old-growth-letter.pdf (Accessed 19 September 2015).

old-growth forest (Appendix D), including species such as rough-skinned newt, Keen's Myotis, Prince of Wale's flying squirrel, Alexander Archipelago wolf, and Queen Charlotte Goshawk.

Logging of white spruce forests, especially along riparian habitats, in the Central and Southcentral regions is a potential threat to some wildlife species that inhabit the boreal forest (see Threats chapter). The Alaska Department of Fish and Game is currently working with the Alaska Department of Natural Resources, Division of Forestry, to identify and evaluate forest practices that can create early seral habitat beneficial to game species through tree harvest and prescribed burning. These land-management activities will continue into the next planning period.

Species Management

Native Species

Species management refers to managing or restoring a species, focused on the species itself. It can include adjusting harvest levels of populations of concern (e.g., bowhead whale, polar bear, walrus, Spectacled and Steller's eiders, Pacific salmon, Alexander Archipelago wolf). It can also involve the reintroduction of species to areas where they formerly occurred (e.g., wood bison and muskoxen reintroductions). Species management is a very direct and potentially effective tool for conservation of a species, especially if that species is subject to commercial, sport, or subsistence harvest. Because

A brace of Ptarmigan. Photo by Ken Marsh.

most hunted and trapped species are not included in this action plan, this conservation action has most relevance to fished aquatic species, most of which are important for cultural and economic reasons (see Appendix A). Although the goal is to manage all of these species sustainably, management is often required based on incomplete information. Sometimes declines occur that were not anticipated, and recovery of the stocks can be slow or incomplete (e.g., some king crab and herring stocks and Cook Inlet beluga whale). Careful and conservative management of individual species is necessary in these cases to promote recovery, and federal and state agencies are jointly committed to that action when necessary. These actions, which are implemented by federal and state boards, play a critical role in conserving exploited populations.

Invasive species

Conservation actions related to invasive species is placed in the Species Management category because efforts to control or eradicate invasive species are largely about killing invasive species, either to eradicate them, or control their spread.

Introduced species are considered one of the top 2 threats to imperiled species in the U.S. (Wilcove et al. 1998), and are the leading cause of historical extinctions in the world.[77] Today, of 1,186 bird species in the world threatened with imminent extinction (12% of the world's avifauna), 510 (almost half) are threatened wholly or partly by introduced species (Simberloff 2005).

The European black slug was recently introduced to the Cordova area where it quickly proliferated in the temperate rain forest. Photo by Anne Sutton, ADF&G

Alaska has relatively few nonnative plant and wildlife species. There are 116 species of animal that are considered nonnative (including game transplants of certain animals around the state). However, the state does have extensive island archipelagos (Aleutians and in Southeast Alaska) that have, at one time or another, harbored nonnative mammals that either have wreaked or have the potential to wreak havoc on those ecosystems. Some of the island invasive or nonnative introduced mammals in various areas of Alaska include arctic and red fox, ground squirrel, Norway rat, house mouse, caribou, reindeer, cattle, and Arctic and European hare (Ebbert and Byrd 2002).

USFWS has removed exotic fox populations from 39 islands (totaling more than 500,000 acres).[78] This is a remarkable accomplishment, and has resulted in recovery of a number of threatened or numerically depressed seabird species (Byrd et al. 1994). Although introduced foxes and large mammals may be

[77] Groombridge, B., World Conservation Monitoring Centre, British Museum (Natural History), and World Conservation Union. 1992.
[78] Ibid.

Species of Conservation Need: Steller Sea Lion, Eumetopias jubatus

The Steller sea lion, or northern sea lion, occurs in Alaska along the Aleutian Islands, southern Bering Sea, and Gulf of Alaska. It prefers colder subarctic waters. Adult males can weigh up to 2,500 pounds, while females weigh up to 770 pounds. Steller sea lions forage long distances from shore and can dive to 1,300 feet. They use land habitat (ledges, beaches) for periods of rest, molting, and rookeries for mating and pupping during the breeding season. The Alaska population is divided into 2 segments based on genetic and physical differences. The western segment (west of 144 degrees latitude) declined 75% between 1975 and 1990, and another 40% between 1991 and 2000. The western segment is listed as endangered. The eastern segment is stable or increasing in Alaska, and declining south of Alaska. Threats include ship strikes, illegal shooting, and offshore oil and gas extraction. Photo by Eliezg.

hunted and trapped to eradication, small mammals occur at high densities, often underground. For these species, poisons are the most effective means of eradication; however, poison application does carry risk to native birds, particularly scavengers. Rats were recently eliminated from a relatively large (10 square mile) island in the Aleutians, but with some mortality among nontarget species of native birds (scavenging gulls and eagles). Small rodents remain a significant problem on important Aleutian Islands where colonial seabirds nest in large numbers (Witmer et al. 2006).

In a comprehensive review by Nadol (1999) the level of state regulation of invasive species in the western U.S. (including Alaska), was deemed inadequate.

Further eradication efforts are needed (Major et al. 2013). Currently, the Alaska Department of Natural Resources has partnered with U.S. Customs Agricultural and Plant Health Inspection Service, the U.S. Forest Service, and the U.S. Fish and Wildlife Service to implement an "Early Detection, Rapid Response" program to prevent the introduction of invasive plants in the state.

Harmful nonnative species in aquatic systems and on islands are of particularly high concern. Conservation actions to minimize risk of introduction, eradicate, or control the spread of the invasive species is a priority. It represents a specific action that is clear, affordable, and promises lasting benefit to Alaska's native wildlife.

Education and Awareness

This conservation action is aimed at improving understanding and skills, and influencing the behavior of people. State Wildlife Grants projects are statutorily limited to funding education and outreach at no more than 10 percent of the project's total cost. However, citizen science initiatives, if well-designed, can yield useful scientific information, as well as provide ancillary benefits for public education and scientific literacy (Silvertown 2009; Bonney et al. 2009). The Threatened, Endangered, and Diversity Program at the Alaska Department of Fish and Game currently supports citizen science monitoring efforts for loons, grebes, frogs, bats, and select invasive species.

Most of these projects have focused on obtaining basic information on presence and distribution. Reports of bat sightings from citizen scientists greatly expanded the known range of the little brown myotis in the Western and Central regions of Alaska, and provided insights into its seasonal ecology and habitat use. In addition, most of the known bat maternity colonies in the state were first identified and reported by citizen scientists. Since the summer of 2014, citizen scientists have been helping conduct acoustic driving surveys for bats. These data will be contributed to the new North American Bat Monitoring Program (NABat) to help develop estimates of population trends at both regional and continental scales.

Law and Policy

This conservation action is aimed at developing, changing, influencing, and implementing formal legislation, regulation, and voluntary standards. For example, in 2012, with support from the department's Division of Sport Fish, the Alaska Board of Fisheries passed regulation prohibiting the use of felt-soled waders in the freshwaters of Alaska to stop one common vector by which fish diseases and invasive species (plants in this case) can be moved between waterbodies. In addition, the Alaska Department of Natural Resources has quarantined 5 aquatic plant species to eliminate the aquarium trade from importing invasive species.

The Alaska Department of Fish and Game does not generally propose legislation, but it does offer comment on pending proposals or legislation affecting wildlife in the state. Legislation and policy to reduce the importation of nonnative species, even if deemed desirable by some stakeholders (e.g., hunted elk, aquaculture species, aquarium species, and exotic pets), might be strengthened in the future. Legislation that identifies and further protects important wildlife habitats and strengthens habitat protection for wildlife could be actively endorsed. This conservation action also includes voluntary measures that companies or individuals might be encouraged to take. Examples include retaining standing snags when clearcut logging, using nonreflective glass on high-rise buildings to reduce bird strikes, and encouraging establishment of conservation easements on valuable wildlife habitat that is in private ownership.

Livelihood, Economic, and Other Incentives

These types of conservation actions use incentives to influence behavior. Incentives do not have to be monetary. For example, the "Wings Over Alaska" program awards certificates of achievement based on numbers of Alaska birds observed. Participants in citizen science projects may be rewarded with tokens of appreciation, such as Alaska Department of Fish and Game hats, pins, or public recognition in a local newspaper. This has been done successfully with bat and amphibian monitoring programs in Southeast Alaska. Local groups that "adopt" an important bird area, and work to improve habitat, remove invasive plants, or promote responsible dog control, are and can be publicly commended.

External Capacity Building

External capacity building refers to actions that build the infrastructure to do better conservation. Examples include developing close working relationships with NGOs, other agencies, private entities, or in statewide and interstate consortiums. Potential partners include the Boreal Partners in Flight, the Fish Habitat Partnerships, watershed protection groups, The Pacific Bird Joint Venture, the Alaska Bird Conference, the Western Bat Working Group, and Landscape Conservation Cooperatives. The department actively collaborates with most of these external groups, and has provided funding in some cases for the development and formulation of conservation strategies (e.g., bird conservation plans)

and scientific meetings (American Fisheries Society, Wildlife Society, Alaska Bird Conference, etc.) that increase effectiveness of management and conservation. Specific priority areas for improving capacity building include stream and wetland restoration, citizen science monitoring programs, and invasive species control and eradication. Our partner program, which has delivered substantial SWG funding to universities, other agencies, and NGOs for wildlife conservation research, has not only garnered valuable information, but has recruited new voices for collaborative conservation in the state. Nontraditional partners (e.g., oil and gas or timber industry) may also be valuable to work with to promote conservation. Supporting the development of external capacity for conservation can be a powerful tool, and these efforts will continue.

Ruffed Grouse Habitat Management Area, in partnership with Ruffed Grouse Society and Richard King Mellon Foundation.© Ken Marsh Wild Northwest Images.

Monitoring and Evaluation

About half of the world's 70,000 Bald Eagles live in Alaska. Photo by Carl Chapman.

This chapter describes the proposed plans for monitoring species of greatest conservation need and their habitats, for monitoring (evaluating) the effectiveness of conservation actions, and for adapting these conservation actions to respond appropriately to new information and changing conditions.

Monitoring is designed to identify trends in wildlife populations (numbers, movements, reproductive success) and key habitats (condition and use) over time. Existing monitoring efforts the department is aware of are enumerated in Appendix E, and this action plan identifies needs for additional or improved monitoring in the future. The second part of this chapter refers to the need to evaluate our progress toward meeting our conservation goals (Stem et al. 2005): Is the work being conducted the right work, is it being done cost effectively, and is it successful or not? Is the plan flexible enough to respond to new information and changing conditions?

Challenges in Alaska

Monitoring wildlife populations in Alaska presents unique challenges. The terrain is extensive, rugged, and relatively inaccessible, which makes systematic or random sampling of large areas in Alaska difficult. Statistically reliable abundance estimates for SGCN are limited to aerial surveys for large waterbirds,[79]

[79] U.S. Fish and Wildlife Service Migratory Bird Management. Waterfowl: Projects/Reports. http://www.fws.gov/alaska/mbsp/mbm/waterfowl/reports.htm (Accessed July 2015).

or ship-based (and some aerial) surveys of seabirds[80] and marine mammals.[81] Smaller, more accessible areas, may be surveyed if it is assumed that trends in these index areas are representative of trends in broader areas. Examples of such index counts include Christmas Bird Counts (Butcher et al. 1990), Breeding Bird Surveys (Sauer et al. 2012), landbird point counts (Alaska Landbird Monitoring Surveys), shorebird monitoring on the North Slope and in western Alaska (Bart and Johnston, editors 2012), shorebird monitoring in Kachemak Bay,[82] and seabird surveys in selected fjords, straits, or bays (Kirchhoff 2011). There are biases inherent in some of these efforts (Sauer et al. 1994; Keller and Scallan 1999), but they are not so large as to swamp estimated trends for the larger population.

Wildlife Monitoring Efforts in Alaska

Monitoring efforts vary depending on objectives and degree of statistical rigor desired. Lower rigor is usually accepted for monitoring that relies heavily on the public. For example, amateur bird watchers can enter opportunistic sightings of birds into an online database maintained by eBird.[83] These data can yield helpful insights into distribution, habitat use, migration, and, over time, even population trends.[84] Collected data are typically aggregated into a database that is analyzed by a biologist, and results are reported back to the citizen scientists via newsletter, blog, or website. Citizen science monitoring projects for wildlife in Alaska include Christmas Bird Counts,[85] backyard feeder counts,[86] and counts of beached birds,[87] hawks,[88] Marbled Murrelets,[89] loons,[90] grebes,[91] owls (Kissling and Lewis 2009), wood frogs,[92] and bats.[93,94] Although the types of questions citizen science can address are limited, citizen science's redeeming strength is the ability to acquire large quantities of data, over large spatial and temporal scales, at relatively little cost (Bonney et al. 2009; Cohn 2008).

Other monitoring programs in the state are largely overseen by resource agencies, with the monitoring work conducted by trained biologists and ecologists. These efforts tend to be extensively planned, with designs considering statistical power to detect trends (Hatch 2003; Seavy and Reynolds 2007).

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[80] USGS Alaska Science Center. North Pacific Pelagic Seabird Databse (NPPSD). http://alaska.usgs.gov/science/biology/nppsd/index.php (Accessed July 2015).

[81] NOAA Fisheries. Marine Mammal Stock Assessment Reports (SARs) by Species/Stock. http://www.nmfs.noaa.gov/pr/sars/species.htm (Accessed July 2015).

[82] Kachemak Bay Birders. Report: http://kachemakbaybirders.org/attachments/article/155/2014%20Kachemak%20Bay%20Shorebird%20Monitoring%20Project.pdf

[83] Alaska eBird http://ebird.org/content/ak/about-2/ (Accessed July 2015).

[84] The State Wildlife Grant program funded creation of eBird in Alaska. It has > 143,000 checklists submitted to date.

[85] Scher, R. L. (Buzz). Christmas Bird Count. 113th CBC Alaska Regional Summary. Audubon. https://www.audubon.org/content/113th-cbc-alaska-regional-summary (Accessed July 2015).

[86] Alaska Songbird Institute. Fbks Feedercount: You can help track bird populations around Fairbanks in winter! http://aksongbird.org/education/bird-feeding-resources/fairbanks-feedercount/ (Accessed July 2015).

[87] University of Washington. COASST: Coastal Observation and Seabird Survey Team. http://blogs.uw.edu/coasst/ (Accessed July 2015).

[88] Fritz, P. and C. Fritz. 2011. The hawks of Gunsight Mountain, Alaska. Pages 30–36 [In] Birding Magazine. January 2011. American Birding Association. http://www.aba.org/birding/v43n1p30.pdf (Accessed July 2015).

[89] Romanoff, K. 2008. Participate in Murrelet Watch. Alaska Fish and Wildlife News, May 2008. Alaska Department of Fish and Game. http://www.adfg.alaska.gov/index.cfm?adfg=wildlifenews.view_article&articles_id=372 (Accessed July 2015).

[90] UAA Alaska Natural Heritage Program, Alaska Center for Conservation Science. [n.d.]Alaska Loon & Grebe Watch monitoring program. http://aknhp.uaa.alaska.edu/zoology/citizen-science/alaska-loon-grebe-watch/ (Accessed July 2015).

[91] ADF&G. [n.d.] Alaska Loon and Grebe Watch instructions for volunteers [handout]. https://www.adfg.alaska.gov/static/research/programs/citizenscience/pdfs/loons-grebes-volunteer-instructions.pdf (Accessed July 2015).

[92] ADF&G. [n.d.] Wood frog monitoring program [web page]. Division of Wildlife Conservation http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.woodfrog (Accessed July 2015).

[93] UAA Alaska Natural Heritage Program. [n.d.] Alaska Bat Monitoring Project. Alaska Center for Conservation Science. http://aknhp.uaa.alaska.edu/zoology/citizen-science/alaska-bat-project/ (Accessed July 2015).

[94] ADF&G. [n.d.] Alaska Bat Monitoring Program [web page]. http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.bats (Accessed July 2015).

Typically, these monitoring efforts are restricted to the lands and waters (or species) a particular agency has management responsibility for, such as parks or refuges. Often, surveys designed specifically for a species can consider unique aspects of its distribution, habitat, and behavior to produce trend estimates with adequate precision (Kissling et al. 2007; Kirchhoff 2011).

Because most of Alaska is federal land, the spatial coverage in existing federal programs is relatively good (e.g., the National Park Service's Inventory and Monitoring Program across all 16 park units in Alaska). Federal and state agencies are also in a better position than nonprofits to ensure there is a long-term commitment to funding, staffing, and reporting this work. These are important elements of an effective monitoring plan.

The American Dipper occurs year-round in fast-moving, clear, unpolluted streams with cascades, riffles, and waterfalls. Photo by Jim Dau, ADF&G.

Monitoring efforts in Alaska fall into 2 broad categories: (1) environmental monitoring, and (2) wildlife monitoring. Environmental monitoring includes variables like air and water temperature, ocean currents, salinity, carbon dioxide levels, ice extent, forest cover, and development footprint. Environmental monitoring can give us signals on habitat trends that will likely affect wildlife populations in the future. Environmental monitoring can often be collected remotely, from satellites, buoys, or data loggers. This typically translates into more expansive, longer-term, and less expensive coverage.

Wildlife monitoring is often more difficult and costly. With the exception of large animals using open habitats, counts from the air are not possible, and counts from the ground are laborious. An unknown number and often high percentage of animals are missed, requiring some estimate of detection probability if absolute abundance is desired (Thompson 2002). Other issues of species misidentification and the allocation of survey effort spatially and temporally can yield unreliable trend estimates (Pollock et al. 2002; Hodges and Kirchhoff 2012).

These limitations can be overcome to some degree with replication. As with citizen science, enough surveys, over enough years, can yield a meaningful trend result. In the case of agency-sponsored monitoring efforts, these tend to be well-designed, with input from biometricians.

There are a large number of environmental and wildlife monitoring efforts ongoing in Alaska, prompted, in part, by the fact that Alaska is considered "ground zero" for the effects of climate change.[95] A summary of environmental and wildlife monitoring programs in Alaska are outlined in Appendix E. For convenience, monitoring efforts are classified under the subheadings of: (1) Air and Climate, (2) Land, (3) Vegetation, (4) Climate Change, (5) Contaminants, (6) Marine Environment, (7) Fish, (8) Birds, (9) Mammals, (10) Marine Mammals, (11) Terrestrial Mammals, (12) Freshwater Invertebrates, (13) Amphibians, (14) Nonnative Species, (15) Fire, (16) Human Use, (17) Biodiversity, and (18) Other.

Monitoring Plans for the Next 10 Years

State Wildlife Grants have funded monitoring efforts around the state, and will continue to do so in the future. Examples include training field personnel hired to conduct Alaska Landbird Monitoring Surveys, analysis or synthesis of existing survey data (long-term bird banding data),[96] monitoring of Black Oystercatchers (Tessler et al. 2010), and a review of Kittlitz's Murrelet survey data (Day 2011). Alaska has used SWG funding for citizen-science monitoring (for loons, grebes, bats, frogs).[97] Such efforts engage the public, promote awareness and good will for our program, and provide data on distribution and habitat use.

USFWS biologist Michelle Kissling and ADF&G biologist Steve Lewis attach a small backpack-style transmitter to a screech owl near Petersburg. Photo by Riley Woodford, ADF&G.

The department has also funded projects that either fill in surveys gaps (Kirchhoff et al. 2014; Kuletz et al. 2008) or are designed to improve survey methodology (Kirchhoff 2008). It will continue to look for gaps in the ongoing wildlife and habitat monitoring efforts in Alaska, and encourage and facilitate needed monitoring by other resource agencies by providing funding and training, participating in surveys, providing biometric support (both design and analysis), and developing survey methods. There are insufficient State Wildlife Grant funds available for the department to be the sole, or primary, sponsor of monitoring. Through this plan, the department pledges to provide technical, logistical, and

[95] Reiss, B. 2010. Welcome to Barrow, Alaska, Ground Zero for climate change. Smithsonian Magazine (March 2010).

[96] Mowry, T. 2011. Twenty years and counting for the Alaska Bird Observatory banding station. Fairbanks Daily News Miner, 17 August 2011. http://www.newsminer.com/twenty-years-and-counting-for-the-alaska-bird-observatory-banding/article_bb7708a6-491c-53ec-856c-049cd-d47a145.html (Accessed July 2015).

[97] ADF&G. [n.d.] Alaska Citizen Science Program [web page] http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.main (Accessed July 2015).

financial support for a range of existing monitoring efforts. Our priorities will be to monitor the highest priority SGCN and habitats in the plan (see priorities Chapter).

In 2012, The Kittlitz's Murrelet was listed as critically endangered by IUCN, implying extremely high risk of extinction in the wild. After new surveys and analysis, supported by the State Wildlife Grant Program, the bird was found to be more secure, and its status was changed to near vulnerable. Photo by John Schoen.

Evaluation

To evaluate how effectively the state has spent State Wildlife Grant funds requires, first, a clear statement of purpose. The State Wildlife Grant program encourages a conservation paradigm of working towards managing species before they become imperiled, or listed under ESA. To be successful, we must be able to (a) forecast which species are most vulnerable, (b) know which factors are responsible for their vulnerable status, and (c) identify and employ actions that will significantly reduce that vulnerability. These are challenging tasks.

Alaska has emphasized work on species that are not yet listed, but that are at high conservation risk (small, declining, or threatened populations) as determined, mostly, by other agencies and NGOs (see SGCN chapter). Examples include Kittlitz's Murrelet, Marbled Murrelet, Olive-sided Flycatcher, Prince of Wales Spruce Grouse, Rusty Blackbird, and Black Oystercatcher, among others. We have conducted work, and supported work by others, to validate or refine population trend estimates in Alaska. This has included support for developing Alaska eBird, the Alaska Landbird Monitoring System, the Breeding Bird Surveys, Marbled and Kittlitz's Murrelet surveys, and analysis of multi-decadal mist-net data.

The department's participation and support improved these efforts, and affected ESA listing decisions. For example, the survey and research work this program funded on the Kittlitz's Murrelet (Day 2011; Blejwas and Wright 2012; Hodges and Kirchhoff 2012; Kirchhoff et al. 2014) revealed weaknesses in prior trend analyses, and mortality risks (from gill nets). Those findings were weighed by the USFWS in their evaluation of the petition to list the Kittlitz's Murrelet, and contributed to the agency's finding that listing this species as threatened or endangered was not warranted. The conservation status of this species was subsequently down-listed from critically endangered to near threatened by the International Union for the Conservation of Nature (IUCN). This example illustrates the cost-effectiveness of investing in conservation work (including filling data gaps) before a species gets listed.

Our focus in the next 10 years will likely continue to be on gaining a better understanding of trends in wildlife populations and their habitats so we have a more accurate picture of which species and habitats are at greatest risk. This type of work will be aimed largely at gathering pertinent information

on SGCN, with a potentially expanded focus on sentinel species and ecologically important species (see Appendix A).

The department's Threatened, Endangered, and Diversity Program has also funded projects on species that are relatively abundant and secure, such as wood frogs, loons and grebes. These species are easier to observe by citizen scientists and can serve as useful indicators of habitat health. Although these species are not at high risk of extinction, they provide a valuable opportunity to engage the public in conservation work, and may provide insights into those species' conservation status that are unexpected.

Finally, some projects have been funded simply because the species is data-deficient, and impossible to assess with current information. Examples here include surveys for marmots, Gray-headed Chickadees, small mammals, bats, Alaska hare, and other suspected endemics. In these cases, better information on population abundance and habitat use is preliminary to establishing population monitoring programs, and is two steps removed from actually planning conservation actions.

Other research on Black Oystercatcher and Rusty Blackbird, 2 species of continental concern showed populations in Alaska were productive and appeared stable (Greenberg and Droege 1999; Tessler et al. 2010). In such cases, it is unlikely conservation actions could be implemented on these species' breeding grounds in Alaska that would directly improve their global conservation status. Still, it is worth conducting research on such species if only to better point to conservation actions that might be called for at migratory stop over sites and wintering areas in other states and countries.

Figure 5. Extent of the 1989 Exxon Valdez Oil Spill in Alaska. Knowing where important wildlife habitats occur can help prioritize mitigation and recovery efforts and reduce wildlife loss. ADF&G illustration.

Habitat Work

The conservation status of many species is linked to the amount and quality of important habitat. Recognizing this, the department funded a number of projects aimed at identifying important habitats for wildlife conservation. Examples include Globally Important Areas for Marine Birds (Smith et al. 2014), the Gap Analysis Program (GAP) project,[98] and the Anadromous Waters Catalog.[99] The Alaska Department of Natural Resources also compiled data into the 2014 Habitat Atlas that included habitat maps of the following categories: anadromous waters, land cover, seabirds, seals, shorebirds, subsistence use, ungulates, walrus, waterfowl, wetlands, and whales.[100]

Mapping of high use areas and important habitat types has been used by NGOs and federal agencies to make recommendations on areas that should be protected from possible damage associated with oil and gas exploration in the 23 million-acre National Petroleum Reserve–Alaska (NPRA).[101] These are conservation recommendations that make use of summarized and well-presented information to minimize future risks to wildlife from development, if necessary.

Igushik River. Photo by Pete Johnson, ADF&G.

Defining Success

It is difficult to evaluate the effectiveness of conservation actions in terms of things that didn't happen (e.g., species listings). ADF&G partnered with the USFWS and others in assessing the status of species currently considered or proposed for listing as threatened or endangered. Between 2005 and 2015, federal agencies received 17 petitions to list species as threatened or endangered under the ESA, including Distinct Population Segments, and species groups like marine corals. Final Decisions have been issued on 12. Seven were judged not warranted, and 5 warranted. Of the 7 species where listing was not warranted, the state used SWG funding to conduct research or monitoring on 3 (Table 4), and thereby contributed to better informed decisions.

Beyond looking at the record of species listing, we should eventually be able to demonstrate that conservation actions aimed at a declining

[98] UAA. [n.d.] Alaska GAP analysis project: vertebrate distribution models for Alaska [web page]. Alaska Natural Heritage Program, Alaska Center for Conservation Science. http://akgap.uaa.alaska.edu/ (Accessed July 2015).

[99] ADF&G. [n.d.] Anadromous Waters Catalog—Overview [web page]. https://www.adfg.alaska.gov/sf/SARR/AWC/ (Accessed July 2015).

[100] Alaska Department of Natural Resources. [n.d.] Habitat Atlas. Division of Mining, Land, and Water. http://dnr.alaska.gov/mlw/planning/mgtplans/nsmp/bio.cfm. (Accessed July 2015)

[101] Bureau of Land Management 2013 record of decision, Final NPR-A IAP/Eis. https://eplanning.blm.gov/epl-front-office/projects/nepa/5251/42462/45213/NPR-A_FINAL_ROD_2-21-13.pdf

Table 4. List of at-risk species in Alaska petitioned for listing under ESA during the last planning period (2001–2015), record of SWG funding and final resolution.

Species	Date of Petition	Funded by SWG?	Final Status
Kittlitz's Murrelet	May 9, 2001	Yes	Not Warranted
Polar Bear	February 16, 2005	No	Threatened
Cook Inlet Beluga Whale	April 20, 2006	No	Endangered
Pacific Herring (SE Alaska DPS)	April 2, 2007	No	Not Warranted
Loggerhead Sea Turtle (N. Pacific Pop.)	July 12, 2007	No	Threatened
Pacific Walrus	February 7, 2008	No	Pending
Bearded Seal (Beringea DPS)	May 28, 2008	No	Threatened
Ringed Seal (arctic subspecies)	May 28, 2008	No	Threatened
Spotted Seal (Bering Sea DPS)	May 28, 2008	No	Not Warranted
Little Brown Bat[1]	December 16, 2010	Yes	Pending
Alexander Archipelago Wolf	August 10, 2011	No	Pending
Prince of Wales Flying Squirrel	September 30, 2011	Yes	Not Warranted
Iliamna Lake Seals	November 19, 2012	No	Pending
Yellow-billed Loon	March 30, 2004	Yes	Not Warranted
Marine corals (43 species)	August 12, 2012	No	Not Warranted
Pinto abalone	August 1, 2013	No	Not Warranted
Alaska Yellow Cedar	June 24, 2014	No	Pending

[1] For eastern core of its range: http://www.bu.edu/cecb/files/2010/12/Final-Status-Review.pdf

species have successfully slowed or reversed population declines. Restrictions on hunting of certain waterfowl species appear to have reversed significant declines or stabilized populations (e.g., Trumpeter Swan, Aleutian Canada Geese, Spectacled Eider, Steller's Eider). These species provide good examples because they are (a) intensively monitored, and (b) hunting contributes significantly to observed trends. With the development of more rigorous monitoring for other SGCN, the department will be in a better position to initiate conservation actions, and be able to monitor success.

In the future, our success in meeting conservation objectives may be assessed through the new USFWS Wildlife and Sport Fish Restoration (WSFR) TRACS program (http://tracs.fws.gov/public/). TRACS (Tracking and Reporting Actions for the Conservation of Species) has 2 platforms that will be used, a data platform that is accessible to authorized entities such as the department, and a public platform that is available online to the public. The data platform should provide the department with summaries and breakdowns of where and how conservation dollars are spent in the state. Within the public platform, ADF&G can use the Auxiliary TRACS to include additional information from partners and other planning efforts on SGCN outside of WSFR projects. Additionally, ADF&G will be able to track and highlight its successful conservation actions for SGCNs and their habitats through the Wildlife TRACS Population Status Module. By using TRACS, ADF&G will be able to format data so they are also readily comparable with other states and can be quickly included in national summaries. Because TRACS is a very new initiative, information on conservation actions on SGCN species in Alaska is not yet available on the public platform. However, populating the public and data platforms with detailed measures of conservation actions taken on SGCNs and their habitats in Alaska will provide an effective tool to evaluate the effectiveness of our conservation actions and demonstrate our successes.

Alaska Priorities

Augustine Volcano, located in Cook Inlet, last erupted in 2006. Photo by Michelle Coombs, Alaska Volcano Observatory.

In a review of the original state action plans, the Association of Fish and Wildlife Agencies recommended greater prioritization of SGCN, habitats, threats, and conservation actions in plan revisions (AFWA 2012). To address that recommendation, this chapter identifies the department's top priorities.

There is a rich literature on the need for, and the approaches to, setting conservation priorities (Margules and Pressey 2000; Bunnell et al. 2004a; Arponen 2012; Joseph et al. 2009). In addition to extinction risk, other factors such as ecological, and cultural and economic importance may be considered (AFWA 2012), as well as subjective factors such as threats (Master 1991), what remedies are available, at what cost (Hughey et al. 2003), and with what prospects for a given project's success (Wilson et al. 2003). In this chapter we focus on priority species, habitats, threats, and conservation actions.

The Spectacled Eider is listed as a threatened species due to significant declines in the 1990s. Photo by Olaf Reimer.

Species Priorities

The list of SGCN is intentionally large. This reflects the inherent uncertainty surrounding SGCN in Alaska, where the landscapes are large and data are sparse. As a preliminary screen, highest priority is assigned to SGCN for which Alaska has high stewardship responsibility, and for which there is a documented conservation concern. Examples of high-priority taxa on this basis are shown in Table 5.

The highest priority species logically include those that meet multiple criteria for inclusion as SGCN. For example a species with a small population that is declining (so at risk), that is also a stewardship species, and/or an ecologically important species, and/or a culturally important species, and/or a sentinel species would naturally rank high. Our initial efforts to develop a list of priority species was hampered by the lack of information on the conservation status of many taxa (e.g., unknown population size, trend, and percentage of population in Alaska), and the fact that there are no bright lines defining ecologically important species, or sentinel species. The exercise resulted in the highest priority species being those relatively well recognized, and on which more research had been, or was being, conducted. There was much more information on birds and marine mammals, for example, than there was on small mammals and marine invertebrates. Preliminary attempts to prioritize species by a single suite of criteria met with objection from those whose interest and concern was on data-deficient taxa.

The list in Table 5 represents one set of species priorities for Alaska. Other species, not listed, may be data-deficient and warrant an investment to ascertain their status. We refer the reader to Appendix A which lists the reason(s) for each SGCN being identified. Depending on what category of conservation need one wishes to prioritize, be it a sentinel species, an invasive species, a data-deficient species, or an "at-risk" species, different taxa rise to the top in different sorts.

In addition to assessing the perceived need for work on a given species, other factors such as feasibility, affordability, and utility of expected results should be considered before a project is proposed and approved. The process for considering those additional factors is covered in the next chapter on plan implementation.

Table 5. Examples of high-priority SGCN from diverse taxonomic groups. Each is notable for having a relatively small, declining, and/or vulnerable population that is heavily dependent on habitats in Alaska. (The list is not ordered by priority.)

Species	Population Size	% in Alaska	Trend	Status
N. Pac. Right Whale (E. Pop)	< 30	100%	Stable	Very small, depleted population
Beluga Whale (Cook Inlet)	312	100%	Stable	Declined, depleted population
Steller Sea Lion (western stock)	~21,000	100%	Stable	Declined
Alaska Hare	Unknown	100%	Unknown	Endemic species, hunted
McKay's Bunting	31,200	100%	Unknown	Small population, endemic
Gray-headed Chickadee	Unknown	~90%	Unknown	Small population, declining range, endemic
POW Spruce Grouse	<8,300	100%	Unknown	Small population, endemic, vulnerable
Pacific Black Brant	~150,000	100%	Stable	All pass through Izembek, vulnerable
Spectacled Eider	~375,000	>90%	Declining	Depleted population, vulnerable
W. Arctic King Eider	21,000	100%	Declining	Small population in decline
Bristle-thighed Curlew	10,000	100%	Stable	Small population, vulnerable
Marbled Godwit *(beringiae)*	2,000	100%	Declining	Small population, declining, vulnerable
Rock Sandpiper *(ptilocnemis)*	19,832	100%	Unknown	Small population, restricted breeding range
Kittlitz's Murrelet	> 35,000	~80%	Uncertain	Small population, vulnerable
Aleutian Tern	9,500	100%	Declining	Small population, declining

Aquatic species have been, and will continue to be, handled differently than terrestrial species. Few aquatic species are at risk, and the existing funding mechanism is inadequate for managing some exploited species and stocks. Therefore, use of SWG funding by the department's Division of Sport Fish for conservation of aquatic species has been directed more strongly towards species that are fished, either for sport, subsistence, or commercial uses. Protecting the habitats of these exploited species not only aids in their conservation and management, but promotes the conservation of many other aquatic species using similar habitats. The focus on aquatic species, including those that are culturally and economically important, continues in this revised action plan.

Habitat Priorities

Habitats which are essential to a rare and declining species are themselves priorities to conserve. If the critical habitat types are not known, habitats that (a) have high species richness naturally, and (b) are expected to diminish with foreseeable climate change or development are the conservation priorities.

For example, beach-fringe forest habitat in Southeast Alaska is far rarer than upland forest habitat, and also holds more species per unit area. This is because it represents an ecotone, or edge, between closed forest and open beach. Moreover, the beach-fringe forest has been subject to a high level of historic and proposed future logging because this ecotone is accessible, flat, and contains (as a rule) larger, more valuable trees than average forestland. Knowing nothing about the requirements of a specific SGCN in this case, beach fringe habitats should be prioritized over upland forest habitat for conservation.

With these general rules in mind, the following habitats rise as priorities (with the main reason in parentheses):

- Sea ice (diminishing with climate change, important for threatened species like ice seal, walrus, and polar bear).
- Alpine and arctic tundra (diminishing with climate change).
- Rivers, streams, and fjords dependent on ice-melt flow (diminishing with climate change).

Species of Conservation Need: Collared Pika, Ochotona collaris

Out of 30 pika species, only 2 occur in North America. The northern-most is the collared pika, found only in Alaska and Northwest Canada. In Alaska, it inhabits the mountains of Central and Southcentral regions. Preferred habitats include rock slides, talus slopes and large boulder fields near meadows. They do not dig burrows, and they do not hibernate, but remain active in rock piles under the snow throughout the winter. They rely on large caches of food gathered during the summer to sustain themselves. They maintain territories of about 30 yards in diameter, and will defend their food caches vigorously against others. Due to collared pika being a cold-adapted species, its resilience to climate change is limited. Collared pikas are considered a sensitive indicator species for the effect of climate change on alpine ecosystems. Photo by Jacob Frank.

- Wetlands underlain by permafrost (diminishing with climate change, productive for many breeding waterbirds).
- Beaches and sea cliffs, especially mudflats and eel-grass beds (these support high numbers of invertebrates, waterfowl, and shorebirds).
- Temperate rainforest (old growth), especially stands with big trees (rare, impacted by past logging, unique structural and functional attributes).
- Nearshore and shelf marine (highly productive habitats, important for at-risk species including whales and eiders, many populations exploited commercially, subject to oil and gas development).

Most of these habitats are expected to shrink in extent, and shift northward in location, as the climate warms. Appendix D shows which species use these vulnerable habitats.

Threat Priorities

There are innumerable threats that affect every wildlife species at some time, and some place during its life cycle. If the primary purpose of the conservation plan is to keep species off the endangered species list, then threats that affect wildlife at a global or continental scale rise to the top. Climate change is likely the most impactful threat to wildlife in Alaska. Species that inhabit the northern edge of the continent, or that depend on sea ice, are most vulnerable to climate change because their niche is not just shifting, it is disappearing. Climate change has been the principle driver of ESA listing petitions in Alaska in the last 15 years, and is the basis for recent positive findings with respect to ice seals and polar bears. Even though these species may be fairly abundant at present, there is uncertainty about their status in the future. For many marine aquatic species, the potential for climate change, and associated oceanographic effects (e.g., current patterns, acidification, temperature rise) could affect entire food chains. For these reasons, climate change is a very high priority threat.

Rapidly thawing Arctic permafrost and coastal erosion on the Beaufort Sea, Arctic Ocean, near Point Lonely, Alaska. Photo by Awning88.

Another significant threat that can operate at the species level, and threaten persistence, is overharvest by humans. This was the basis for dramatic declines in a number of listed species in Alaska including the great whales (Trites et al. 2007), Short-tailed and Laysan albatrosses (Hasegawa and DeGange 1982) and a number of extinctions, or near-extinctions, in the nineteenth century (Eskimo Curlew, Great Auk, elephant seal, Plains bison, and American beaver, to name a few). Many once-threatened species are now recovered through a variety of science-based conservation partnerships among state and federal agencies, various conservation/hunting organizations and many others (Mahoney 2013; Mahoney and Jackson 2013). Alaska and federal statutes prohibit setting harvest levels above sustainable yields. However, uncertainty and unanticipated environmental variability can lead to lower than anticipated numbers in harvested populations. Examples of species that have suffered modern declines for various reasons include crab stocks in the Gulf of Alaska (Armstrong et al. 1998), some Pacific herring stocks in

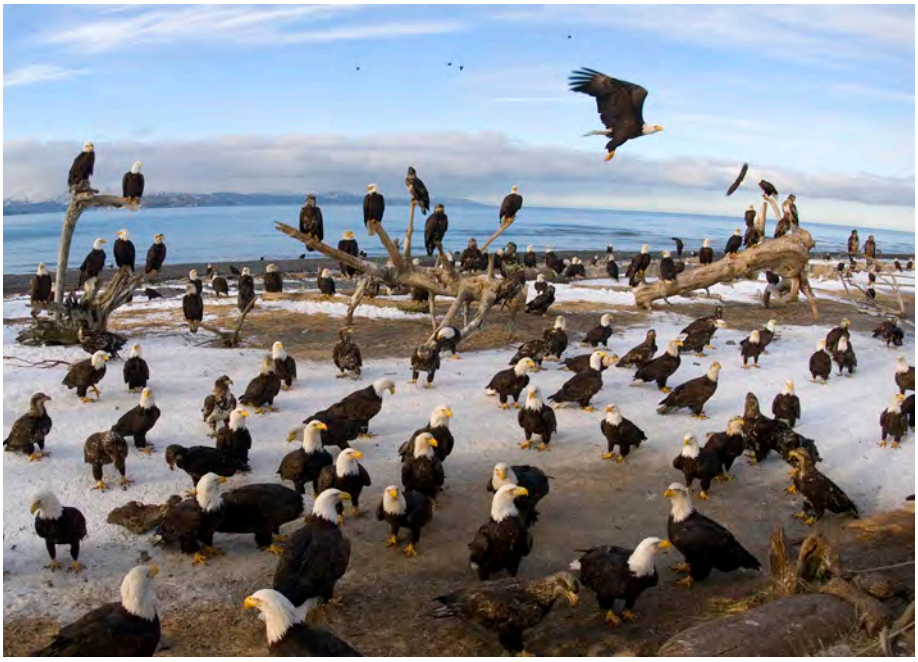
Southeast Alaska (Woodby et al. 2005), Alaska abalone (Woodby et al. 2000), and king salmon stocks in the Yukon River (Howard et al. 2009).

Invasive species represent a high priority threat due to the potential for widespread effects on native wildlife populations. They are elevated in priority because relatively few species are widely established, making eradication and control efforts feasible and potentially cost effective.

Another priority threat is the threat of a major oil spill in arctic waters (Huntington 2009).[102] Recent oil and gas leases in the Chukchi and Beaufort seas suggest production wells are likely in the foreseeable future. Although there are redundant measures in place to minimize the risk of catastrophic accidents (e.g., Exxon Valdez, Deepwater Horizon), the potential impact of such an accident on the region's wildlife would be serious. The region is remote from any response centers (ships and personnel), and experience in containment and cleanup under arctic conditions (potentially 24-hour darkness, and ice cover) is limited. Efforts to better understand the wildlife resources at risk to this threat, and options for reducing risk, are worth investing resources in.

Priority Conservation Actions

Alaska will flexibly engage in priority conservation actions over the next 10 years through individual project plans that take advantage of opportunities for success. One would expect that the highest priority conservation actions would be directed at the highest priority species, and the highest priority threats. But other factors necessarily weigh in the assignment of conservation actions (see discussion in Implementation chapter). For example, it might be clear that habitat loss and degradation in the Yellow Sea is the preeminent threat to a number of Alaska's breeding shorebirds (Martin et al. 2007). If those are the population bottlenecks controlling demographics, conservation actions aimed at breeding habitat in Alaska might be ineffective. Identifying a problem is one thing; fixing it is quite another. The recent listing of ice seals, and polar bears, based on current and predicted climate change, presents just such a conundrum. The problem is recognized, but the conservation actions that might be applied are unlikely to alter the rate at which sea ice is melting.



In 1978, the Bald Eagle was listed as endangered in the contiguous 48 states. Conservation actions were implemented, and in 2007, the species was deemed recovered, and removed from the Endangered Species List. Populations in Alaska remained abundant throughout that time. Photo of eagles in Homer, Alaska, © Mark Emery.

[102] McLendon, R. 2015. 5 dangers of oil drilling in the Arctic Ocean. Mother Nature Network. 12 May 2015. http://www.mnn.com/earth-matters/wilderness-resources/blogs/5-dangers-of-oil-drilling-in-the-arctic-ocean (Accessed July 2015).

Species of Conservation Need: Pacific Herring, Clupea pallasii

Pacific herring are found in coastal Alaska waters from Southeast Alaska to the eastern Bering Sea. Adults can live 8–16 years, and can reach up to 18 inches. They spawn annually in bays and estuaries, preferring eel-grass and kelp beds. Spawning aggregations can number tens of thousands of fish. A single female can lay 20,000 eggs. Pacific herring is ecologically very important in Alaska marine ecosystems as a major prey item of many fish, seabird, and marine mammal species. It is also an important subsistence and commercial species for humans. Because of their dense spawning aggregations, large numbers can be harvested in a short time. Historic harvesting for roe, oil, and fertilizer reduced herring abundance and extirpated some local populations. Herring populations today are carefully managed for sustained yield. Primary threats are loss or alteration of important spawning habitat through pollution or coastal development. Photo of herring roe by Scott Walker.

With these factors in mind, the types of conservation action that we believe will emerge as priorities over the next 10 years include the following:

Monitoring Vulnerable Populations

Identifying a population that is in need of conservation requires basic information on trends in the population, or the habitat of a given species. Having quantitative information on population size and rate of decline allows informed judgment about the severity of the concern, and the type of conservation action called for. If we know a population is declining, the next question should be "Why?" Answering this often requires reliable information on reproductive success, mortality, movements, and habitat use. Acquiring this information once population status is known will be a subsequent priority.

Removing Invasive Species

An example of an effective, and achievable, conservation action is the removal of invasive species from places they don't belong (e.g., arctic fox from islands, northern pike from lakes). This one-time action, if successful, can have profound and essentially permanent effects on native flora and fauna (Maron et al. 2006, Ebbert and Byrd 2002). Because invasive species are especially problematic on islands, we stand to protect centers of endemism, or places where Alaska has high stewardship responsibility. Because invasive species have not spread as widely in Alaska as other places, we have a better chance of successfully eradicating them. These factors, collectively, point to removing invasive species as a priority conservation action in Alaska.

Identification of High-Use Terrestrial and Marine Areas for Wildlife

All areas are not equal in value to wildlife. Where tradeoffs must be made, knowing what areas and habitats are most valuable provides great negotiating leverage. For example, with good information on seabird and marine mammal distribution in space and time, oil and gas development in the Chukchi Sea, or shipping through the Arctic Ocean might be placed to avoid most breeding and feeding areas for birds and mammals (Lovvorn et al. 2009). With good information on the forest types most important to certain wildlife species, better decisions can be made about minimizing impacts from logging. Being able to provide decision makers with good data on likely tradeoffs is an important, high priority conservation action in Alaska.

Plan Development, Implementation, and Review

The southwestern stock of the northern sea otter has experienced a sharp decline in the last 20 years, and is listed as threatened under the Endangered Species Act. Photo by Michael L. Baird.

This chapter addresses the seventh and eighth required elements of the plan. The seventh element requires describing "strategies for the development, implementation, review and revision of the revised action plan with federal, state, and local agencies and Indian tribes that manage significant land and water areas within the state, or administer programs that significantly affect the conservation of identified species and habitats." The eighth required element requires describing public participation in the development and implementation of the plan.

We started the revision process with an evaluation of what elements of the prior plan worked well and needed no revision, and what elements were less useful. The review feedback indicated that the former plan was too long. It identified too many species, threats, and actions, without prioritizing them. The labelling was also confusing, with "nominee species" and "featured species" used as surrogate names for species of greatest conservation need. While the plan was comprehensive in identifying the species, concerns, and conservation actions that were possible, it was obvious only a small fraction could possibly ever be addressed. The document was long on information and short on strategic guidance.

The original (2006) plan identified hundreds of research, inventory, and monitoring needs for the 74 "featured" species in the plan. Those write-ups occupied more than 400 pages.[103] Only a handful

[103] Alaska Department of Fish and Game, Wildlife Action Plan [web page]. http://www.adfg.alaska.gov/index.cfm?adfg=species.wap2015revision

Species of Conservation Need: Aleutian Tern, Onychoprion aleuticus

The Aleutian Tern breeds only in Alaska and eastern Siberia. The largest known colony is at Blacksand Spit, near Yakutat. In Alaska it breeds in widely scattered colonies all along the coast of Alaska, with entire colonies disappearing in some years. Whether this represents local population declines, or simply movement among colony sites, is uncertain. However there is a growing consensus that the Alaska population is declining, possibly quite rapidly. The bird's wintering grounds are not well known, but sightings have been reported from scattered locations in Southeast Asia. Aleutian Terns represent a small population of birds (9,500) that are very poorly studied. They are less aggressive than Arctic Terns, and are more sensitive to disturbance at breeding colonies. Photo by F. Deines, USFWS.

of those hundreds of suggested actions for monitoring, research and conservation could be, or were, implemented. One significant change made in this revision was to reduce the amount of information presented to make the plan manageable to read and use, and to convey a clearer sense of what key species, threats, and conservation actions are priorities.

This revision is intended to provide strategic guidance in terms of general priorities. It does not outline specific projects, with budgets, timelines and outcomes. There are too many possible permutations of the factors that must be considered. As annual work plans are considered, some factors, like populations at risk of decline and stewardship responsibility, can flow directly from the information in this plan. Other factors, such as funding availability, technical feasibility, staff capacity, probability of success, opportunities for partnerships, and political factors, can shift significantly year to year, and affect feasibility and effectiveness.

Below we list the factors the department will consider when deciding what specific species and work will be funded by State Wildlife Grant funds. Evaluations will be conducted on a rolling basis as existing projects conclude, and there is an opportunity to initiate a new project. The public, and our interagency, NGO, and tribal partners will be included in these discussions.

- *Extinction Risk.* Is a species proposed likely to become threatened, endangered, or extinct in the near future?
- *Stewardship Responsibility.* Does a species have a high proportion of its population in Alaska relative to its range?
- *Cultural, Economic, Commercial, and Ecological Importance.* Is the species important to conserve for other reasons?
- *Sentinel Species.* Is the species sensitive to anticipated environmental change?
- *Efficiency and Feasibility.* What specific research or monitoring projects are most likely to succeed (technically feasible, results useful for conservation)?

- *Program Capacity.* Does ADF&G have the needed expertise and capacity to successfully address a given species, habitat, threat, or action? If not, is creating new capacity a good alternative? Or should the work be directed to a partner with existing capacity and expertise?
- *Opportunity for Synergy.* Does an action take advantage of synergies available by partnering with other agencies and organizations, or alternatively, is it redundant, with work other agencies are already doing well?
- *Funding Availability.* Can an action be completed successfully with the current funds available? Are there other opportunities for match that might elevate one proposal over another?

Multi-day workshops with other agency staff, NGOs, and the public were convened to develop the original plan (ADF&G 2006). This level of engagement was not repeated with the revision because: (a) most of the information in the original plan remains valid, (b) smaller meetings with species experts that were undertaken provided richer, more useful interchange for purposes of the revision, and (c) a shorter, more streamlined draft action plan posted on the department's website allowed for broader public review and detailed comments.

Meetings were held with a number of groups and agency staff, including Fish Habitat Partnerships, Bird Groups, University of Alaska faculty, and staff of the Alaska Natural Heritage Program. Presentations were made at the Alaska Chapter of the American Fisheries Society, USFWS – Wildlife and Sport Fish Restoration Program, and USFWS - Migratory Birds (with waterfowl, seabird, and shorebird biologists). A list of the organizations contacted as the plan was revised is given in Table 6.

Table 6. Groups consulted with during development of the revised State Wildlife Action Plan (pre-draft).

GROUP
Alaska Natural Heritage Program (UAA)
Audubon Alaska
Juneau Audubon
U.S. Fish and Wildlife Service–Wildlife and Sport Fish Restoration Program (Region 7)
U.S. Fish and Wildlife Service–Migratory Birds (Waterfowl, Seabird, Landbird, and Shorebird groups)
U.S. Fish and Wildlife Service –Endangered Species program
ADF&G leadership (Directors and Deputies)
ADF&G Statewide Programs (Wildlife Diversity [now TED], Waterfowl, Marine Mammals)
ADF&G LCC coordinator
Agency Biologists (USGS, USFWS, ADF&G, NPS)
Pacific Coast Joint Venture
Alaska Fish–Habitat Partnerships
American Fisheries Society–Alaska Chapter
University of Alaska Fairbanks
Boreal Partners in Flight
Alaska Raptor Group
Alaska Shorebird Group
Action Plan coordinators from Idaho and Washington
Association of Fish and Wildlife Agencies (AFWA) coordinator

Eligible Activities

As the state implements the revised action plan, it is important to describe the types of activities that are eligible for funding by State Wildlife Grants (Table 7).

Public Comment on the 2015 Plan Revision

One of the recommendations in the best practices guide (AFWA 2012) was to provide mechanisms for conservation partner engagement to further collaboration and understanding of how their input is used and valued. In this section, we provide a summary of review comments and department responses.

After a draft revision was completed, we invited more than 150 organizations, agencies, and industry groups to review the plan. It was also made available on the department's website for comment from the general public, and a news release was issued and interviews given to news reporters for

Table 7. Activities eligible for State Wildlife Grant (SWG) funding.

Type of Funding Eligible Activity	Specific Activities and Limitations
(1) Conservation and management actions	a. Research. b. Surveys. We may approve surveys and monitoring to obtain data for the State of Alaska to decide if it should designate a species as a Species of Greatest Conservation Need. c. Species monitoring. d. Species and habitat management. If a species of greatest conservation need depends on a plant species for its survival, we consider the plant species as part of its habitat. e. Habitat evaluations. f. Evaluations of the effectiveness of conservation and management actions. g. Acquisition of real property, including monitoring acquired properties to ensure that they continue to serve the purpose for which they were acquired. h. Facilities development.
(2) Coordination and administrative activities	a. Developing and maintaining data management systems to record, store, or disseminate information. b. Monitoring progress of projects. c. Developing strategic and operational plans. d. Coordinating implementation meetings with partners. Partners are entities that take part in planning or carrying out a state plan. These entities include, but are not limited to: federal, state, and local agencies; tribes; nonprofit organizations; academic institutions; industry groups; and private individuals.
(3) Education and law enforcement activities when the activities	a. Are critical to achieving the project's objectives. b. Are no more than 10 percent of the respective project costs.

Source: Fish and Wildlife Service, Federal Financial Assistance, State Wildlife Grants http://www.fws.gov/policy/517fw10.pdf (Accessed 21 September 2015

news stories to encourage public participation. We received comments back from 28 agencies, NGOs, and industry groups, and 169 individuals. Their review comments were generally detailed and helpful. All comments, and the department's responses, are public record and available from the department and were made available following the end of the review period via the department's website.[104]

Delta River fishing. Photo by Brian Collyard, ADF&G.

Below, we provide a brief summary of the main comments received, and the changes made:

Most reviewers appreciated the shorter, more streamlined plan. They found it well organized, nicely illustrated, and easy to read. In the final, we added more photos to the text-heavy sections of the plan.

Some reviewers sought a clearer connection between species, habitats, threats, and actions. We added a series of species accounts throughout the plan that do just that, providing stories that connect these elements for the reader.

Some wanted to gain a better sense of the department's priorities in specific terms. What exactly were the projects we would be working on in the next 10 years? Others thought the priorities were clear. We revised to make clear that developing specific work plans is a two-stage process requiring different information at the strategic (action plan) stage, and the operational (proposal) stage.

Some reviewer's recommended we include or exclude a particular species of greatest conservation need. In almost every case, suggestions to add species were adopted.

Southeast Alaska rainforest. Photo by Riley Woodford, ADF&G.

[104] Alaska Department of Fish and Game, Wildlife Action Plan [web page]. http://www.adfg.alaska.gov/index.cfm?adfg=species.wap2015revision

Industry perspectives thought the plan overstated some threats to wildlife, and some environmental organizations thought the plan understated some threats. We edited the threats discussion of oil and gas and logging to be more neutral, and strengthened it with additional scientific literature citations.

The majority of commenters liked the emphasis on climate change. A few thought we could have written more, modelled future scenarios, or characterized the threat as more imminent. We increased the emphasis on climate change in the final.

Some thought the priorities did not flow logically from the threats (some inconsistent terminology). We revised this to strengthen the linkage.

Several commented that allowing 30 days for public comment was inadequate, especially because the comment period fell during late summer.

Many individuals (>150) thought that 9a) the nonhunting public was being ignored in matters related to wildlife management and conservation, (b) that the Board of Game was not representative of all wildlife users in Alaska, (c) that more managing specifically for ungulate abundance (via predator control) altered ecosystems to the detriment of some species, and (d) that the state should work more cooperatively with federal land managers in managing and conserving Alaska's wildlife.

2025 Revision of Alaska's Wildlife Action Plan

A study of the migratory movements of golden eagles, just underway, will be completed by the time the Action Plan is next revised. Photo by Travis Booms, ADF&G.

The sixth element required in the plan is a description of procedures to review the plan at intervals not to exceed 10 years.

The Alaska Department of Fish and Game will monitor the implementation and effectiveness of the current plan annually. If new SGCN or issues are raised that are not in the current plan, we will amend through the "process to address emerging issues"[105] with the USFWS. Should there be new information that suggests a major revision is warranted prior to 2025, the department will undertake that effort. Barring that circumstance, we expect to revise this plan on the normal 10-year schedule. That would put the next revision of this action plan due in October 2025.

Prior to undertaking the next revision, the department will meet with partners to decide the process that will produce the most useful plan, in the most efficient manner possible.

[105] The following requirements for documenting emerging issues must be met if applicant(s) propose to address an emerging issue:

a) Describe the emerging issue fully by identifying the species of greatest conservation need (SGCN) or habitats that would benefit from the proposed action(s);

b) Explain why it is an emerging issue; and

c) Commit the State to monitoring the effectiveness of the completed action(s) so the State can adaptively manage future activities.

The application must include a commitment letter that the director of the state fish and wildlife agency has signed stating that the next version of the SWAP will include the emerging issue if it remains a priority. The Assistant Regional Director for Migratory Birds and State Programs, or a Service official in a similar position associated with WSFR, must review the grant application or any future amendments that include emerging issues not in the SWAP before the application is sent to the national review panel for scoring. The Assistant Regional Director of the Service must concur that the issue is an emerging issue, or the application will not be considered for funding. WSFR must retain the original paper copy, or an electronic copy of the concurrence or non-concurrence document.

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Pribilof Rock Sandpiper. Photo by Dan Ruthrauff.

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Appendices

Horned Puffin. Photo by Maria Gladziszewski, ADF&G.

Appendix A. Species of Greatest Conservation Need (SGCN) in Alaska by justification.

EN=Endangered (or G1 for NatureServe), TH=Threatened (or G2 for NatureServe), VU=Vulnerable (or G3 for NatureServe), NT = Near Threatened, P = Petition for ESA listing under review, C = Candidate for ESA listing. SOC = Species of Concern. BBS = Breeding Bird Survey. CBC = Christmas Bird Count.

Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Freshwater Invertebrates														
Ephemeroptera, (Order-Mayflies)														●
Odonata (Order-Dragon and Damselflies)														●
Plecoptera, (Order-Stoneflies)														●
Trichoptera, (Order-Caddisflies)														●
*Cladocera (*Order-Water Fleas)														●
Margaritifera falcate, Western Pearlshell Mussel												●		●
Adonata beringiana, Yukon Floater Mussel												●		●
Adonata adionata kennerlyi, Western Floater Mussel												●		●
Marine Zooplankton														
Euphasiacea, Euphasids														●
Copepoda, Copepods, primarily Calanoida														●
Mysida, Mysids														●
Amphipoda, Benthic Amphipods														●
Crabs														
Cancer magister, Dungeness Crab												●	●	
Chionoecetes bairdi, Tanner Crab												●	●	
Chionoecetes opilio, Snow Crab												●	●	
Lithodes aequispinus, Golden King Crab												●	●	
Paralithodes camtschaticus, Red King Crab												●	●	
Paralithodes platypus, Blue King Crab												●	●	
Erimacrus isenbeckii, Hair Crab														●
Telmessus cheiragonus, Helmet Crab														●
Cockles, Scallops, Clams, Mussels and Abalone														
Chlamys rubida, Pink Scallop												●		
Haliotis kamtschatkana, Pinto Abalone												●		
Macoma balthica, Baltic Macoma														●
Mytilus trossulus, Pacific Blue Mussel												●		
Panopea generosa, Geoduck Clam												●		
Patinopecten caurinus, Weathervane Scallop												●	●	
Protothaca stamineais, Littleneck Clam												●		
Saxidomus gigantean, Butter Clam												●		

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Siliqua patula, Razor Clam												●		
Clinocardium nuttallii, Nuttall's Cockle												●		
Octopus and Squid														
Enteroctopus dofleini, Giant Pacific Octopus												●	●	
Berryteuthis anonychus, Minimal Armhook Squid														●
Berrytheuthis magister, Red Squid /Magistrate Armhook														●
Shrimp														
Pandalus borealis, Northern Shrimp												●	●	
Pandalus dispar, Sidestripe Shrimp												●	●	
Pandalus goniurus, Humpy Shrimp												●	●	
Pandalus hypsinotis, Coonstripe Shrimp												●	●	
Pandalus patyceros, Spot Shrimp												●	●	
Hippolyte clarki, Eelgrass Shrimp														●
Chitons and Snails														
Cryptochiton stelleri, Gumboot Chiton												●		
Katharina tunicate, Black Katy Chiton												●		
Sea Cucumbers, Sea Stars and Sea Urchins														
Parastichopus californicus, Sea Cucumber												●	●	
Echinodermata, Sea Stars														●
Strongylocentrotus droebachiensis , Green Sea Urchin												●		
Strongylocentrotus franciscanus, Red Sea Urchin												●		
Salmon														
Oncorhynchus gorbuscha, Pink Salmon												●	●	●
Oncorhynchus keta, Chum Salmon												●	●	
Oncorhynchus kisutch, Coho Salmon										●		●	●	
Oncorhynchus nerka, Sockeye Salmon										●		●	●	
Oncorhynchus tshawytscha, Chinook Salmon										●		●	●	
Trout and Steelhead														
Oncorhynchus mykiss, Rainbow Trout												●		
Oncorhynchus clarki clarki, Coastal Cutthroat Trout												●		
Salvelinus namaycush, Lake Trout												●		
Oncorhynchus mykiss, Steelhead												●		
Sharks														
Lamna ditropis, Salmon Shark														●

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Sablefish, Halibut and Flounder														
Anoplopoma fimbria, Sablefish													●	
Hippoglossus stenolepis, Pacific Halibut												●	●	
Atheresthes stomias, Arrowtooth flounder													●	
Forage Fish														
Hypomesus olidus, Pond Smelt												●		●
Hypomesus pretiosus, Surf Smelt												●		●
Osmerus mordax, Rainbow Smelt												●		●
Spirinchus starksi, Night Smelt												●		●
Spirinchus thaleichthys, Longfin Smelt												●		●
Mallotus villosus, Capelin												●		●
Thaleichthys pacificus, Eulachon												●		●
Ammodytes hexapterus, Pacific Sand Lance												●		●
Clupea pallasii, Pacific Herring												●		●
Percopsis omiscomaycus, Trout-Perch											●			
Cod and Mackerel														
Boreogadus saida, Arctic Cod											●	●		
Gadus microcephalus, Pacific Cod												●	●	
Ophiodon elongates, Lingcod												●		
Eleginus gracilis, Saffron Cod												●		
Microgadus proximus, Pacific Tomcod												●		
Lota lota, Burbot												●		●
Pleurogrammus monopterygius, Atka Mackerel													●	
Rockfish														
Sebastes variabilis, Dusky Rockfish												●		
Sebastes alutus, Pacific Ocean perch													●	
Sebastes auriculatus, Brown Rockfish												●		
Sebastes caurinus, Copper rockfish												●		
Sebastes maliger, Quillback Rockfish												●		
Sebastes melanops, Black Rockfish												●		
Sebastes nebulosus, China Rockfish												●		
Sebastes paucispinis, Bocaccio												●		
Sebastes ruberrimus, Yelloweye Rockfish												●	●	
Stickleback														
Pungitius pungitius, Ninespine Stickleback														●

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Suckers and Chub														
Couesius plumbeus, Lake Chub														●
Whitefish, Blackfish and Inconnu														
Coregonus pidschian, Humpback Whitefish												●		
Coregonus nasus, Broad Whitefish												●		
Prosopium coulterii, Pygmy Whitefish											●			
Prosopium cylindraceum, Round Whitefish												●		
Dallia pectoralis, Alaska Blackfish										●		●		
Stenodus leucichthys, Inconnu										●				
Coregonus autumnalis autumnalis, Arctic Cisco												●		
Coregonus laurettae, Bering Cisco												●		
Coregonus sardinella, Least Cisco												●		
Pike, Char and Grayling														
Esox Lucius, Northern Pike												●		●
Salvelinus alpinus, Arctic Char												●		
Salvelinus malma, Dolly Varden										●		●		
Thymallus arcticus, Arctic Grayling												●		
Lamprey														
Lethenteron alaskense, Alaskan Brook lamprey			VU								●			
Lethenteron camtschatica, Arctic Lamprey												●		
Lampetra ayresii, Western River lamprey											●			
Entosphenus tridentate, Pacific Lamprey												●		
Amphibians														
Taricha granulosa, Roughskin Newt											●			
Anaxyrus boreas, Western Toad											●	●		
Lithobates sylvaticus, Wood frog											●			
Ambystoma gracile, Northwestern Salamander											●			
Ambystoma macrodactylum, Long-toed salamander											●			
Terrestrial Invertebrates														
*Hymenoptera (*Order- ants, bees, wasps, hornets)													●	●
*Diptera (*Order – flies, midges, mosquitos, gnats)													●	●
Odonata (Order – dragonflies, damselflies, skimmers)													●	●
Lepidoptera (Order – butterflies and moths)													●	●
Arachnida (Order – spiders)													●	●

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Ducks, Geese and Swans														
Cygnus buccinator, Trumpeter Swan										●				
Anser albifrons elgasi, Tule Greater White-fronted Goose			VU							●		●		
Anser albifrons frontalis, Greater White-fronted Goose (midcontinent population)[1]											●	●		
Chen canagica, Emperor Goose		NT	VU							●		●		
Branta hutchinsii taverneri, Taverner's Cackling Goose										●		●		
Branta hutchinsii leucopareia, Aleutian Cackling Goose			VU							●				
Branta hutchinsii minima, Cackling Cackling Goose										●		●		
Branta canadensis occidentalis, Dusky Canada Goose			VU							●	●	●		
Branta bernicula nigricans, Pacific Black Brant												●		
Athya affinis, Lesser Scaup[1]											●	●		
Somateria mollissima, Common Eider (Pacific Population)										●	●	●		
Polysticta stelleri, Steller's Eider	TH	VU	VU		●					●	●	●		
Somateria fischeri , Spectacled Eider	TH		VU		●					●	●	●		
Somateria spectablis, King Eider (W. Arctic)										●	●	●		
Melanitta deglandi, White-winged Scoter											●	●		
Melanitta americana, Pacific Black Scoter		NT								●	●	●		
Clangula hyemalis, Long-tailed Duck											●	●		
Raptors														
Accipiter gentilis laingi, Queen Charlotte Goshawk			TH						●		●			
Buteo lagopus, Rough-legged Hawk										●				
Buteo jamaicensis alascensis, Alaska Red-tailed Hawk			VU						●	●				
Buteo jamaicensis harlani, Harlan's Red-tailed Hawk									●	●				
Haliaeetus leucocephalus, Bald Eagle										●	●	●		
Aquila chrysaetos canadensis, Golden Eagle									●	●				
Falco rusticolus, Gyrfalcon									●	●	●			
Falco perigrinus, Peregrine Falcon										●				
Falco perigrinus pealei, Peale's Peregrine Falcon										●				
Falco sparverius, American Kestrel				●					●					
Circus cyaneus, Northern Harrier				●					●		●			
Asio flammeus flammeus, Short-eared Owl				●	●	●			●					
Strix nebulosi, Great Gray Owl									●					
Surnia ulula, Northern Hawk Owl									●	●				
Megascops kennicottii, Western Screech-Owl					●				●		●			

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Bubo scandiacus, Snowy owl					●	●			●	●		●		
Aegolius funereus, Boreal Owl									●	●	●			
Kingfishers and Woodpeckers														
Megaceryle alcyon, Belted Kingfisher				●		●								
Picoides villosus sitkensis, Hairy Woodpecker										●				
Picoides pubescens glacialis, DownyWoodpecker										●				
Picoides dorsalis, American Three-toed Woodpecker														●
Picoides arcticus, Black-backed Woodpecker										●				●
Colaptes auratus luteus, Northern Flicker				●		●				●				
Sphyrapicus ruber, Red-breasted Sapsucker										●	●			
Loons and Grebes														
Gavia stellata, Red-throated Loon					●									
Gavia adamsii, Yellow-billed Loon				●	●									
Gavia arctica, Arctic Loon											●			
Procellarids														
Phoebastria immutabilis, Laysan Albatross		NT	VU		●									
Phoebastria nigripes, Black-footed Albatross		NT	VU		●									
Phoebastria albatrus, Short-tailed Albatross	EN	VU	EN		●									
Fulmarus glacialis, Northern Fulmar										●				
Oceanodroma furcata furcata, Fork-tailed Storm-Petrel										●				
Cormorants														
Phalacrocorax urile, Red-faced Cormorant					●			●		●				
Phalacrocorax pelagicus, Pelagic Cormorant								●						
Cranes														
Grus canadensis canadensis, Lesser Sandhill Crane										●		●		
Oystercatchers and Plovers														
Haematopus bachmani, Black Oystercatcher					●		●			●				
Pluvialis dominica, American Golden-Plover					●		●							
Pluvialis fulva, Pacific Golden-Plover										●				
Pluvialis squatarola, Black-bellied Plover										●				
Charadrius vociferous, Killdeer				●										
Sandpipers														
Actitus macularius, Spotted Sandpiper				●										
Tringa flavipes, Lesser Yellowlegs				●	●		●							
Bartramia longicauda, Upland Sandpiper							●				●			

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Numenius phaeopus hudsonicus, Whimbrel					●		●			●				
Numenius tahitiensis, Bristle-thighed Curlew		VU	TH		●		●			●	●			
Limosa lapponica baueri, Bar-tailed Godwit					●		●			●				
Limosa haemastica, Hudsonian Godwit					●		●							
Limosa fedoa beringea, Marbled Godwit			VU		●		●			●				
Arenaria melanocephala, Black Turnstone					●		●			●				
Calidris canutus roselaari, Red Knot					●		●			●				
Calidris virgata, Surfbird							●			●				
Tringa solitaria cinnomomea, Solitary Sandpiper							●			●				
Calidris alpina arcticola, Dunlin					●		●			●				
Calidris alpina pacifica, Dunlin					●		●			●				
Calidris alba, Sanderling							●							
Calidris ptilocnemis couesi, Rock Sandpiper										●				
Calidris ptilocnemis ptilocnemis, Rock Sandpiper			VU				●			●	●			
Calidris ptilocnemis tschuktschorum, Rock Sandpiper										●				
Tringa incana, Wandering Tattler										●				
Calidris subruficollis, Buff-breasted Sandpiper					●		●				●			
Calidris melanotos, Pectoral Sandpiper					●					●				
Calidris pusilla, Semipalmated Sandpiper					●					●				
Calidris mauri, Western Sandpiper							●			●				
Limnodromus griseus caurinus, Short-billed Dowitcher					●		●			●				
Limnodromus scolopaceus, Long-billed Dowitcher										●				
Phalaropus fulicarius, Red Phalarope										●				
Auks														
Aethia cristatella, Crested Auklet										●	●			
Aethia psittacula, Parakeet Auklet										●				
Aethia pusilla, Least Auklet										●				
Aethia pygmaea, Whiskered Auklet										●				
Alle alle, Dovekie											●			
Brachyramphus brevirostris, Kittlitz's Murrelet		NT	TH		●			●		●	●			
Brachyramphus marmoratus, Marbled Murrelet		EN	VU					●		●				
Synthliboramphus antiquus antiquus, Ancient Murrelet								●			●			
Cepphus columba columba, Pigeon Guillemot										●				
Cepphus grille, Black Guillemot											●			
Uria lomvia arra, Thick-billed Murre												●		

-continued-

Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Uria aalge inornata, Common Murre												●		
Fratercula cirrhata, Tufted Puffin										●				
Fratercula corniculata Horned Puffin										●				
Ptychoramphus aleuticus aleuticus, Cassin's Auklet								●						
Gulls, Terns and Jaegers														
Rissa tridactyla, Black-legged Kittiwake										●				
Rissa brevirostris, Red-legged Kittiwake		VU	VU		●			●		●				
Larus canus brachyrhynchus, Mew Gull												●		
Larus smithsonianus, Herring Gull				●										
Larus glaucescens, Glaucous-winged Gull										●				
Larus hyperboreus, Glaucous Gull										●				
Xema sabini, Sabines's, Gull										●	●			
Sterocarius pomarinus, Pomarine Jaeger										●	●			
Stercarius longicaudus, Long-tailed Jaeger										●	●			
Sterna paradisaea, Arctic Tern								●						
Onychoprion aleuticus, Aleutian Tern					●			●		●				
Swifts and Hummingbirds														
Selasphorus rufus, Rufous Hummingbird				●	●	●								
Cypseloides niger borealis, Northern Black Swift				●	●	●								
Larks, Crows, and Jays														
Eremophila alpestris arcticola, Horned Lark				●	●	●				●				
Perisoreus canadensis pacificus, Gray Jay										●				
Cyanocitta stelleri, Steller's Jay										●				
Corvus corax kamtschaticus, Common Raven										●				
Nuthatches, Chickadees and Swallows														
Riparia riparia, Bank Swallow				●	●	●								
Hirundo rustica, Barn Swallow				●										
Tachycineta bicolor, Tree Swallow				●										
Poecile atricapillus , Black-capped Chickadee										●				
Poecile rufescens, Chestnut-backed Chickadee				●						●				
Poecile hudsonicus, Boreal Chickadee						●				●				
Poecile cinctus lathami, Gray-headed Chickadee										●	●			
Lanius excubitor, Northern Shrike										●				
Kinglets, Creepers, Flycatchers and Wrens														
Regulus calendula grinnelli, Ruby-crowned Kinglet										●				

-continued-

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Regulus satrapa, Golden-crowned Kinglet				●										
Certhia americana occidentalis, Brown Creeper											●			
Certhia americana alascensis, Brown Creeper										●				
Empidonax alnorum, Alder Flycatcher				●						●				
Contopus cooperi, Olive-sided Flycatcher				●	●	●					●			
Empidonax difficilis, Pacific-slope Flycatcher				●						●				
Contopus sordidulus, Western Wood-Pewee				●										
Troglodytes pacificus, Pacific Wren				●	●	●				●				
Troglodytes pacificus alascensis, Pacific Wren										●				
Troglodytes pacificus helleri, Pacific Wren										●				
Troglodytes pacificus kiskensis, Pacific Wren										●				
Troglodytes pacificus meligerus, Pacific Wren										●				
Troglodytes pacificus ochroleucus, Pacific Wren										●				
Troglodytes pacificus semediensis, Pacific Wren										●				
Luscinia svecica, Bluethroat										●				
Oenathe oenanthe oenanthe, Northern Wheatear										●				
Thrushes														
Catharus ustulatus, Swainson's Thrush				●										
Catharus guttatus guttatus Hermit Thrush										●				
Catharus guttatus nanus, Hermit Thrush										●				
Ixoreus naevius, Varied Thrush					●					●				
Waxwings, Pipits and Warblers														
Bombycilla garrulus, Bohemian Waxwing										●				
Setophaga striata, Blackpoll Warbler					●					●				
Cardellina pusilla pileolata, Wilson's Warbler				●		●				●				
Anthus rubescens, American Pipit				●										
Phylloscopus borealis, Arctic Warbler										●				
Oreothlypis celata, Orange-crowned Warbler				●										
Geothlypis tolmiei, MacGillivary's Warber				●										
Geothlypis trichas, Common Yellowthroat				●										
Setophaga petechia, Yellow Warbler				●										
Setophaga petechial banksi, Yellow Warbler										●				
Setophaga petechial rubiginosa, Yellow Warbler										●				
Setophaga townsendi, Townsend's Warbler										●	●			
Setophaga ruticilla, American Redstart				●							●			

-continued-

Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Longspurs, Buntings and Sparrows														
Calcarius lapponicus alascensis, Lapland Longspur										●	●			
Calcarius pictus, Smith's Longspur						●				●	●			
Plectrophenax hyperboreus, McKay's Bunting			VU		●	●				●	●			
Plectrophenax nivalis nivalis, Snow Bunting						●					●			
Plectrophenax nivalis townsendi, Snow Bunting						●				●	●			
*Zonotrichia leucophrys,*White-crowned Sparrow				●										
Spizella passerina, Chipping Sparrow				●										
Spizella arborea, American Tree Sparrow				●										
Passerella iliaca, Fox Sparrow				●										
Passerella iliaca annectens, Sooty Fox Sparrow										●				
Passerella iliaca chilkatensis, Sooty Fox Sparrow										●				
Passerella iliaca insularis Sooty Fox Sparrow										●				
Passerella iliaca sinuosa Sooty Fox Sparrow										●				
Passerella iliaca townsendi Sooty Fox Sparrow										●				
Passerella iliaca unalaschcensis Sooty Fox Sparrow										●				
Melospiza melodia, Song Sparrow				●										
Melospiza melodia caurina, Song Sparrow										●				
Melospiza melodia insignis, Song Sparrow										●				
Melospiza melodia kenaiensis, Song Sparrow										●				
Melospiza melodia maxima, Song Sparrow										●				
Melospiza melodia rufina, Song Sparrow										●				
Melospiza melodia sanaka, Song Sparrow										●				
Melospiza lincolnii, Lincoln's Sparrow										●				
Passerculus sandwichensis, Savannah Sparrow				●										
Zonotrichia atricapilla, Golden-crowned Sparrow										●				
Junco hyemalis oreganus, Dark-eyed Junco										●				
Blackbirds, Finches, Crossbills, Grosbeaks and Redpoll														
Agelaius phoeniceus, Red-winged Blackbird				●										
Euphagus carolinus carolinus, Rusty Blackbird				●	●	●				●	●			
Leucosticte tephrocotis griseonucha, Gray-crownd Rosy-Finch										●				
Leucosticte tephrocotis umbrina, Gray-crowned Rosy-Finch										●				
Loxia leucoptera, White-winged Crossbill										●				
Pinicola enucleator flammula, Pine Grosbeak										●				
Acanthis flammea, Common Redpoll				●										

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Acanthis hornemanni, Hoary Redpoll										●				
Spinus pinus, Pine Siskin				●	●	●								
Squirrels														
Marmota broweri, Alaska marmot										●				
Urocitellus parryii, Arctic Ground Squirrel														●
Urocitellus parryii albusus, Arctic Ground Squirrel										●				●
Urocitellus parryii kennicottii, Arctic Ground Squirrel										●				●
Urocitellus parryii kodiacensis, Arctic Ground Squirrel										●				●
Urocitellus parryii lyratus, Arctic Ground Squirrel										●				●
Urocitellus parryii nebulicola, Arctic Ground Squirrel										●				●
Urocitellus parryii osgoodi, Arctic Ground Squirrel										●				●
Tamiasciurus hudsonicus, Red Squirrel														●
Tamiasciurus hudsonicus kenaiensis, Red Squirrel Kenai										●				
Tamiasciurus hudsonicus picatus, Red Squirrel Kupreanof										●				
Glaucomys sabrinus, Northern Flying Squirrel														●
Glaucomys sabrinus griseifrons, N. Flying Squirrel POW		●								●				●
Lemmings														
Lemmus trimucronatus, Nearctic Brown lemming														●
Lemmus sibiricus, Black-footed (Brown) Lemming														●
Dicrostonyx groenlandicus, Northern Collared Lemming											●			●
Dicrostonyx nelson, Nelson's Collared Lemming											●			●
Dicrostonyx unalascensis, Aleutian Collared Lemming										●	●			●
Synaptomys borealis, Northern Bog Lemming														●
Voles and Deermice														
Myodes rutilus, Northern Red-backed Vole														●
Microtus abbreviatus, Insular Vole										●				●
Microtus longicaudus, Long-tailed Vole														●
Microtus miurus, Singing Vole										●				●
Microtus oeconomus, Tundra Vole (aka root vole)										●				●
Microtus pennsylvanicus, Meadow Vole										`				●
Microtus xanthognathus, Taiga Vole										●				●
Peromyscus keeni, Northwestern Deermouse										●				●
Mice														
Zapus hudsonius, Meadow Jumping Mouse														●

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Hares and Pikas														
Lepus americanus, Snowshoe Hare												●		●
Lepus othus, Alaska Hare			VU							●		●		●
Ochotona collaris, Collared Pika										●				●
Shrews														
Sorex cinereus streatori, Common Shrew										●				
Sorex alaskanus, Glacier Bay Water Shrew										●				
Sorex jacksoni, St. Lawrence Island Shrew										●				
Sorex monticolus, Dusky (montane Shrew*)*											●			
Sorex monticolus alascensis, Dusky (montane Shrew)										●				
Sorex monticolus longicaudus, Dusky (montane Shrew)										●				
Sorex monticolus shumaginensis, Dusky (montane) Shrew										●				
Sorex monticolus malitiosus, Dusky (montane) Shrew										●				
Sorex palustris, American Watershrew											●			
Sorex pribilofensis, Pribilof Island shrew										●				
Sorex tundrensis, Tundra Shrew											●			
Sorex ugyunak, Barren Ground Shrew										●	●			
Bats														
Myotis keenii, Keen's Long-eared Bat										●	●			
Myotis lucifugus, Little Brown Bat											●			
Myotis Volans, Long-legged Myotis											●			
Myotis californicus, California Myotis											●			
Lasionycteris noctivagans, Silver-haired Bat											●			
Felids and Canids														
Canis lupus ligoni, Alexander Archipelago Wolf	P									●		●		●
Vulpes lagopus, Arctic Fox										●	●			
Bears														
Ursus maritimus, Polar Bear	TH	VU									●	●		
Otters														
Enhydra lutris kenyoni, Sea Otter (Northern)	TH	EN								●				●
Walrus and Sea Lions														
Odobenus rosmarus, PacificWalrus	C											●		
Eumetopias jubatus, Steller Sea Lion (western DPS)	EN	EN										●		
Callorhinus ursinus, Northern Fur Seal		VU								●			●	

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Species of Conservation Need	ESA Listed or Petitioned	IUCN Species of Concern	NatureServe Global Concern	Declining Birds (BBS and CBC)	State of the Birds – SOC	AK Landbird Plan – SOC	AK Shorebird Plan – SOC	AK Seabird Plan – SOC	AK Raptor Group – SOC	Stewardship Species	Sentinel Species	Culturally Important	Economically Important	Ecologically Important es
Seals														
Erignathus barbatus nauticus, Bearded Seal (Beringia DPS)	TH									●	●	●		
Histriophoca fasciata, Ribbon Seal										●	●			
Pusa hispida hispida, Ringed Seal (arctic subspecies)	TH									●	●	●		
Phoca largha, Spotted Seal										●	●	●		
Phoca vitulina richardii, Pacific Harbor Seal										●	●	●		
Baleen Whales														
Balaena mysticetus, Bowhead	EN									●		●		
Balaenoptera borealis, Sei Whale	EN	EN												
Balaenoptera physalus, Fin Whale	EN	EN												
Eschrichtius robustus, Eastern North Pacific Gray Whale										●	●			
Eubalaena japonica, North Pacific Right Whale	EN	EN								●				
Megaptera novaeangliae, Humpback Whale	EN									●				
Toothed Whales														
Orcinus orca, Killer Whale														●
Delphinapterus leucas, Beluga		NT								●		●		
Delphinapterus leucas, Beluga (Cook Inlet DPS)	EN	NT								●		●		
Physeter macrocephalus, Sperm Whale	EN	VU											●	
Dolphins and Porpoises														
Phocoena phocoena, Harbor Porpoise														●

[1] These two species (Lesser Scaup and Greater White-fronted Goose, mid-continent population) were added on the recommendation of the USFWS in final review as priority species that are at risk, as well as culturally important and sentinel species.

Appendix B. Distribution of Species of Greatest Conservation Need in Alaska by Bioregion.

● = Regular or common, naturally occurring. SE=Southeast, SC=Southcentral, C=Central, SW=Southwest, W=West, N=North, AO=Arctic Ocean, BER=Bering Sea, GOA=Gulf of Alaska.

SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Freshwater Invertebrates									
Ephemeroptera, (Order-Mayflies)	●	●	●	●	●	●			
Odonata (Order-Dragon and Damselflies)	●	●	●	●	●	●			
Plecoptera, (Order-Stoneflies)	●	●	●	●	●	●			
Trichoptera, (Order-Caddisflies)	●	●	●	●	●	●			
*Cladocera (*Order-Water Fleas)	●	●	●	●	●	●			
Margaritifera falcate, Western Pearlshell Mussel		●							
Adonata beringiana, Yukon Floater Mussel		●	●	●	●				
Adonata adionata kennerlyi, Western Floater Mussel		●	●	●	●				
Saltwater Invertebrates									
Euphasiacea, Euphasids							●	●	●
Copepoda, Copepods, primarily Calanoida							●	●	●
Mysida, Mysids							●	●	●
Amphipoda, Benthic Amphipods							●	●	●
Crabs									
Cancer magister, Dungeness Crab								●	●
Chionoecetes bairdi, Tanner Crab								●	●
Chionoecetes opilio, Snow Crab								●	●
Lithodes aequispinus, Golden King Crab								●	●
Paralithodes camtschaticus, Red King Crab								●	●
Paralithodes platypus, Blue King Crab								●	●
Erimacrus isenbeckii, Hair Crab								●	●
Telmessus cheiragonus, Helmet Crab								●	●
Cockles, Scallops, Clams, Mussels and Abalone									
Erimacrus isenbeckii, Hair Crab								●	●
Telmessus cheiragonus, Helmut Crab								●	●
Chlamys rubida, Pink Scallop								●	●
Haliotis kamtschatkana, Pinto Abalone								●	●
Macoma balthica, Baltic Macoma								●	●
Mytilus trossulus, Pacific Blue Mussel							●	●	●
Panopea generosa, Geoduck Clam									●
Patinopecten caurinus, Weathervane Scallop									●
Protothaca stamineais, Littleneck Clam								●	●
Saxidomus gigantean, Butter Clam								●	●

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Siliqua patula, Razor Clam								●	●
Clinocardium nuttallii, Nuttall's Cockle								●	●
Octopus and Squid									
Enteroctopus dofleini, Giant Pacific Octopus								●	●
Berryteuthis anonychus, Minimal Armhook Squid								●	●
Berrytheuthis magister, Red Squid /Magistrate Armhook								●	●
Shrimp									
Pandalus borealis Northern Shrimp								●	●
Pandalus dispar Sidestripe Shrimp								●	●
Pandalus goniurus Humpy Shrimp								●	●
Pandalus hypsinotis Coonstripe Shrimp								●	●
Pandalus patyceros Spot Shrimp								●	●
Hippolyte clarki Eelgrass Shrimp								●	●
Chitons and Snails									
Cryptochiton stelleri, Gumboot Chiton								●	●
Katharina tunicate, Black Katy Chiton								●	●
Sea Cucumbers, Sea Stars and Sea Urchins									
Parastichopus californicus, Sea Cucumber							●	●	●
Echinodermata, Sea Stars							●	●	●
Strongylocentrotus droebachiensis , Green Sea Urchin								●	●
Strongylocentrotus franciscanus, Red Sea Urchin								●	●
Salmon									
Oncorhynchus gorbuscha, Pink Salmon	●	●	●	●	●	●	●	●	●
Oncorhynchus keta, Chum Salmon	●	●	●	●	●	●	●	●	●
Oncorhynchus kisutch, Coho Salmon	●	●	●	●	●			●	●
Oncorhynchus nerka, Sockeye Salmon	●	●	●	●	●			●	●
Oncorhynchus tshawytscha, Chinook Salmon	●	●	●	●	●	●	●	●	●
Trout and Steelhead									
Oncorhynchus mykiss, Rainbow Trout	●	●	●	●					
Oncorhynchus clarki clarki, Coastal Cutthroat Trout	●								●
Salvelinus namaycush, Lake Trout	●	●	●	●	●	●			
Oncorhynchus mykiss, Steelhead	●	●						●	●
Sharks									
Lamna ditropis, Salmon Shark								●	●
Sablefish, Flounder and Halibut									
Anoplopoma fimbria, Sablefish								●	●
Hippoglossus stenolepis, Pacific Halibut								●	●
Atheresthes stomias, Arrowtooth flounder							●	●	●

-continued-

SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Forage Fish									
Hypomesus olidus, Pond Smelt							●	●	●
Hypomesus pretiosus Surf Smelt									●
Osmerus mordax, Rainbow Smelt							●	●	●
Spirinchus starksi, Night Smelt									●
Spirinchus thaleichthys, Longfin Smelt									●
Mallotus villosus, Capelin							●	●	●
Thaleichthys pacificus, Eulachon								●	●
Ammodytes hexapterus, Pacific Sand Lance							●	●	●
Clupea pallasii, Pacific Herring							●	●	●
Percopsis omiscomaycus, Trout-Perch			●		●				
Cod and Mackerel									
Boreogadus saida, Arctic Cod							●	●	
Gadus microcephalus, Pacific Cod								●	●
Ophiodon elongates, Lingcod									●
Eleginus gracilis, Saffron Cod							●	●	●
Microgadus proximus, Pacific Tomcod								●	●
Lota lota, Burbot	●	●	●	●	●	●			
Pleurogrammus monopterygius, Atka Mackerel								●	●
Rockfish									
Sebastes variabilis, Dusky Rockfish								●	●
Sebastes alutus, Pacific Ocean perch								●	●
Sebastes auriculatus, Brown Rockfish								●	●
Sebastes caurinus, Copper rockfish								●	●
Sebastes maliger, Quillback Rockfish								●	●
Sebastes melanops, Black Rockfish								●	●
Sebastes nebulosus, China Rockfish								●	●
Sebastes paucispinis, Bocaccio								●	●
Sebastes ruberrimus, Yelloweye Rockfish								●	●
Sebastes variabilis, Dusky Rockfish								●	●
Sticklebacks									
Pungitius pungitius, Ninespine Stickleback		●	●	●	●	●	●	●	●
Suckers and Chub									
Couesius plumbeus, Lake Chub			●						
Whitefish, Blackfish, Inconnu and Cisco									
Coregonus pidschian, Humpback Whitefish			●	●	●	●		●	
Coregonus nasus, Broad Whitefish			●		●	●	●	●	
Prosopium coulterii, Pygmy Whitefish				●					

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Prosopium cylindraceum, Round Whitefish	●	●	●	●	●	●			
Dallia pectoralis, Alaska Blackfish		●	●	●	●	●			
Stenodus leucichthys, Inconnu			●	●	●		●	●	
Coregonus autumnalis autumnalis, Arctic Cisco						●	●		
Coregonus laurettae, Bering Cisco			●	●	●	●	●	●	
Coregonus sardinella, Least Cisco			●	●	●	●	●		
Pike, Char and Grayling									
Esox Lucius, Northern Pike	●	●	●	●	●	●			
Salvelinus alpinus, Arctic Char		●	●	●	●	●		●	
Salvelinus malma, Dolly Varden	●	●	●	●	●	●	●	●	●
Thymallus arcticus, Arctic Grayling	●	●	●	●	●	●			
Lamprey									
Lethenteron alaskense, Alaskan Brook lamprey				●					
Lethenteron camtschatica, Arctic Lamprey		●	●	●	●	●	●	●	●
Lampetra ayresii, Western River lamprey	●								
Entosphenus tridentate, Pacific Lamprey	●	●		●	●			●	●
Amphibians									
Taricha granulosa, Roughskin Newt	●								
Anaxyrus boreas, Western Toad	●	●							
Lithobates sylvaticus, Wood frog	●	●	●	●	●				
Ambystoma gracile, Northwestern Salamander	●								
Ambystoma macrodactylum, Long-toed salamander	●								
Terrestrial Invertebrates									
Hymenoptera (Order- ants, bees, wasps, hornets)	●	●	●	●	●	●			
Diptera (Order – flies, midges, mosquitos, gnats)	●	●	●	●	●	●			
Odonata (Order – dragonflies, damselflies, skimmers)	●	●	●	●	●	●			
Lepidoptera (Order – butterflies and moths)	●	●	●	●	●	●			
Arachnida (Order – spiders)	●	●	●	●	●	●			
Ducks, Geese and Swans									
Cygnus buccinator, Trumpeter Swan	●	●	●						
Anser albifrons elgasi, Tule Greater White-fronted Goose		●	●						
Anser albifrons frontalis, Greater White-Fronted Goose, Mid Cont. Pop)	●	●	●		●	●			
Chen canagica, Emperor Goose				●	●				
Branta hutchinsii taverneri, Taverner's Cackling Goose					●	●			
Branta hutchinsii leucopareia, Aleutian Cackling Goose				●					
Branta hutchinsii minima, Cackling Cackling Goose					●				
Branta canadensis occidentalis, Dusky Canada Goose		●							
Branta bernicula nigricans, Pacific Black Brant		●		●	●	●			

-continued-

SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Athya affinis, Lesser Scaup	●		●						
Somateria mollissima, Common Eider		●		●	●	●			
Polysticta stelleri, Steller's Eider		●		●		●			
Somateria fischeri , Spectacled Eider					●		●		
Somateria spectablis, King Eider (W. Arctic)		●		●	●	●			
Melanitta deglandi, White-winged Scoter	●	●	●	●					
Melanitta americana, Pacific Black Scoter		●		●	●				
Clangula hyemalis, Long-tailed Duck	●	●	●	●	●	●			
Raptors									
Accipiter gentilis laingi, Queen Charlotte Goshawk	●								
Buteo lagopus, Rough-legged Hawk		●	●	●	●	●			
Buteo jamaicensis alascensis, Alaska Red-tailed Hawk	●								
Buteo jamaicensis harlani, Harlan's Red-tailed Hawk			●	●	●				
Haliaeetus leucocephalus, Bald Eagle	●	●	●	●	●	●			
Aquila chrysaetos canadensis American Golden Eagle	●	●	●	●	●	●			
Falco rusticolus, Gyrfalcon		●	●	●	●	●			
Falco perigrinus, Peregrine Falcon	●	●	●	●	●	●			
Falco peregrinus pealei, Peale's Peregrine Falcon	●	●						●	
Falco sparverius, American Kestrel			●						
Circus cyaneus, Northern Harrier	●	●	●	●	●	●			
Asio flammeus flammeus, Short-eared Owl	●	●	●	●	●	●			
Strix nebulosa, Great Gray Owl		●	●						
Surnia ulula, Northern Hawk Owl		●	●	●					
Megascops kennicottii, Western Screech-Owl	●	●							
Bubo scandiacus, Snowy owl				●	●	●			
Aegolius funereus, Boreal Owl		●	●	●					
Kingfishers and Woodpeckers									
Megaceryle alcyon, Belted Kingfisher	●	●	●	●					
Picoides villosus sitkensis, Hairy Woodpecker	●								
Picoides pubescens glacialis, Downy Woodpecker	●								
Picoides dorsalis, American Three-toed Woodpecker	●	●	●	●	●				
Picoides arcticus, Black-backed Woodpecker		●	●						
Colaptes auratus luteus, Northern Flicker			●						
Sphyrapicus ruber, Red-breasted Sapsucker	●								
Loons and Grebes									
Gavia stellata, Red-throated Loon		●	●	●	●	●	●	●	●
Gavia adamsii, Yellow-billed Loon	●	●			●	●	●	●	●
Gavia arctica, Arctic Loon					●				

-continued-

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Procellarids									
Phoebastria immutabilis, Laysan Albatross								●	●
Phoebastria nigripes, Black-footed Albatross								●	●
Phoebastria albatrus, Short-tailed Albatross				●				●	●
Fulmarus glacialis, Northern Fulmar							●	●	●
Oceanodroma furcata furcata, Fork-tailed Storm-Petrel	●	●		●				●	●
Cormorants									
Phalacrocorax urile, Red-faced Cormorant		●		●	●			●	●
Phalacrocorax pelagicus, Pelagic Cormorant	●	●		●	●			●	●
Cranes									
Grus canadensis Canadensis, Sandhill Crane		●	●	●	●	●			
Oystercatchers and Plovers									
Haematopus bachmani, Black Oystercatcher	●	●		●					
Pluvialis dominica, American Golden-Plover		●	●	●	●	●			
Pluvialis fulva, Pacific Golden-Plover				●	●				
Pluvialis squatarola, Black-bellied Plover	●	●		●	●	●			
Charadrius vociferous, Killdeer	●								
Sandpipers									
Actitus macularius, Spotted Sandpiper	●	●	●						
Tringa flavipes, Lesser Yellowlegs	●	●	●	●					
Numenius phaeopus hudsonicus, Whimbrel		●	●	●	●	●			
Bartramia longicauda, Upland Sandpiper			●						
Numenius tahitiensis, Bristle-thighed Curlew					●				
Limosa lapponica baueri, Bar-tailed Godwit				●	●	●			
Limosa haemastica, Hudsonian Godwit		●	●		●				
Limosa fedoa beringea, Marbled Godwit		●	●						
Arenaria melanocephala, Black Turnstone	●	●		●	●				
Calidris canutus roselaari, Red Knot		●			●				
Calidris virgata, Surfbird	●	●							
Tringa solitaria cinnomomea, Solitary Sandpiper		●	●						
Calidris alpina arcticola, Dunlin					●	●			
Calidris alpina pacifica, Dunlin	●	●		●	●				
Calidris alba rubida, Sanderling	●	●		●	●	●			
Calidris ptilocnemis couesi, Rock Sandpiper				●					
Calidris ptilocnemis ptilocnemis, Rock Sandpiper		●			●				
Calidris ptilocnemis tschuktschorum, Rock Sandpiper	●	●		●	●				
Tringa incana, Wandering Tattler	●	●	●	●	●				
Calidris subruficolli,s Buff-breasted Sandpiper						●			

-continued-

SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Calidris melanotos, Pectoral Sandpiper	●	●	●	●	●	●			
Calidris pusilla, Semipalmated Sandpiper		●	●			●			
Calidris mauri, Western Sandpiper	●	●		●	●				
Limnodromus griseus caurinus, Short-billed Dowitcher	●	●		●					
Limnodromus scolopaceus, Long-billed Dowitcher		●	●	●	●	●			
Phalaropus fulicarius, Red Phalarope		●		●	●	●			
Auks									
Aethia cristatella, Crested Auklet				●	●		●	●	●
Aethia psittacula, Parakeet Auklet				●	●		●	●	●
Aethia pusilla, Least Auklet				●	●		●	●	●
Aethia pygmaea, Whiskered Auklet				●				●	
Alle alle, Dovekie					●			●	
Brachyramphus brevirostris, Kittlitz's Murrelet		●					●	●	●
Brachyramphus marmoratus, Marbled Murrelet	●	●						●	●
Synthliboramphus antiquus antiquus, Ancient Murrelet	●	●		●				●	●
Cepphus columba Columba, Pigeon Guillemot	●	●		●	●			●	●
Cepphus grille, Black Guillemot						●	●	●	
Uria lomvia arra, Thick-billed Murre				●	●		●	●	●
Uria aalge inornata, Common Murre	●	●		●	●		●	●	●
Fratercula cirrhata, Tufted Puffin	●	●		●	●		●	●	●
Fratercula corniculata, Horned Puffin	●	●		●	●		●	●	●
Ptychoramphus aleuticus aleuticus, Cassin's Auklet	●	●		●				●	●
Gulls, Terns and Jaegers									
Rissa tridactyla, Black-legged Kittiwake	●	●		●	●	●	●	●	●
Rissa brevirostris, Red-legged Kittiwake				●	●			●	
Larus canus brachyrhynchus, Mew Gull	●	●	●	●	●	●		●	●
Larus smithsonianus, Herring Gull	●	●	●					●	●
Larus glaucescens, Glaucous-winged Gull	●	●		●	●			●	●
Larus hyperboreus, Glaucous Gull				●	●	●	●	●	●
Xema sabini, Sabines's, Gull					●	●			
Sterocarius pomarinus, Pomarine Jaeger		●		●	●	●	●	●	●
Stercarius longicaudus, Long-tailed Jaeger			●		●	●			
Sterna paradisaea, Arctic Tern	●	●	●	●	●	●	●	●	●
Onychoprion aleuticus, Aleutian Tern		●		●	●			●	●
Swifts and Hummingbirds									
Selasphorus rufus, Rufous Hummingbird	●	●							
Cypseloides niger borealis, Northern Black Swift	●								

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Larks, Crows, and Jays									
Eremophila alpestris arcticola, Horned Lark		●	●		●	●			
Perisoreus Canadensis, Gray Jay		●	●						
Cyanocitta stelleri, Steller's Jay	●	●							
Corvus corax kamtschaticus, Common Raven	●	●	●	●	●	●			
Nuthatches, Chickadees and Swallows									
Riparia riparia Bank Swallow		●	●	●	●				
Hirundo rustica, Barn Swallow	●								
Tachycineta bicolor, Tree Swallow	●	●	●	●	●				
Poecile atricapillus , Black-capped Chickadee	●	●	●	●					
Poecile rufescens Chestnut-backed Chickadee	●	●							
Poecile hudsonicus Boreal Chickadee		●	●	●	●				
Poecile cinctus lathami Gray-headed Chickadee			●		●	●			
Lanius excubitor Northern Shrike	●	●	●	●	●	●			
Kinglets, Creepers, Flycatchers and Wrens									
Regulus calendula grinnelli Ruby-crowned Kinglet	●	●							
Regulus satrapa, Golden-crowned Kinglet	●	●							
Certhia americana occidentalis, Brown Creeper	●		●						
Certhia americana alascensis, Brown Creeper		●	●						
Empidonax alnorum, Alder Flycatcher		●	●	●	●				
Contopus cooperi, Olive-sided Flycatcher	●	●	●						
Empidonax difficilis, Pacific-slope Flycatcher	●								
Contopus sordidulus, Western Wood-Pewee	●	●	●						
Troglodytes pacificus Pacific Wren	●			●					
Troglodytes pacificus alascensis Pacific Wren					●				
Troglodytes pacificus helleri Pacific Wren		●		●					
Troglodytes pacificus kiskensis Pacific Wren				●					
Troglodytes pacificus meligerus Pacific Wren				●					
Troglodytes pacificus ochroleucus Pacific Wren				●					
Troglodytes pacificus semediensis Pacific Wren				●					
Luscinia svecica, Bluethroat					●				
Oenathe oenanthe oenanthe, Northern Wheatear			●		●	●			
Thrushes									
Catharus ustulatus Swainson's Thrush	●		●						
Catharus guttatus guttatus Hermit Thrush			●	●					
Catharus guttatus nanus Hermit Thrush	●								
Ixoreus naevius Varied Thrush	●	●	●	●	●				

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Waxwings, Pipits and Warblers									
Bombycilla garrulus Bohemian Waxwing		●	●						
Setophaga striata Blackpoll Warbler				●	●				
Cardellina pusilla pileolata Wilson's Warbler	●	●	●	●					
Anthus rubescens, American Pipit	●	●	●	●	●	●			
Phylloscopus borealis, Arctic Warbler			●	●	●	●			
Oreothlypis celata, Orange-crowned Warbler	●	●	●	●					
Geothlypis tolmiei, MacGillivary's Warber	●								
Geothlypis trichas, Common Yellowthroat	●								
Setophaga petechia, Yellow Warbler	●		●	●	●				
Setophaga townsendi, Townsend's Warbler	●	●	●						
Setophaga ruticilla American Redstart	●								
Longspurs, Buntings and Sparrows									
Calcarius lapponicus alascensis, Lapland Longspur		●	●	●	●	●			
Calcarius pictus, Smith's Longspur						●			
Plectrophenax hyperboreus, McKay's Bunting					●				
Plectrophenax nivalis nivali,s Snow Bunting	●	●	●	●	●	●			
Plectrophenax nivalis townsendi, Snow Bunting				●					
Junco hyemalis, Dark-eyed Junco	●	●	●						
*Zonotrichia leucophrys,*White-crowned Sparrow		●	●	●	●				
Spizella passerinea, Chipping Sparrow	●		●						
Passerella iliaca, Fox Sparrow	●	●	●	●	●				
Passerella iliaca annectens, Sooty Fox Sparrow		●							
Passerella iliaca chilkatensis, Sooty Fox Sparrow	●								
Passerella iliaca insularis, Sooty Fox Sparrow	●	●							
Passerella iliaca sinuosa, Sooty Fox Sparrow		●							
Passerella iliaca townsendi, Sooty Fox Sparrow	●								
Passerella iliaca unalaschcensis, Sooty Fox Sparrow				●					
Melospiza melodi, Song Sparrow	●	●		●					
Melospiza melodia caurina, Song Sparrow		●							
Melospiza melodia insignis, Song Sparrow		●		●					
Melospiza melodia kenaiensis, Song Sparrow		●							
Melospiza melodia maxima, Song Sparrow				●					
Melospiza melodia rufina, Song Sparrow	●								
Melospiza melodia sanaka, Song Sparrow				●					
Melospiza lincolnii, Lincoln's Sparrow	●	●	●						
Passerculus sandwichensis, Savannah Sparrow	●	●	●	●	●	●			

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Zonotrichia atricapilla, Golden-crowned Sparrow	●	●		●	●				
Junco hyemalis oreganus, Dark-eyed Junco	●	●	●	●	●				
Blackbirds, Finches, Crossbills, Grosbeaks and Redpoll									
Agelaius phoeniceus, Red-winged Blackbird	●		●						
Euphagus carolinus carolinus, Rusty Blackbird	●	●	●	●	●				
Leucosticte tephrocotis griseonucha, Gray-crowned Rosy-Finch				●					
Leucosticte tephrocotis umbrina, Gray-crowned Rosy-Finch					●				
Loxia leucoptera, White-winged Crossbill	●	●	●						
Pinicola enucleator flammula, Pine Grosbeak	●	●	●						
Acanthis flammea, Common Redpoll	●	●	●	●	●	●			
Acanthis hornemanni, Hoary Redpoll			●		●	●			
Spinus pinus Pine Siskin	●	●		●					
Squirrels									
Marmota boweri, Alaska marmot			●			●			
Urocitellus parryii Arctic Ground Squirrel	●	●	●	●	●	●			
Urocitellus parryii albusus Arctic Ground Squirrel		●			●	●			
Urocitellus parryii kennicottii Arctic Ground Squirrel						●			
Urocitellus parryii kodiacensis Arctic Ground Squirrel		●							
Urocitellus parryii lyratus Arctic Ground Squirrel					●				
Urocitellus parryii nebulicola Arctic Ground Squirrel				●					
Urocitellus parryii osgoodi Arctic Ground Squirrel			●						
Tamiasciurus hudsonicus Red Squirrel	●	●	●	●	●				
Tamiasciurus hudsonicus kenaiensis Red Squirrel Kenai		●							
Tamiasciurus hudsonicus picatus Red Squirrel Kupreanof	●								
Glaucomys sabrinus Northern Flying Squirrel	●	●	●						
Glaucomys sabrinus griseifrons N. Flying Squirrel POW	●								
Lemmings									
Lemmus trimucronatus Nearctic Brown lemming	●	●	●	●	●	●			
Dicrostonyx groenlandicus Northern Collared Lemming				●	●	●			
Dicrostonyx nelsoni Nelson's Collared Lemming				●	●				
Dicrostonyx unalascensis Aleutian Collared Lemming				●					
Synaptomys borealis Northern Bog Lemming	●	●	●	●					
Voles and Deermice									
Myodes rutilus Northern Red-backed Vole	●	●	●	●	●	●			
Myodes gapperi Southern Red-backed Vole	●								
Microtus abbreviatus Insular Vole					●				
Microtus longicaudus Long-tailed Vole	●	●	●						

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SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Microtus miurus Singing Vole		●	●	●	●	●			
Microtus oeconomus Tundra Vole (aka root vole)	●	●	●	●	●	●			
Microtus pennsylvanicus Meadow Vole	●	●	●	●					
Microtus xanthognathus Taiga Vole			●		●				
Peromyscus keeni Northwestern Deermouse	●								
Mice									
Zapus hudsonius Meadow Jumping Mouse	●	●	●	●	●				
Hares and Pikas									
Lepus americanus, Snowshoe Hare	●	●	●	●	●	●			
Lepus othus, Alaska Hare				●	●				
Ochotona collaris Collared Pika	●	●	●	●					
Shrews									
Sorex cinerus streatori, Common Shrew	●	●	●	●	●	●			
Sorex alaskanus, Glacier Bay Water Shrew	●								
Sorex jacksoni, St. Lawrence Island Shrew					●				
Sorex monticolus, Dusky (montane Shrew)	●	●	●	●	●	●			
Sorex monticolus, alascencis Dusky (montane Shrew)	●	●							
Sorex monticolus, longicaudus Dusky (montane Shrew)	●								
Sorex monticolus, shumaginensis Dusky (montane) Shrew				●					
Sorex monticolus, malitiosus Dusky (montane) Shrew									
Sorex palustris, American Watershrew	●	●	●						
Sorex pribilofensis, Pribilof Island Shrew					●				
Sorex tundrensis, Tundra Shrew		●	●	●	●	●			
Sorex ugyunak, Barren Ground Shrew					●	●			
Bats									
Myotis keenii, Keen's Long-eared Bat	●								
Myotis lucifugus, Little Brown Bat	●	●	●	●					
Myotis volan,s Long-legged Myotis	●								
Myotis californicus, California Myotis	●								
Lasionycteris noctivagans, Silver-haired Bat	●								
Felids and Canids									
Canis lupus ligoni, Alexander Archipelago Wolf	●								
Vulpes lagopus, Arctic Fox				●	●	●			
Bears									
Ursus maritimus, Polar Bear							●	●	
Otters									
Enhydra lutris kenyoni, Sea Otter (Northern)								●	●

-continued-

Appendix B. Page 12 of 12.

SGCN	BIOREGION								
	SE	SC	C	SW	W	N	AO	BER	GOA
Walrus and Sea Lions									
Odobenus rosmarus, Pacific Walrus							●	●	
Eumetopias jubatus, Steller Sea Lion (western DPS)								●	●
Callorhinus ursinus, Northern Fur Seal								●	●
Seals									
Erignathus barbatus nauticus, Bearded Seal (Beringia DPS)							●	●	
Histriophoca fasciata, Ribbon Seal							●	●	
Pusa hispida hispida, Ringed Seal (arctic subspecies)							●	●	
Phoca largha, Spotted Seal							●	●	
Phoca vitulina richardii, Pacific Harbor Seal								●	●
Baleen Whales									
Balaena mysticetus, Bowhead							●	●	
Balaenoptera borealis, Sei Whale								●	●
Balaenoptera physalus Fin Whale								●	●
Balaenoptera musculus, Blue Whale									●
Eschrichtius robustus, East N Pacific Gray Whale							●	●	●
Eubalaena japonica, N Pacific Right Whale								●	●
Megaptera novaeangliae, Humpback Whale								●	●
Toothed Whales									
Orcinus orca, Killer Whale							●	●	●
Delphinapterus leucas, Beluga							●	●	
Delphinapterus leucas, Beluga (Cook Inlet DPS)									●
Physeter macrocephalus, Sperm Whale								●	●
Dolphins and Porpoises									
Phocoena phocoena, Harbor Porpoise							●	●	●

Appendix C. Alaska population estimates for Species of Greatest Conservation Need (SGCN). Population size in Alaska for most SGCN is unknown, or very approximate. Estimates that report to the individual animal (e.g., 10,209, 160,235) are the result of quantitative surveys, and have greater reliability than rounded numbers. Smaller population estimates have smaller coefficients of variation.

Species (or DPS)	Subspecies, Stock, DPS, or Region	Population est. (95% CI)	Reference
Dusky Canada Goose	*occidentalis*	10,000-15,000	Pacific Flyway Council (2008).
Trumpeter Swan	Alaska	24,928	Conant et al. (2007).
Tule Greater White-fronted Goose	Alaska	12,000	ADF&G Waterfowl program (pers comm).
Greater White-fronted Goose	*Frontalis* in Alaska	175,000-200,000	Marks and Fischer (2014).
Emperor Goose	Alaska	73,879 (3-yr avg)	Wilson and Dau (2014).
Taverner' s Cackling Goose	Alaska	10,209	Bollinger and Eldridge (2009).
Aleutian Cackling Goose	Alaska	111,809 (91,793—113,824)	Mini et al. (2013).
Cackling Cackling Goose	Alaska	160,635	Bollinger and Hodges (2009).
Pacific Black Brant	Alaska	162,900	USFWS (2014).
Common Eider	Alaska	45,000-53,000	USFWS (2006).
Steller's Eider	Alaska	>138,000 (wintering)	USFWS (2002).
Spectacled Eider	Alaska	>330,000 (wintering)	Petersen et al (1999)
King Eider	Alaska	21,000	Suydam et al. (2000)
Pacific Black Scoter	Alaska	140,000	Stehn and Platte (2012)
Long-tailed Duck	Alaska	200,000	http://seaduckjv.org/wp-content/uploads/2015/01/ltdu_sppfactsheet.pdf
Yellow-billed Loon	Alaska	2,221 (1,206-3,235)	Earnst et al. (2005).
Northern Fulmar	Alaska (breeding)	1,400,000	USFWS (2009)
Fork-tailed Storm-Petrel	Alaska (breeding)	3,200,000	USFWS (2009)
Crested Auklet	Alaska (breeding)	3,000,000	USFWS (2009)
Parakeet Auklet	Individuals in Alaska	1,000,000	USFWS (2009)
Least Auklet	Individuals in Alaska	5,500,000-9,000,000	USFWS (2009)
Whiskered Auklet	Individuals in Alaska	116,000	USFWS (2009)
Dovekie	Alaska (breeding)	<100	USFWS (2009)
Kittlitz's Murrelet	Main breeding areas only	>33,583 (25,620-41,546)	Federal Register /Vol. 78, No. 192 /Thursday, October 3, 2013 /
Marbled Murrelet	Alaska (breeding)	859,000	USFWS (2009)
Ancient Murrelet	Alaska (breeding)	300,000	USFWS (2009)
Pigeon Guillemot	Alaska (breeding)	49,000	USFWS (2009)
Black Guillemot	Alaska (breeding)	700	USFWS (2009)
Thick-billed Murre	Alaska (breeding)	2,200,000	USFWS (2009)
Common Murre	Alaska (breeding)	2,800,000	USFWS (2009)
Tufted Puffin	Alaska (breeding)	2,300,000	USFWS (2009)
Horned Puffin	Alaska (breeding)	900,000	USFWS (2009)
Cassin's Auklet	Alaska (breeding)	473,000	USFWS (2009)

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Appendix C. Page 2 of 4.

Species (or DPS)	Subspecies, Stock, DPS, or Region	Population est. (95% CI)	Reference
Black-legged Kittiwake	Alaska (breeding)	1,300,000	USFWS (2009)
Red-legged Kittiwake	Alaska (breeding)	210,000	USFWS (2009)
Aleutian Tern	Alaska	9,500	USFWS (2009)
Mew Gull	Alaska (breeding) (coast only)	14,400	USFWS (2009)
Herring Gull	Alaska (coast only)	1,600	USFWS (2009)
Glaucous-winged Gull	Alaska (breeding)	250,000	USFWS (2009)
Glaucous Gull	Alaska (breeding)	100,000	USFWS (2009)
Black Oystercatcher	Alaska	4,500-7,000	Alaska Shorebird Group (2008).
American Golden-Plover	Alaska	37,500-75,000	Alaska Shorebird Group (2008)
Pacific Golden-Plover	Alaska	35,000-50,000	Alaska Shorebird Group (2008)
Black-bellied Plover	*squatarola*	50,000	Alaska Shorebird Group (2008)
Lesser Yellowlegs	Alaska	100,000-200,000	Alaska Shorebird Group (2008)
Upland Sandpiper	Alaska	<100,000	Alaska Shorebird Group (2008)
Whimbrel	*rufiventris*	>20,800	Alaska Shorebird Group (2008)
Bristle-thighed Curlew	Alaska	10,000	Alaska Shorebird Group (2008)
Hudsonian Godwit	Alaska	<17,500	Alaska Shorebird Group (2008)
Bar-tailed Godwit	*baueri*	50,000-120,000	Alaska Shorebird Group (2008)
Marbled Godwit	*beringiae*	2,000	Alaska Shorebird Group (2008)
Black Turnstone	Alaska	95,000	Alaska Shorebird Group (2008)
Red Knot	*roselaari*	<50,000	Alaska Shorebird Group (2008)
Surfbird	Alaska	>52,500	Alaska Shorebird Group (2008)
Solitary Sandpiper	*cinnamomea*	>37,500	Alaska Shorebird Group (2008)
Dunlin	*arcticola*	200,000-750,000	Alaska Shorebird Group (2008)
Dunlin	*pacifica*	550,000	Alaska Shorebird Group (2008)
Sanderling	Alaska	<30,000	Alaska Shorebird Group (2008)
Rock Sandpiper	*couesi*	75,000	Alaska Shorebird Group (2008)
Rock Sandpiper	*ptilocnemis*	25,000	Alaska Shorebird Group (2008)
Rock Sandpiper	*tschuktschorum*	50,000	Alaska Shorebird Group (2008)
Wandering Tattler	Alaska	>5,000-12,500	Alaska Shorebird Group (2008)
Buff-breasted Sandpiper	Alaska	<10,000	Alaska Shorebird Group (2008)
Pectoral Sandpiper	Alaska	>350,000	Alaska Shorebird Group (2008)
Semipalmated Sandpiper	Alaska	>500,000	Alaska Shorebird Group (2008)
Western Sandpiper	Alaska	3,500,000	Alaska Shorebird Group (2008)
Short-billed Dowitcher	*caurinus*	75,000	Alaska Shorebird Group (2008)
Long-billed Dowitcher	Alaska	>360,000	Alaska Shorebird Group (2008)
Red Phalarope	Alaska	750,000	Alaska Shorebird Group (2008)

-continued-

Species (or DPS)	Subspecies, Stock, DPS, or Region	Population est. (95% CI)	Reference
Rufous Hummingbird	Alaska	3,000,000	Parters in Flight online database - Population Estimates
Black Swift	*borealis*	300	Parters in Flight online database - Population Estimates
Belted Kingfisher	Alaska	190,000	Parters in Flight online database - Population Estimates
Hairy Woodpecker	Alaska	200,000	Parters in Flight online database - Population Estimates
Downy Woodpecker	Alaska	300,000	Parters in Flight online database - Population Estimates
American Three3-toed Woodpecker	Alaska	180,000	Parters in Flight online database - Population Estimates
Black-backed Woodpecker	Alaska	30,000	Parters in Flight online database - Population Estimates
Northern Flicker	Alaska	90,000	Parters in Flight online database - Population Estimates
Red-breasted Sapsucker	Alaska	1,000,000	Parters in Flight online database - Population Estimates
Gray Jay	Alaska	4,000,000	Parters in Flight online database - Population Estimates
Steller's Jay	Alaska	300,000	Parters in Flight online database - Population Estimates
Common Raven	Alaska	160,000	Parters in Flight online database - Population Estimates
Bank Swallow	Alaska	1,900,000	Parters in Flight online database - Population Estimates
Barn Swallow	Alaska	30,000	Parters in Flight online database - Population Estimates
Tree Swallow	Alaska	2,000,000	Parters in Flight online database - Population Estimates
Black-capped Chickadee	Alaska	1,500,000	Parters in Flight online database - Population Estimates
Boreal Chickadee	Alaska	1,800,000	Parters in Flight online database - Population Estimates
Chestnut-backed Chickadee	Alaska	300,000	Parters in Flight online database - Population Estimates
Ruby-crowned Kinglet	Alaska	11,000,000	Parters in Flight online database - Population Estimates
Golden-crowned Kinglet	Alaska	8,000,000	Parters in Flight online database - Population Estimates
Brown Creeper	Alaska	700,000	Parters in Flight online database - Population Estimates
Alder Flycatcher	Alaska	30,000,000	Parters in Flight online database - Population Estimates
Western Wood-Pewee	Alaska	130,000	Parters in Flight online database - Population Estimates
Pacific Wren	Alaska	2,000,000	Parters in Flight online database - Population Estimates
Hermit Thrush	Alaska	6,000,000	Parters in Flight online database - Population Estimates
Swainson’s Thrush	Alaska	20,000,000	Parters in Flight online database - Population Estimates
Varied Thrush	Alaska	14,000,000	Parters in Flight online database - Population Estimates
Bohemian Waxwing	Alaska	700,000	Parters in Flight online database - Population Estimates
American Tree Sparrow	Alaska	6,000,000	Parters in Flight online database - Population Estimates
White-crowned Sparrow	Alaska	20,000,000	Parters in Flight online database - Population Estimates
Chipping Sparrow	Alaska	300,000	Parters in Flight online database - Population Estimates
Sooty Fox Sparrow	Alaska	9,000,000	Parters in Flight online database - Population Estimates
Lincoln's Sparrow	Alaska	7,000,000	Parters in Flight online database - Population Estimates
Savannah Sparrow	Alaska	40,000,000	Parters in Flight online database - Population Estimates
Song Sparrow	Alaska	900,000	Parters in Flight online database - Population Estimates
Dark-eyed Junco	Alaska	50,000,000	Parters in Flight online database - Population Estimates
White-winged Crossbill	Alaska	4,000,000	Parters in Flight online database - Population Estimates
Pine Grosbeak	Alaska	800,000	Parters in Flight online database - Population Estimates
Smith’s Longspur	Global	75,000	Parters in Flight online database - Population Estimates

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Appendix C. Page 4 of 4.

Species (or DPS)	Subspecies, Stock, DPS, or Region	Population est. (95% CI)	Reference
McKay's Bunting	Alaska	31,200 (27,500-35,400)	Matsuoka and Johnson (2008)
Blackpoll Warbler	Alaska	13,000,000	Parters in Flight online database - Population Estimates
Wilson's Warbler	Alaska	30,000,000	Parters in Flight online database - Population Estimates
Arctic Warbler	Alaska	6,000,000	Parters in Flight online database - Population Estimates
Townsend's Warbler	Alaska	5,000,000	Parters in Flight online database - Population Estimates
Orange-crowned Warbler	Alaska	30,000,000	Parters in Flight online database - Population Estimates
MacGillivary's Warber	Alaska	140,000	Parters in Flight online database - Population Estimates
Common Yellowthroat	Alaska	100,000	Parters in Flight online database - Population Estimates
Yellow Warbler	Alaska	11,000,000	Parters in Flight online database - Population Estimates
American Redstart	Alaska	80,000	Parters in Flight online database - Population Estimates
Red-winged Blackbird	Alaska	16,000	Parters in Flight online database - Population Estimates
Rusty Blackbird	Alaska	700,000	Parters in Flight online database - Population Estimates
Pine Siskin	Alaska	3,000,000	Parters in Flight online database - Population Estimates
Alexander Archipelago Wolf	GMU2	89 (50-159)	15 June 2015 memo from G. Roffler to R. Scott, ADFG
E. North Pacific Right Whale	Alaska	31 (23 – 54)	Wade et al. (2011)
Humpback Whale	N Pacific	23,212	Wade et al. (in review).
Bowhead Whale	Western Arctic stock	16,892 (15,074 – 18,928)	Givens et al. (2013).
Sperm Whale	NE North Pacific	26,300-32,100	Barlow and Taylor (2005).
Gray Whale	Eastern North Pacific Stock	19,126 (CV = 0.071)	Laake et al. (2012).
Killer Whale	NE Pacific, CA to Bering Sea	~2,500	http://www.nmfs.noaa.gov/pr/species/mammals/whales/killer-whale.html#population
Beluga Whale	Cook Inlet DPS	312	Allen and Angliss (2013).
Beluga Whale	other stocks	~55,356	NMFS Beluga Stock Assessment reports (Allen and Angliss)
Bearded Seal	Alaska stock (Bering Sea only)	299,174 (245,476–360,544)	Conn et al. (2014).
Ringed Seal	Alaska stock	>300,000	Kelly et al. (2010).
Spotted Seal	Alaska stock (Bering Sea only)	141,479 (92,769-321,882)	Ver Hoef et al. (2014).
Northern Fur Seal	Eastern Pacific stock	648,534	Northern Fur Seal: E. Pacific Stock Assessment Report (2105)
Pacific Harbor Seal	12 Alaska stocks - sum	205,090 (171,568-238,612)	Harbor seal: Assessment Reports for 12 Alaska stocks (2015)
Pacific Walrus	North Pacific	129,000 (55,000-507,000)	Speckman et al. (2011).
Polar Bear	Southern Beaufort stock	1,526 (1211-1841)	Regehr et al. (2006).
Northern Sea Otter	Alaska	72,329	Sea Otter Stock Assessment Reports, (2008)
Steller Sea Lion	Western DPS (excluding Russia)	54,850 (50,930 – 58,788)	Steller Sea Lion Stock Assessment Report (draft Mar. 2015)
Steller Sea Lion	E DPS (includes BC, WA, OR, & CA)	63,160--78,198	Allen and Angliss (2013).

Appendix D. Distribution of Species of Greatest Conservation Need in Alaska by Habitat Type. See Key Habitats Chapter for habitat type descriptions. Scientific names are shown in Appendix A.

	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Freshwater Invertebrates																					
Mayflies									●	●	●	●									
Dragon and Damselflies									●	●	●	●									
Stoneflies									●	●	●	●									
Caddisflies									●	●	●	●									
Water Fleas									●	●	●	●									
Western Pearlshell Mussel									●	●	●	●									
Yukon Floater Mussel									●	●	●	●									
Western Floater Mussel									●	●	●	●									
Saltwater Invertebrates																					
Euphasids													●	●	●						
Copepods													●	●	●						
Mysids													●	●	●						
Amphipods													●	●	●						
Crabs																					
Dungeness Crab													●	●	●						
Tanner Crab													●	●	●						
Snow Crab													●	●	●						
Golden King Crab													●	●	●						
Red King Crab													●	●	●						
Blue King Crab													●	●	●						
Hair Crab													●	●	●						
Helmut Crab													●	●	●						
Cockles, Scallops, Clams, Mussels and Abalone																					
Pink Scallop													●	●	●	●					
Pinto Abalone													●	●	●	●					
Baltic macoma													●			●					
Pacific Blue Mussel													●			●					
Geoduck Clam													●	●							
Wheathervane Scallop													●	●		●					
Littleneck Clam													●			●					
Butter Clam													●			●					
Razor Clam													●			●					

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Octopus and Squid																					
Giant Pacific Octopus													●	●	●						
Red Squid/Magistrate armhook													●	●	●						
Shrimp																					
Northern Shrimp													●	●							
Sidestripe Shrimp													●	●							
Humpy Shrimp													●	●							
Coonstripe Shrimp													●	●							
Spot Shrimp													●	●							
Eelgrass Shrimp													●			●					
Chitons and Snails																					
Gumboot Chiton													●			●					
Black Katy Chiton													●			●					
Sea Cucumbers, Sea Stars, and Sea Urchins																					
Sea Stars													●			●					
Sea Cucumber													●			●					
Green Sea Urchin													●			●					
Red Sea Urchin													●			●					
B. schlosseri Tunicate													●			●					
B. violaceus Tunicate													●			●					
Salmon																					
Pink Salmon												●	●	●	●	●					
Chum Salmon												●	●	●	●	●					
Coho Salmon												●	●	●	●	●					
Sockeye Salmon											●	●	●	●	●	●					
Chinook Salmon												●	●	●	●	●					
Atlantic Salmon													●	●	●	●					
Trout and Steelhead																					
Rainbow Trout											●	●									
Cutthroat Trout											●	●	●								
Lake Trout											●	●									
Steelhead												●	●	●	●						
Sharks																					
Salmon Shark														●	●						

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Sablefish, Flounder and Halibut																					
Sablefish														●	●						
Pacific Halibut														●	●						
Arrowtooth flounder														●	●						
Forage Fish																					
Pond Smelt											●	●									
Surf Smelt													●	●	●	●					
Rainbow Smelt												●	●	●	●	●					
Night Smelt													●	●	●	●					
Longfin Smelt												●	●	●	●	●					
Capelin													●	●	●	●					
Eulachon												●	●	●	●	●					
Pacific Sand Lance													●	●		●					
Pacific Herring													●	●	●	●					
Trout-Perch											●	●									
Cod and Mackerel																					
Arctic Cod													●	●	●						
Pacific Cod													●	●	●						
Lingcod													●	●	●						
Saffron Cod													●	●	●						
Pacific Tomcod													●	●	●						
Burbot											●	●									
Atka mackerel													●	●	●						
Rockfish																					
Dusky Rockfish													●	●	●						
Pacific Ocean perch													●	●	●						
Brown Rockfish													●	●	●						
Copper Rockfish													●	●	●						
Yellowtail Rockfish													●	●	●						
Quillback Rockfish													●	●	●						
Black Rockfish													●	●	●						
China Rockfish													●	●	●						
Bocaccio													●	●	●						
Yelloweye Rockfish													●	●	●						

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Appendix D. Page 4 of 12.

	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Sticklebacks																					
Ninespine Stickleback											●	●	●	●		●					
Suckers and Chub																					
Lake Chub											●	●									
Whitefish, Blackfish, and Inconnu																					
Humpback Whitefish											●	●	●			●					
Broad Whitefish											●	●	●			●					
Pygmy Whitefish											●	●									
Round Whitefish											●	●									
Alaska Blackfish											●	●									
Inconnu												●	●	●		●					
Arctic Cisco											●	●	●	●		●					
Bering Cisco											●	●	●	●		●					
Least Cisco											●	●	●	●		●					
Pike, Char and Grayling																					
Northern Pike											●	●									
Arctic Grayling											●	●									
Arctic Char											●	●	●	●		●					
Dolly Varden												●	●	●	●	●					
Lamprey																					
Alaska Brook lamprey											●	●									
Arctic Lamprey											●	●	●	●		●					
Western. River lamprey											●	●	●			●					
Pacific Lamprey											●	●	●	●		●					
Amphibians																					
Roughskin Newt								●	●	●	●	●									
Western Toad		●									●										
Wood frog	●	●							●	●	●										
NW Salamander		●							●	●	●										
Long-toed Salamander		●							●	●	●										
Pacific Chorus Frog		●							●	●	●										
Red-legged Frog		●							●	●	●										
Terrestrial Invertebrates																					
Ants, bees, wasps, hornets	●	●	●	●	●	●	●	●	●	●										●	

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
*F*lies, midges, mosquitos, gnats	●	●	●	●	●	●	●	●	●	●	●									●	
*D*ragonflies, damselflies, skimmers	●	●	●	●	●	●	●	●	●	●	●									●	
*B*utterflies and moths	●	●	●	●	●	●	●	●	●	●										●	●
*S*piders	●	●	●	●	●	●	●	●	●	●										●	
Ducks Geese and Swans																					
Trumpeter Swan							●	●	●	●	●										
Greater White-fronted Goose (Tule)							●	●	●	●	●										
Greater White-fronted Goose (Mid-cont)						●	●	●	●	●	●										
Emperor Goose							●			●	●										
Cackling Goose							●	●	●	●	●										
Dusky Canada Goose							●	●	●	●	●										
Pacific Black Brant						●	●	●		●	●		●								
Lesser Scaup							●	●	●	●	●										
Common Eider						●	●	●			●		●	●		●					
Steller's Eider						●	●	●			●		●	●							
Spectacled Eider						●	●	●			●		●	●							
King Eider (W. Arctic)						●	●	●			●		●	●							
White-winged Scoter			●								●	●	●								
Pacific Black Scoter			●			●					●	●	●								
Long-tailed Duck				●		●					●		●								
Raptors																					
QCI Goshawk		●																			
Harlan's Red-tailed Hawk																				●	
Rough-legged Hawk						●						●									
Alaska Red-tailed Hawk		●			●			●	●		●									●	
Bald Eagle	●	●					●				●	●	●			●				●	●
American Golden Eagle					●	●	●					●				●					
Gyrfalcon					●	●	●			●	●	●				●					
Peregrine Falcon	●				●	●	●			●	●	●				●					●
Peale's Peregrine Falcon		●					●									●					
American Kestrel	●							●												●	●

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Northern Harrier						●	●	●		●										●	
Great Gray Owl	●							●													
Snowy Owl						●				●						●	●	●			
Short-eared Owl						●	●	●		●						●				●	
Northern Hawk Owl	●							●	●											●	
Western Screech-Owl		●																			
Boreal Owl	●																			●	●
Kingfishers and Woodpeckers																					
Belted Kingfisher											●	●				●					
Hairy Woodpecker	●	●																			
Downy Woodpecker		●																			
American Three-toed Woodpecker	●	●																			
Black-backed Woodpecker	●	●																			
Northern Flicker	●	●																			
Yellowbellied Sapsucker	●	●																			
Red-breasted Sapsucker		●																			
Loons and Grebes																					
Red-throated Loon						●					●		●								
Yellow-billed Loon						●					●		●	●	●						
Arctic Loon						●					●		●	●	●						
Procellarids																					
Laysan Albatross													●	●	●						
Black-footed Albatross														●	●						
Short-tailed Albatross														●	●						
Northern Fulmar													●	●	●	●					
Fork-tailed Storm-Petrel													●	●	●	●					
Cormorants																					
Red-faced Cormorant													●			●					
Pelagic Cormorant													●			●					
Cranes																					
Sandhill Crane						●			●	●						●					
Oystercatchers and Plovers																					
Black Oystercatcher																●					
American Golden-Plover						●										●					

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Pacific Golden-Plover						●										●					
Killdeer								●		●	●	●				●					
Sandpipers																					
Spotted Sandpiper										●	●	●				●					
Black-bellied Plover						●				●	●					●					
Lesser Yellowlegs									●	●	●					●					
Upland Sandpiper							●														
Whimbrel						●										●					
Bristle-thighed Curlew						●										●					
Hudsonian Godwit						●	●	●	●	●						●					
Bar-tailed Godwit						●										●					
Marbled Godwit																●					
Black Turnstone						●					●					●					
Red Knot					●											●					
Surfbird					●											●					
Solitary Sandpiper									●	●	●	●									
Dunlin						●	●									●					
Sanderling						●										●					
Rock Sandpiper						●										●					
Wandering Tattler												●				●					
Buff-breasted Sandpiper						●	●									●					
Pectoral Sandpiper						●	●	●		●	●					●					
Semipalmated Sandpiper						●					●					●					
Western Sandpiper						●										●					
Short-billed Dowitcher									●		●					●					
Long-billed Dowitcher						●				●	●					●					
Red Phalarope						●					●		●	●	●						
Auks																					
Crested Auklet													●	●	●	●					
Parakeet Auklet													●	●	●	●					
Least Auklet													●	●	●	●					
Whiskered Auklet													●	●	●	●					
Dovekie													●	●	●	●					
Kittlitz's Murrelet													●	●	●	●					

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Marbled Murrelet													●	●	●	●					
Ancient Murrelet													●	●	●	●					
Pigeon Guillemot													●	●	●	●					
Black Guillemot													●	●	●	●	●				
Thick-billed Murre													●	●	●	●					
Common Murre													●	●	●	●					
Tufted Puffin													●	●	●	●					
Horned Puffin													●	●	●	●					
Cassin's Auklet													●	●	●	●					
Gulls, Terns and Jaegers																					
Black-legged Kittiwake													●	●	●	●					
Red-legged Kittiwake													●	●	●	●					
Mew Gull						●					●	●	●	●	●	●					
Herring Gull							●				●		●	●		●				●	
Glaucous-winged Gull							●				●		●	●		●				●	●
Glaucous Gull						●	●				●		●	●		●					
Sabines's, Gull																					
Pomarine Jaeger							●				●		●	●	●						
Long-tailed Jaeger						●	●				●		●	●	●						
Arctic Tern											●	●	●	●	●	●					
Aleutian Tern										●		●	●	●	●	●					
Swifts and Hummingbirds																					
(Northern) Black Swift		●														●					
Rufous Hummingbird	●	●	●	●																	
Larks, Crows and Jays																					
Horned Lark					●		●									●					
Gray Jay	●																			●	
Steller's Jay	●	●																			
Common Raven	●	●	●	●	●	●	●									●				●	●
Creepers, Nuthatches, Chickadees and Swallows																					
Bank Swallow											●	●								●	
Barn Swallow		●								●										●	●
Tree Swallow	●	●					●	●	●	●										●	●●
Black-capped Chickaee	●	●	●																		

-continued-

	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Chestnut-backed Chickadee		●	●																		
Boreal Chickadee	●		●																		
Gray-headed Chickadee	●		●									●									
Kinglets, Creepers, Flycatchers and Wrens																					
Ruby-crowned Kinglet	●	●																			
Golden-crowned Kinglet	●	●	●																		
Brown Creeper	●	●																			
Alder Flycatcher			●									●									
Olive-sided Flycatcher	●	●							●												
Pacific-slope Flycatcher		●										●								●	
Western Wood-Pewee	●	●																			
Pacific Wren	●	●														●				●	
Bluethroat						●															
Northern Wheatear					●	●															
Northern Shrike	●		●							●											
Thrushes																					
Swainson's Thrush	●	●																			
Hermit Thrush	●	●	●																		
Varied Thrush	●	●							●							●					
Tanagers, Warblers, Waxwings and Wagtails																					
Bohemian Waxwing	●	●	●						●												
Blackpoll Warbler	●	●	●																		
Wilson's Warbler	●	●	●																		
American Pipit					●		●		●	●	●	●				●					
Arctic Warbler	●		●																		
Orange-crowned Warbler		●	●																		
MacGillivary's Warber		●	●																		
Common Yellowthroat		●						●		●		●									
Yellow Warbler	●	●	●	●																	
Townsend's Warbler	●	●																			
American Redstart	●											●									
Sparrows, Longspurs, and Buntings																					
Lapland Longspur					●	●	●			●											
Smith's Longspur					●	●					●										

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
McKay's Bunting																●					
Snow Bunting						●	●									●				●	●
White-crowned Sparrow	●			●				●													
Chipping Sparrow	●	●	●									●									
Fox Sparrow			●																		
Song Sparrow			●				●									●					
Lincoln's Sparrow			●							●						●					
Savannah Sparrow						●	●									●					
Golden-crowned Sparrow			●													●					
American Tree Sparrow			●	●		●	●														
House Sparrow																				●	●
Dark-eyed Junco	●	●	●																	●	
Finches, Blackbirds, Crossbills, Grosbeaks and Redpolls																					
Red-winged Blackbird										●										●	
Rusty Blackbird	●	●	●						●			●				●				●	
Gray-crowned Rosy-Finch					●											●				●	
White-winged Crossbill	●	●																			
Pine Grosbeak	●	●																			
Common Redpoll	●	●	●	●		●	●													●	
Hoary Redpoll	●	●	●	●		●	●													●	
Pine Siskin	●	●																			
MAMMALS																					
Rodents																					
Arctic Ground Squirrel					●	●	●												●	●	
Northern Bog Lemming			●	●			●	●	●	●		●									
Alaska Marmot					●														●		
Red Squirrel	●	●																			●
Northern Flying Squirrel	●	●																			
Voles and Lemmings																					
Southern Red-backed Vole			●	●								●									
Northern Red-backed Vole			●	●	●							●							●	●	●
Black-footed Lemming				●	●	●	●	●	●			●							●		
St. Lawrence Isl. Collared Lemming							●														
N Collared Lemming						●															

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
Nelson's Collared Lemming					●																
Bering Collared Lemming					●																
Aleutian Collared Lemming					●																
Insular Vole				●			●	●				●							●		
Long-tailed Vole				●	●		●	●		●		●							●		
Singing Vole				●	●		●					●							●		
Tundra Vole			●	●	●	●	●	●	●	●		●							●		
Meadow Vole							●	●	●	●		●									
Taiga Vole			●	●			●					●									
Deermice																					
NW Deermouse		●	●	●	●		●					●							●	●	●
Peromyscus maniculatus, N. American Deermouse							●													●	●
Mice																					
Zapus hudsonius Meadow Jumping Mouse			●		●			●		●		●									
Hares and Pikas																					
Lepus americanus, Snowshoe Hare			●									●									
Lepus othus, Alaska Hare			●	●		●	●					●									
Ochotona collaris Collared Pika					●														●	●	
Shrews																					
Glacier Bay Water							●			●	●	●									
St. Lawrence Isl. Shrew							●	●	●			●							●		
Dusky Shrew			●	●	●		●					●							●		
American Watershrew			●				●			●	●	●									
Pribilof Island Shrew							●	●		●		●							●		
Tundra Shrew			●		●	●						●									
Common Shrew			●	●	●		●	●	●	●		●							●		
Barren Ground Shrew					●	●	●			●		●							●		
Bats																					
Keen's Long-eared Bat		●										●							●		
Little Brown Bat	●	●										●							●		●
Long-legged Myotis		●										●							●		●

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	Forest		Shrub		Tundra			Wetland			Freshwater		Marine				Ice		Ice		
Species of Greatest Conservation Need	Boreal	Coastal Temperate	Tall	Low	Alpine	Arctic	Maritime	Grass-Sedge	Bog	Marsh	Lakes & Ponds	Rivers-Streams-Riparian	Nearshore	Shelf	Oceanic	Beaches & Sea cliffs	Shore	Pack	Rocks & caves	Cultivated-Developed	Artificial Structures
California Myotis		●								●	●	●							●		●
Silver-haired Bat		●								●	●	●							●		●
Bears																					
Polar Bear						●											●	●			
Otters																					
Northern Sea Otter													●			●					
Walrus and Sea Lions																					
Walrus													●	●		●		●			
Steller Sea Lion													●	●		●					
Northern Fur Seal															●	●					
Seals																					
Bearded Seal																		●			
Ribbon Seal																	●	●			
Ringed Seal																	●	●			
Spotted Seal													●	●				●			
Pacific Harbor Seal													●			●					
Baleen Whales																					
Bowhead Whale														●				●			
Sei Whale															●						
Blue Whale															●						
Fin Whale														●	●						
Gray Whale													●	●							
North Pacific Right Whale														●	●						
Humpback Whale													●	●	●						
Toothed Whales and Porpoises																					
Beluga Whale													●					●			
Sperm Whale															●						
Harbor Porpoise													●	●							

Appendix E. A summary of past and ongoing wildlife and habitat monitoring efforts in the state of Alaska. It includes many, but not all, of the efforts currently underway.

Variable	Agency or Organization	Program	More Information
Air and Water			
Water Quality	ADEC and Cook Inlet RCAC	EMAP Survey	https://dec.alaska.gov/water/wqsar/Docs/summary.pdf
Water Quality	Cook Inlet Keeper	CEMP	http://inletkeeper.org/clean-water/citizen-monitoring
Water Quality	Alaska Ocean Observing System	Community-based Monitoring	http://www.aoos.org/community-based-monitoring/
Water Quality	Yukon River Inter-tribal Watershed Council	(ION) Indigenous Observation Network	http://www.aoos.org/community-based-monitoring/
Water Quality	Alaska Ocean Observing System	BSSN (Bering Sea Sub-Network)	http://www.aoos.org/community-based-monitoring/
Water Quality	Anchorage Waterways Council	(CEMP) Citizen's Environmental Monitoring Program	http://anchoragecreeks.org/pages/monitoring_cemp.php
Water Quality	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Water Quality	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Water Quality	UAF, KBERR	GulfWatch -Ecological Trends in Kachemak bay	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/ecological-trends-in-kachemak-bay/
Lake and Stream Ecology	USFWS-ANWR	LTER – Long-Term Ecological Research -Arctic program	http://www.lternet.edu/sites/arc
River and Stream Hydrology	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Streamflow	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Lakes	NPS	CAKN - Shallow Lake Monitoring program	Larsen AS and Kristenson H. 2012. Alaska Shallow Lake Monitoring Program: Limnology of Denali National Park and Preserve. Natural Resource Data Series. NPS/CAKN/NRDS—2012/410. National Park Service. Fort Collins, Colorado. Published Report-2191609.
Water Chemistry	NPS	SWAN- SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=7
Hydrology	NPS	SWAN- SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Air Quality	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Air Quality	NPS	SWAN- SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Air Quality	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf

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Variable	Agency or Organization	Program	More Information
Land			
Shoreline	USFWS, International Permafrost Assoc., NSB	Beaufort Coastal Monitoring Project	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Shoreline	NOAA	Shorezone Project	http://alaskafisheries.noaa.gov/shorezone/factsheet.pdf
Coastal Change	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=6
Coastal Features and Processes	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Land Cover and Use	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Land Cover	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Landform and Land Cover	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Vegetation			
Phenology & Availability	ADFG, USGS, CWS, Environment Yukon	Muskoxen and Caribou studies- Arctic NWR	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Nesting Habitat quality	USFWS-ANWR	Waterfowl and Shorebird Studies	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Alpine Biodiversity	USFWS-ANWR	GLORIA – Global Observation Research Initiative on Alpine Environments	http://www.gloria.ac.at/
Vegetation Composition	USFWS-ANWR	Photo Comparison project (1908-1952-1956-2015)	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Vegetation Composition	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Vegetation Composition	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Forage Quantity and quality	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Phenology	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Seagrass beds	UAF, KBERR	GulfWatch - Ecological Trends in Kachemak bay	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/ecological-trends-in-kachemak-bay/
Climate Change			
Ocean Acidification	NOAA	(OAP) Ocean Acidification Program	http://oceanacidification.noaa.gov/AreasofFocus/OceanAcidificationMonitoring.aspx
Ocean Acidification	AOOS	Ocean Acidification Research Center - UAF	http://www.aoos.org/ocean-acidification-arctic/

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Variable	Agency or Organization	Program	More Information
Arctic Species Trend Index	CAFF	Conservation of Arctic Flora and Fauna	http://www.caff.is/asti
Environmental Observations	Alaska Native Tribe Health Consortium	(LEO) Local Environmental Observer	http://www.anthc.org/chs/ces/climate/leo/
Glacial Features and processes	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Sea Ice Conditions	Study of Environmental Arctic Change (SEARCH)	(SIWO) Sea Ice for Walrus Outlook	http://www.arcus.org/search-program/siwo
Glacial Dynamics	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Glaciers	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Sea Ice Conditions	USFWS, USGS	ANWR Monitoring Program	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Sea Ice Conditions	AOOS		http://www.aoos.org/ice-atlas/
Sea Ice Conditions	UAF	Geophysical Institute and School of Fisheries and Ocean Sciences	Druckenmiller, M. L., Eicken, H., Johnson, M. A., Pringle, D. J., & Williams, C. C. (2009). Toward an integrated coastal sea-ice observatory: System components and a case study at Barrow, Alaska. *Cold Regions Science and Technology*, *56*(2), 61-72.
Sea Ice	CAFF	Conservation of Arctic Flora and Fauna	http://www.caff.is/sea-ice-associated-biodiversity
Climate-related data	UAF	International Arctic Research center- Clearinghouse for Arctic Climate data	http://www.iarc.uaf.edu/about/mission_statement
Snow and Ice	NSIDC	National Snow and Ice Data Center	http://nsidc.org/data/masie/
Phenology-mismatch	Manomet Center, USGS, UAF, USFWS-MBM	ANWR Monitoring	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Permafrost	UWFWS-ANWR, UAF	Active layer, plant composition, bore-hole monitoring	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Permafrost	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Weather and Shoreline	Alaska Sealife Center and UAA	(AkCCO) Alaska Corp of Coastal Observers	http://www.akcoastalcorps.org/
Climate	USFWS –ANWR, USGS	Remote Climate Stations	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Arctic Warming	LTER Network	Long-term Ecological Research	http://www.lternet.edu/research/keyfindings/arctic-warming
Weather and Climate	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Weather and Climate	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf

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Variable	Agency or Organization	Program	More Information
Climate	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Snow pack	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Subarctic Steppe	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Sea Level and Storm Surge	USFWS, International Permafrost Assoc., NSB	Beaufort Coastal Monitoring Project	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Permafrost level & thaw depth	USFWS, International Permafrost Assoc., NSB	Beaufort Coastal Monitoring Project	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Permafrost and Climate	USGS, BLM, USFWS	Real-Time Permafrost and Climate Monitoring network in Arctic Alaska	http://data.usgs.gov/climateMonitoring/region/show?region=alaska
Sea Surface Temperature	USFWS, ABR, UAF	Beaufort Coastal Monitoring Project	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Glacier Mass Balance	UAF, USFWS-ANWR	Mass changes in glaciers of the Brooks range	http://drmattnolan.org/mccall/index.htm
Contaminants			
In mussels (PSP)	Regional Citizen's Advisory Council	LTEMP (Long-Term Environmental Monitoring	http://www.pwsrcac.org/programs/environmental-monitoring/ltemp/
Sediment	ADEC and Cook Inlet RCAC	EMAP Survey	https://dec.alaska.gov/water/wqsar/Docs/summary.pdf
Oil	NOAA	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/lingering-oil/lingering-oil-weathering-and-tracking/
Marine Contaminants	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Freshwater Contaminants	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Marine contaminants and Stable Isotopes	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/
Benthic Communities	ADEC and Cook Inlet RCAC	EMAP Survey	https://dec.alaska.gov/water/wqsar/Docs/summary.pdf
Shellfish and PST	ADEC	Community-based monitoring	http://dec.alaska.gov/eh/RecShell/index.html
Intertidal			
Biodiversity and nutrient cycling	USFWS-ANWR, U of Texas, Austin,	Coastal Lagoon Monitoring project	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Intertidal Community	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Intertidal Community	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/

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Variable	Agency or Organization	Program	More Information
Coastal Lagoon ecology	NPS	Arctic Network – Inventory and Monitoring	Reynolds M and Clough LM. 2010. The development of a long-term monitoring protocol for the coastal lagoons of Cape Krusenstern National Monument: Pilot sampling July 2009. Natural Resource Data Series. NPS/ARCN/NRDS—2010/127. National Park Service, Natural Resource Program Center. Fort Collins, Colorado. Published Report-2167248.
Intertidal Invertebrates	UAF, KBERR	GulfWatch Alaska -Ecological Trends in Kachemak bay	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/ecological-trends-in-kachemak-bay/
Clams and Mussels	UAF, KBERR	GulfWatch Alaska - Ecological Trends in Kachemak bay	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/ecological-trends-in-kachemak-bay/
Clams, Mussels, Cockles	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/
Marine			
Marine predators	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Marine Biodiversity	CAFF- Conservation of Arctic Flora and fauna	Arctic Marine Biodiversity Monitoring Plan: USA	http://www.caff.is/marine/marine-monitoring-publications/271-arctic-marine-biodiversity-monitoring-plan-u-s-a-2013-implementation
Oceans	AOOS	A site that has all of the AOOS studies and monitoring efforts available in a spatial map-based tool.	http://portal.aoos.org/research-assets.php#map?lg=a612dc24-c1ee-46de-8553-f07c4bc124cd&z=4&ll=61.30295%2C-142.86190
Oceanography	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Plankton	Foundation for Ocean Sciences	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/environmental-drivers/continuous-plankton-recorder/
Kelp and Eel Grass	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=2
Intertidal Invertebrates	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=3
Condition of subsistence spp.	FWS-Fairbanks, UAF	Monitoring Sea Surface Temp effects	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Forage Fish	USGS, USFWS	Gulfwatch Alaska	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/forage-fish-2/
Freshwater Fish	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Nearshore Fish	NOAA	National Marine Fisheries Service	http://www.alaskafisheries.noaa.gov/habitat/fishatlas/
Marine Fish	NOAA	BOEMRE - Beaufort	https://www.afsc.noaa.gov/REFM/Stocks/fit/PDFS/FINAL_REPORT.pdf
Fisheries - Subsistence	USDOI-Subsistence	Fisheries Monitoring Reports	http://www.doi.gov/subsistence/library/monitor_fish/index.cfm
Birds			
Waterfowl	USGS, UAF, USFWS-MBM	ANWR Monitoring	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Eiders and other waterfowl	USFWS-MBM	North Slope Eider Breeding Surveys	http://www.fws.gov/alaska/mbsp/mbm/waterfowl/surveys/nsesurvy.htm

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Variable	Agency or Organization	Program	More Information
Cormorants, Glaucous Gull,	NPS, USFWS	Nearshore Marine Bird Surveys-Methods	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/data-synthesis-analysis-and-recommendation-for-sampling-frequency-and-intensity-of-nearshore-marine-bird-surveys-to-detect-trends-utilizing-existing-data-from-prince-william-sound-katmai-and-kenai-f/
Kittlitz's Murrelet	NPS, ADFG	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Kittlitz's Murrelet	ADFG, NPS	Monitoring in Tracy Arm, Yakutat Bay, and SW Alaska lakes	Kelly Nesvacil, ADFG ESA Biologist, Juneau
Black-legged Kittiwake	NPS	Glacier Bay long-term population monitoring	Black-legged kittiwakes in Glacier Bay National Park and Preserve: a review of existing data and recommendations for long-term population monitoring. Natural Resource Technical Report NPS/SEAN/NRTR—2013/672. National Park Service, Fort Collins, Colorado
Pigeon Guillemot	NPS, USFWS	Nearshore Marine Bird Surveys - Methods	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/data-synthesis-analysis-and-recommendation-for-sampling-frequency-and-intensity-of-nearshore-marine-bird-surveys-to-detect-trends-utilizing-existing-data-from-prince-william-sound-katmai-and-kenai-f/
Goldeneyes, Harlequin, Mergansers, , Scoters	NPS, USFWS	Nearshore Marine Bird Surveys - Methods	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/data-synthesis-analysis-and-recommendation-for-sampling-frequency-and-intensity-of-nearshore-marine-bird-surveys-to-detect-trends-utilizing-existing-data-from-prince-william-sound-katmai-and-kenai-f/
Harlequin Ducks	USGS – Alaska Science Center	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/lingering-oil/harlequin-ducks-and-sea-otters/
Black Oystercatcher	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=5
Black Oystercatcher	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/
Seabird Colonies	USFWS	Alaska Maritime National Wildlife Refuge	http://www.fws.gov/uploadedFiles/Region_7/NWRS/Zone_1/Alaska_Maritime/PDF/summ_2013.pdf
Seabirds	AOOS – Pelagic Surveys	Axiom Seabirds Project	http://axiom.seabirds.net/maps/js/seabirds.php?app=north_pacific#z=3&ll=55.00000,-170.00000
Seabirds	CAFF	Conservation of Arctic Flora and Fauna – Seabird Assessment	http://www.caff.is/publications?task=search&filter_tag=seabird%20assessment
Seabirds	USFWS	Alaska Maritime National Wildlife Refuge	https://absilcc.org/science/amnwr/Shared%20Documents/Seabird%20monitoring%20on%20AMNWR.pdf
Marine Birds	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/
Marine Birds	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=4
Sea Bird Mortality	University of Washington	COASST -- Coastal Observation and Seabird Survey Team	http://depts.washington.edu/coasst/

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Variable	Agency or Organization	Program	More Information
Seabird Bycatch	NOAA	Seabird Bycatch Reduction program	http://www.alaskafisheries.noaa.gov/protectedresources/seabirds.htm
Waterbirds	USFWS	Beaufort-Chukchi coastal monitoring	http://www.fws.gov/alaska/mbsp/mbm/waterfowl/surveys/pdf/NSSANC.pdf
Shorebirds	Manomet and 17 partners	ASDN - Arctic Shorebird Demographic Network	https://www.manomet.org/ASDN
Shorebirds	USFWS	Boreal Species Assessment	http://www.fws.gov/alaska/mbsp/mbm/shorebirds/pdf/boreal_species_assessment_dec_04.pdf
Shorebirds	Manomet Center, USGS, UAF, USFWS	ANWR Monitoring	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Shorebirds	USFWS, Manomet, USGS, PWS science Center, & others	Comprehensive Shorebird Monitoring Plan	http://www.shorebirdplan.org/wp-content/uploads/2013/01/MONITOR3.pdf
Surfbird, Great Knot, Wandering Tattler, and American and Pacific Golden-Plovers	NPS, USGS	Inventory of Alpine and Montane Nesting Shorebirds in Alaska	http://alaska.usgs.gov/science/biology/shorebirds/inventory_nesting.php
Bristle-thighed Curlews	ADFG, USFWS, USGS	Assessing Bird Abundance in Interior, Western and Northern Alaska	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Rusty Blackbird	ADFG, Audubon Alaska	Rusty Black Bird Spring Migration Blitz	http://ak.audubon.org/rusty-blackbird-spring-migration-blitz
Gray-headed Chickadee	ADFG	Distribution Surveys	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Landbirds	USGS-USFWS	North American Breeding Bird Survey	https://www.pwrc.usgs.gov/bbs/about/
Landbirds	USGS,	ALMS – Alaska Landbird Monitoring Survey	http://alaska.usgs.gov/science/biology/bpif/monitor/alms.php
Landbirds	USGS, USFWS, Alaska Bird Migration Station	Alaska Landbird Migration Monitoring	http://alaska.usgs.gov/science/biology/bpif/monitor/monitorprojects.php#bbs
Landbirds	USGS – National Audubon Society	Christmas Bird Count	http://www.audubon.org/content/history-christmas-bird-count
Loons and Grebes	ADFG, AKNHP	Loon and Grebe Watch program	http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.loonsgrebesoverview
Short-eared Owls	ADFG, USFWS	Wildlife Diversity Program	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Bald Eagles	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Cliff-nesting Raptors	BLM	NPRA cliff-nesting raptors	http://www.blm.gov/nstc/library/pdf/RaptorTN413.pdf
Raptors	ADFG	Alaska Raptor metadata database	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Peregrine Falcons	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf

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Variable	Agency or Organization	Program	More Information
Golden Eagles	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Gyrfalcons	ADFG	Wildlife Diversity Program	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Olive-sided Flycatchers	ADFG	Wildlife Diversity Program	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Snowy Owl	Owl Research Institute	Snowy Owl Studies	http://www.owlinstitute.org/
Passerines	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Marine Mammals			
Marine Mammals	NOAA-NMFS	Marine Mammal Stock Assessment Reports	http://www.nmfs.noaa.gov/pr/sars/species.htm#smallwhales
Marine Mammals	ADFG	Marine Mammal Acoustic Monitoring – Bering Strait	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.acoustics
Steller's Sea Lion	ADFG	Research and Monitoring	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.stellerresearch
Steller's Sea Lion	NOAA	National Marine Fisheries Service	http://www.alaskafisheries.noaa.gov/protectedresources/stellers/default.htm
Polar Bear	USFWS, USGS	ANWR Monitoring Program	http://www.fws.gov/alaska/climate/pdf/FactSheet_Arctic_NWR.pdf
Polar Bear	USFWS	Marine Mammals Management	http://www.fws.gov/alaska/fisheries/mmm/polarbear/what.htm
Walrus	USFWS, Eskimo Walrus Commission, Marine Mammal Advisory Committees, North Slope Borough, USGS, NMFS, Alaska Sealife Center	Population Estimation, Harvest Monitoring, Haulout Monitoring	http://www.fws.gov/alaska/fisheries/mmm/walrus/current.htm
Walrus	ADFG	Walrus Research - Chukchi	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.walrusresearch
Ice Seals	ADFG	Biological and Harvest Monitoring	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.icesealmonitoring
Harbor Seal	ADFG	Research and Monitoring	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.harborsealresearch
Harbor Seal	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=8
Bowhead Whale	ADFG	Research – Western Arctic	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.bowhead
Beluga Whale	ADFG	Research – Bristol Bay	http://www.adfg.alaska.gov/index.cfm?adfg=marinemammalprogram.bristolbaybeluga
Humpback Whale	NOAA, UAS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/humpback-whales/
Humpback Whale	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Killer Whale	North Gulf Oceanic Society	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/pelagic-ecosystem/killer-whales/

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Variable	Agency or Organization	Program	More Information
Sea Otter	USGS, NOAA, NMFS, NPS	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/nearshore-benthic-systems-in-the-gulf-of-alaska/
Sea Otter	UAF, KBERR	GulfWatch - Ecological Trends in Kachemak bay	http://www.gulfwatchalaska.org/monitoring/nearshore-ecosystems/ecological-trends-in-kachemak-bay/
Sea Otter	USFWS, Indigenous People's Council, AK Sealife Center	Marine Mammals Management	http://www.fws.gov/alaska/fisheries/mmm/seaotters/what.htm
Sea Otter	USGS – Alaska Science Center	GulfWatch Alaska	http://www.gulfwatchalaska.org/monitoring/lingering-oil/harlequin-ducks-and-sea-otters/
Sea Otter	NPS	SW Alaska Inventory and Monitoring Network	http://science.nature.nps.gov/im/units/swan/monitor/nearshore.cfm?tab=1
Terrestrial Mammals			
Small Mammals	ADFG	Wildlife Diversity program	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Small Mammals	Owl Research Institute	Snowy Owl Studies	http://www.owlinstitute.org/
Small Mammals	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Arctic Ground Squirrel	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Snowshoe hare	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Alaskan Hare	ADFG, UAF	Distribution and genetics	http://www.adfg.alaska.gov/index.cfm?adfg=wildlifediversity.projects
Bats	ADFG	Alaska Bat Monitoring program	http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.bats
Freshwater Invertebrates			
Freshwater Macroinvertebrates	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Freshwater Benthic Macroinvertebrates	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Western Toads	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Wood Frogs	ADFG, AKNHP	Alaska Wood Frog Monitoring Project	http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.woodfrog
Non-native Species			
Invasive Species	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Exotic Species	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Invasive/Exotic Plants	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Invasive Species	ANHP UAA	Alaska Exotic Plant Information Clearinghouse	http://aknhp.uaa.alaska.edu/botany/akepic/

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Variable	Agency or Organization	Program	More Information
Insect Outbreaks	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Amphibians			
Insect Outbreaks	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Fire Monitoring	BLM	Interagency Fire Effects Task Group	http://fire.ak.blm.gov/administration/awfcg.php
Fire Monitoring	USFWS	Fire Management	http://www.fws.gov/fire/what_we_do/
Fire Occurrence and Extent	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Human Use			
Consumptive and Recreation Use	NPS	SW Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SWAN_MonitoringPlan.pdf
Consumptive Hunan Use	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Non-Consumptive Human use	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Sound	NPS	CAKN- Central Alaska Network Inventory and Monitoring Program	http://www.nps.gov/dena/learn/nature/upload/Central-Alaska-Network.pdf
Human Use	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Sound	NPS	SEAN – Southeast Alaska Inventory and Monitoring Network	https://science.nature.nps.gov/im/monitor/plans/SEAN_Monitoring%20Plan.pdf
Bycatch	NMFS	Fish, seabird, and marine mammal bycatch	NMFS (National Marine Fisheries Service). 2004. Evaluating bycatch: a national approach to standardized bycatch monitoring programs. U.S. Dep. Commer., NOAA Tech. Memo. NMFSF/ SPO-66, 108 p.
Biodiversity			
Biodiversity	ADFG, UAS, NOAA, Forest Service, USFWS	Bioblitz project	http://www.adfg.alaska.gov/index.cfm?adfg=citizenscience.bioblitz
Arctic Biodiversity	CAFF	Arctic Biodiversity Trends	http://arcticbiodiversity.is/abt2010/
Community Based Monitoring in the Arctic	CAFF	Arctic Marine Biodiversity Monitoring	http://www.caff.is/community-based-monitoring/community-based-monitoring-publications/51-a-Plan-for-facilitating-and-developing-community-based-monitoring-approaches
Ecological Monitoring	USFWS- Kenai NWR	Long term Ecological Monitoring program	Morton, J. M., Bowser, M., Berg, E., Magness, D., & Eskelin, T. (2008, October). Long term ecological monitoring program on the Kenai National Wildlife Refuge, Alaska: an FIA adjunct inventory.
Grazing and predation	LTER – Long Term Ecological Research	Top-down or bottom up control in Arctic	http://www.lternet.edu/sites/arc/research-topics

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Black Oystercatcher	Black Oystercatcher	Black Oystercatcher	Black Oystercatcher
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