7 | Threats to Wildlife

Pacific walrus. A. Underwood, ADF&G.

This chapter outlines the potential threats that could affect fish and wildlife populations in Alaska at local, regional, or statewide scales. The threats described in this chapter are generally not expected to have population-level impacts on "species of greatest conservation need" (SGCN) due to the availability of undisturbed and intact fish and wildlife habitats, the small spatial scale of human-associated threats, and the large areas of land already managed for fish and wildlife conservation across the state. Importantly, Alaska has adequate regulatory mechanisms to ensure that development and other human activities are compatible with fish and wildlife conservation.

Both the Alaska Constitution (Art. VIII) and Alaska Department of Fish and Game's (ADF&G) mission prioritize the long-term sustainable use of all natural resources, guiding ADF&G to manage fish and wildlife populations in a way that supports both conservation and public use. The state's approach is not to eliminate all potential threats, but to ensure that threats are managed to maintain healthy, viable populations of fish and wildlife. This reflects a balanced strategy—supporting the beneficial use of resources while safeguarding the long-term sustainability of fish and wildlife populations, recognizing that there may be impacts from resource use at a local scale. Using this strategy, ADF&G already addresses many of the threats described in this chapter through current regulations that support its constitutional mandates.

The 11 primary threat categories outlined in this chapter use standardized terminology from the Classification of Direct Threats to Ecosystems and Species, version 4.0, created by the International Union for the Conservation of Nature (IUCN) and Conservation Measures Partnership (CMP; Salafsky et al. 2024). Version 4.0 updates version 1.0 (Salafsky et al. 2008), which was used in the 2015 Alaska State Wildlife Action Plan (SWAP). The presentation of the primary threat categories and

subcategories below follows the standardized order used by Salafsky et al. (2024); however, some modifications to the subcategories in the climate change section were made to reflect conditions unique to Alaska ecosystems and wildlife. Because the SWAP undergoes a major revision at least once a decade, this version focuses on the extent of threats over the next one to two decades. Though our discussion about threats to Alaska's wildlife are organized into discrete categories, interactions among multiple threat types may occur, resulting in compounded or intensified impacts on wildlife and their habitats.

Waterfront houses, Ketchikan. ADF&G.

Residential, Commercial, and Recreation Areas

Alaska's human population is small (740,133 people; U.S. Census 2025) compared to the state's large size (586,412 square miles). As of 2019, over half of Alaskans live in the three major cities of Anchorage, Fairbanks, and Juneau, and most live in communities of over 2,500 people (DOLWD 2024). The State's population declined during 2016–2019 for the first time since the late 1980s but is projected to increase slightly until 2033 (DOLWD 2024). Population expansion has occurred in the Southcentral biogeographic region, particularly in the Matanuska-Susitna Borough.

While the number of Alaska residents has declined, the number of visitors to Alaska has increased dramatically. Between May 2022 and April 2023, the state hosted over 2.7 million visitors (Destination Analysts 2023). Most arrived by cruise ship (57%) to the Southeast, Southcentral, and Central regions. A majority of tourists also visited Alaska's national parks (NPS 2022).

Residential Areas

Alaska's small population makes housing an unlikely threat to wildlife at the statewide or regional level during the coming decade. However, given the uneven distribution and growth of population centers, localized impacts are possible. Housing developments can impact aquatic habitats for many fish and wildlife species via the draining and filling of wetlands, the diversion of small water bodies or streams, or the development of high-value riverfront, lakefront, and oceanfront properties. Point source pollution may be associated with failed septic systems or lack of functional sewer or septic systems in some areas of Alaska. Housing expansion into undeveloped areas increases the potential for human-wildlife conflict. It can also lead to increases in populations of non-native and nuisance species that thrive in urbanized areas.

Commercial and Industrial Areas

As with housing, the extent of habitat affected by commercial and industrial development is small relative to Alaska's size. Commercial development often occurs on or adjacent to land already modified by people and is therefore unlikely to affect population viability of most species. Landfills serving

larger population centers are required to meet modern standards (e.g., lined pits, effluent recovery systems) to reduce contamination of nearby habitats. Still, those in rural areas may pose local risks if they are unlined or uncovered. Landfills can attract and concentrate predators (e.g., ravens, gulls, foxes, and bears), increasing predation of nearby species (Weiser 2010). Contaminants from solid waste and incineration may spread into surrounding habitats, affecting terrestrial, freshwater, or marine ecosystems.

Recreation and Tourism Areas

Development of tourism-related infrastructure has mostly occurred in Alaska's population centers and nearby areas. On most state and federal public lands, commercial tourism activities such as sport fishing, river rafting, kayaking, heliskiing, and flightseeing are regulated by permit. Cruise ships, recreational fishing boats, whale watching vessels, and jet ski tours in marine waters, as well as wildlife viewing by boat, plane, and helicopter, all present potential localized, transient impacts to wildlife (see "Human Intrusions and Disturbance: Recreational Activities" below).

Alaska's outdoor recreation economy is larger than its construction economy and has grown in recent years (USBEA 2023). The infrastructure associated with recreational activities (e.g., viewing platforms and visitor centers) at wildlife viewing sites on state or federal lands is modest in extent and unlikely to have significant effects on wildlife habitats or species viability. However, open-topped pipes associated with recreational facilities (e.g., outhouse vents, pipe gates) are a well-documented

Downtown Juneau with Mount Juneau in the background. ADF&G.

threat to birds that investigate and become trapped inside. This threat is easily mitigated by installing covers or grates over open pipes (Hathcock and Fair 2014, Braxton Little 2015).

Agriculture and Aquaculture

Agriculture and aquaculture are not expected to be threats to SGCN at statewide or regional scales due to the relatively small geographic areas in which these activities occur and state regulations that minimize impacts of aquaculture on fish and wildlife. Most agricultural land development in Alaska took place between 1920 and 1980 (Stevenson et al. 2014), though there are recent efforts to increase food production and security (Alaska Food Policy Council 2025). As of 2022, Alaska has 1,173 farm operations, most of which are located in the Southcentral and Central biogeographic regions.

Annual and Perennial Nontimber Crops

Only a very small percentage (approximately 0.2%) of all land in Alaska is currently used for crop production. Top commodity crops include floriculture, sod and hay crops, and barley. Current threats to wildlife populations and habitats are limited but may result from habitat loss, habitat alteration, or pesticide exposure.

Terrestrial Animal Farming, Ranching, and Herding

Livestock production in Alaska is limited in scope, involving approximately 20,500 dairy and beef cattle, pigs, and nearly 11,000 poultry. These animals primarily occupy the same land as that in the annual and perennial nontimber crops category. The majority of the land used for farming and ranching livestock is located in the Southwest, Central, and Southcentral biogeographic regions (USDA 2024). Approximately 688,977 acres of land in Alaska are used for livestock production, though few individual ranching operations exist. Large ranches are present on Umnak and Unalaska islands.

Threats to wildlife related to livestock production in the state include disease transmission from domestic animals (Cleaveland et al. 2001) and habitat loss or alteration. Zoonotic diseases could affect populations of moose, caribou, sheep, and bears (ADF&G 2025a), and many avian species could be affected by pathogens from domestic birds. Additionally, livestock grazing may significantly change the vegetation by foraging, trampling, or enabling invasive or noxious plants to spread. Although livestock production is not a significant threat regionally or statewide, it can be an acute problem for endemic species on islands, particularly those in the Western biogeographic region. Abandoned livestock (e.g., cattle on Chirikof Island) or free-range livestock (e.g., reindeer on Kodiak and St. Paul islands) may enter and damage sensitive wetland habitats or disturb ground nesting birds.

Marine and Freshwater Aquaculture

Aquaculture is regulated by state law to prevent adverse effects on fish, wildlife, and their habitats (AS 16.05.105). Aquaculture is a growing industry in Alaska and can consist of farms or hatcheries for shellfish, finfish, or seaweed. Shellfish aquaculture production sales in Alaska totaled $1.9 million in 2022. There has been an increase in aquaculture farming applications and the quantity of aquatic farm acreage applied for in recent years (NOAA 2024a). The state recently received $100 million in funding to support the growth of the aquaculture industry. In 2023, Alaska was designated as

the next region to begin identification of Aquaculture Opportunity Areas, which will help advance sustainable aquaculture in areas that are environmentally, socially, and economically appropriate (NOAA 2024b).

Although Alaska banned finfish farming in 1990 (AS 16.240.210), the practice is common in China, Korea, Chile, Norway, Japan, and Canada, and products from those countries compete with Alaska's wild-reared salmon on global markets. Hatchery production from Pacific Rim nations, primarily Russia, the U.S., Japan, Canada, and South Korea, increased substantially from the 1970s to about 1990 and since then has remained relatively stable (NPAFC 2024). Atlantic salmon are extensively farmed in British Columbia and Washington state and are occasionally reported in Alaska waters.

In contrast, Alaska's private nonprofit hatcheries rear salmonids (Pacific salmon and trout) from eggs and release juveniles that feed in the ocean for one to four years before being harvested in marine waters or near the hatchery release site. The original broodstocks for hatcheries in Alaska are required to be from local salmon populations. In 2023, Alaska hatcheries released 1.9 billion juvenile salmon (primarily pink and chum salmon), and hatchery salmon accounted for 35% of the salmon harvest (Wilson 2024). ADF&G also stocks many rivers and lakes, primarily to provide sport fishing opportunities. The majority of these stocking programs use triploid fish that cannot reproduce (ADF&G 2025b).

Oysters, blue mussels, and kelp are also grown in Alaska (NOAA 2024a). The majority of permitted aquaculture operations in Alaska are located in the Southeast region, where operations are dedicated to seaweed and shellfish farming. Southcentral and Western Alaska also support shellfish, kelp, and oyster farms.

Alaskan seaweed farmers examine their crop. NOAA Fisheries, used with permission.

Potential threats from shellfish and finfish aquaculture include alteration of marine habitat, disturbance to other marine organisms, disease, invasive species introductions (McLaughlin et al. 2005), potential increased food competition with native aquatic species (Ruggerone et al. 2023), and genetic effects from hybridization of stray hatchery-origin salmon with wild stocks (Grant 2012). ADF&G implements policies to manage threats to wild stocks from hatcheries and aquaculture (Wilson 2024), including sourcing hatchery stocks locally so that any stray hatchery returns will be genetically similar to the wild stocks from nearby streams. Alaska hatcheries do not selectively breed salmon, and there is extensive planning, permitting, and monitoring to prevent the spread of infectious diseases. Shellfish and kelp farms require little or no input in the form of water, feed, or fertilizer, and they can improve water quality by removing excess nutrients, buffering ocean acidification exacerbated by climate change, and creating habitat for marine life (NOAA Fisheries 2022). However, shellfish farms also may negatively impact marine wildlife through direct disturbance (i.e., from boat and vehicular traffic), habitat alteration, or changes in the movement and availability of phytoplankton, nutrients, and organic materials in the water column, resulting in localized changes to coastal areas (Ahmed and Solomon 2016). For example, on-bottom shellfish aquaculture near eelgrass beds can lead to habitat destruction and degradation. Shellfish farming structures also may interfere with roosting, feeding, and nesting behavior of birds and may exclude marine mammals. Other potential threats to marine mammals include entanglement with aquaculture gear such as kelp longlines, behavior altered by the noise or positioning of farming operations, and food conditioning (Bath et al. 2023).

Active claim within Independence Mine State Historical Park. ADF&G.

Energy Production and Mining

Natural resource extraction and renewable energy projects in Alaska are regulated by state, federal, and local agencies through an extensive permitting process to ensure compliance with environmental laws and standards and to minimize impacts on fish, wildlife, and their habitats. Alaska's economy is highly dependent on natural resource extraction, particularly oil and natural gas. Income from the oil and gas sector accounted for 81% of Alaska's unrestricted general revenue from 1959 to 2022 (MRG 2023). Taxation of oil and gas property assets has contributed significant revenue to local governments, particularly those in the Northern and Southcentral biogeographic regions (MRG 2023). Renewable energy projects, including hydroelectric,

Dalton Highway, Alaska. ADF&G.

wind, and solar power, are an emerging industry in Alaska and are predicted to increase in the coming years (Bernton 2024). Global demand for critical minerals including graphite, cobalt, and rare earth elements (e.g., lanthanum, cerium, ytterbium) is increasing. This demand, in part, has led to increased mining exploration in Alaska since 2015 (Szumigala 2024). As demand increases, existing regulations will continue to ensure development is compatible with fish and wildlife conservation, as mandated by the Alaska Constitution (Art. VIII). Overall, the effects of oil and gas exploration and extraction, mining and quarrying, and renewable energy development on fish and wildlife in Alaska are well-managed and do not put the long-term viability of SGCN at risk. As new projects are developed across Alaska during the next 10 years, opportunities may arise for ADF&G to partner with industry and, where needed, conduct additional monitoring, mitigation, and conservation actions.

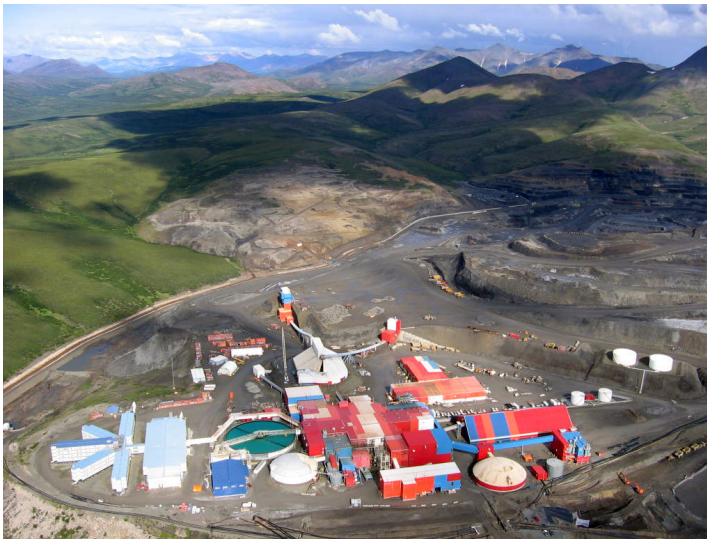
Oil and Gas Exploration and Extraction

Oil and gas drilling primarily occurs in the Northern biogeographic region, which produces approximately 95% of Alaska's crude oil (USEIA 2024). Oil and gas drilling also occurs in Cook Inlet on state and federally managed onshore and offshore leases. Several offshore oil and gas lease sales were held in the Beaufort and Chukchi seas during 2007–2012, but these were later canceled, and a new leasing program has not yet been implemented (BOEM 2016, BOEM 2023).

While oil production in Alaska's existing fields has declined in recent decades, new projects are forecasted to increase North Slope oil production and represent 51% of total production by 2032 (MRG 2023). Overall, the total amount of habitat directly affected by these new projects is small, but the indirect effects of their development can extend beyond the actual footprint of the project. Direct effects include habitat loss and alteration due to winter exploration, gravel mining, construction and operation of drill pads, roads (including ice roads), processing facilities, and employee housing. Spills or pollutant releases, such as oil, saltwater, drilling fluids, and gas flaring from drill sites and production facilities, may also negatively impact habitats.

Indirect effects of oil and gas exploration and extraction include attraction of predators and scavengers to human activity or facilities, habitat alteration or contamination from fugitive dust

and gravel spray, and impacts to prey populations. Increased predator numbers (e.g., gulls, ravens, foxes) associated with camps and infrastructure have been found to decrease nesting success of birds in the surrounding area (Liebezeit et al. 2009). Anthropogenic food sources have led to red foxes displacing Arctic foxes from dens closest to oil field facilities in Prudhoe Bay (Stickney et al. 2014).



Red Dog Mine, Alaska. ABR, used with permission.

If development of unconventional oil sources (e.g., shale formations, coal-bed methane, methane hydrates) increases in the future, these activities may also impact wildlife via drilling, transportation, and infrastructure construction and operation. However, the costs of developing unconventional oil resources on the North Slope are high, given the remoteness and lack of infrastructure, so this type of development may not occur for some time.

Mining and Quarrying

Alaska has large deposits of minerals, including gold, copper, zinc, silver, cobalt, and graphite, as well as other resources, such as coal, gravel, and sand. Currently, across the state, there are seven large mines and eight large exploration projects (DNR 2024a), over 200 placer gold mines, and approximately 120 active rock, sand, and gravel operations (AMA n.d.). The level of impacts to wildlife and habitat from current and future mineral development varies depending on the size, location, and type of mine (i.e., placer, surface, underground, or in-situ), and they may be short-term or long-term in nature. Mining exploration and development will likely intensify as the demand for critical minerals needed to produce renewable energy and computing technology increases (BLM 2021). In Alaska, small-scale mining activities require permits, while large-scale mining operations undergo extensive review and oversight by several state and federal resource agencies. Without this management and mitigation, mining can negatively impact fish, wildlife, and their habitats.

The stages of mineral extraction (e.g., exploratory drilling, construction, tailings disposal, water withdrawal, water impoundment, and water operation) can directly impact fish and wildlife through habitat loss or alteration, reduction of water in aquatic ecosystems, and the release of contaminants. The overall percentage of wildlife habitats affected statewide is small and unlikely to result in population-level effects on Alaska's wildlife, except where mineral extraction activities occur on or very near specific important habitats of at-risk species or when they have the potential to affect a species that exists in very small numbers or has low genetic diversity.

Aquatic habitats and species can be impacted through the emission of toxic contaminants, stream channel burial, and changes to the flow regime (Sergeant et al. 2022). Landscape-scale watershed alterations from large-scale mineral development can be detrimental, and the effects of widespread small placer mines on fish and wildlife can be additive. These effects include increased erosion

and sediment transport, transport of contaminants from dust, mine waste, and mine drainage. Mining can reduce hydrological buffering, resulting in periodic high-water flow, followed by longer periods of decreased flows; these fluctuations can reduce habitat quality for aquatic organisms. Mineral extraction and coal mining typically require the use and 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 negatively affect fish and wildlife.

Renewable Energy

As of 2023, Alaska generates about one-quarter of its total electricity from renewable energy sources, primarily hydropower (USEIA 2024), and the number of renewable energy projects in Alaska is expected to increase over the next decade. Several large wind power projects are currently in the planning stages. Additionally, solar, tidal, in-stream, and geothermal projects are proposed, under construction, or already operated across Alaska. Potential wildlife impacts associated with renewable energy projects include direct habitat loss and collision with structures such as wind turbines, solar panels, in-water turbines, and associated transmission equipment. Except for possible large hydropower development, threats to wildlife from renewable energy production in Alaska are relatively small, localized, and unlikely to impact most species on a population level. Large hydropower development in Alaska would require significant review and oversight by several state and federal resource agencies to manage and mitigate the impacts on fish and wildlife.

Wind turbines behind the U.S. Coast Guard base, Kodiak, Alaska. ADF&G.

The amount of wind-generated power in Alaska is extremely small in relation to the landscape, and wind generation is unlikely to lead to population-level conservation concerns for any wildlife species. In certain locations, these systems could pose localized threats to concentrations of migratory birds and possibly bats. Wind generation in the United States results in a relatively minor direct loss of birds through collisions with rotors (approximately 140,000 to 328,000 birds annually; Loss et al. 2013). Some bird taxa such as raptors (i.e., hawks, eagles, and falcons) are more susceptible to collisions with turbines than others. Bats, particularly those that make long-distance seasonal migrations, are also susceptible to collisions with wind turbines, and data suggests that millions die every year at wind power facilities (BCI 2024). Minimizing the potential impacts of wildlife collisions with wind turbines will involve primarily working with project proponents to develop project-specific mitigation measures, as described in Chapter 10.

Trans-Alaska oil pipeline crossing on South Fork, Koyukuk River. S. Hillebrand, ADF&G.

Offshore wind is likely the most feasible option for renewable energy production on Alaska's Outer Continental Shelf but has not yet been implemented. Wave and tidal energy projects are still in the early stages of development and implementation. A hydrokinetic project in Igiugig was launched in 2019, and another has been proposed in Cook Inlet as of 2024. Potential effects on wildlife from wave or tidal energy development could involve disruptions in migration patterns of marine fishes and mammals, increased disturbance, and potentially increased mortality. Based on project monitoring elsewhere, risks of collision are low for salmon and small, agile cetaceans; however, risks may be greater for large cetaceans and pinnipeds. These energy developments could affect marine mammals if sited in places where large numbers of marine mammals pass through annually, such as the Bering Strait and Unimak Pass.

Transportation, Service, and Security Corridors

Alaska's existing transportation network is mostly contained within a fairly narrow north–south corridor spanning the Northern, Central, and Southcentral biogeographic regions, where other development infrastructure in the state is centered. Alaska has a far lower density of transportation, service, and security corridors than any other state. While all of these are potential threats to fish and wildlife at local scales, they are not expected to impact SGCN at regional or statewide levels due to the large undeveloped expanse of fish and wildlife habitat across the state.

Roads, Trails, and Railroads

Alaska's existing road system is very small relative to the size of the state, comprising nearly 18,000 miles total, most of which are local roads. Fewer than 1,100 miles are classified as interstate highways, and 3,200 miles are classified as arterial and major collector roadways (DOT&PF 2024b). Alaska also has one railroad system, a single line that runs 656 miles from Fairbanks to Seward (AKRR 2024). Alaska's Department of Natural Resources has identified hundreds of public trails across the state, primarily accessible from the road system (DNR 2023).

Roads can have negative effects on fish and wildlife (Bennett 2017). The construction of roads and railroads results in direct habitat loss and habitat alteration within the road prism. Roads, perched culverts, and railroads may block terrestrial and aquatic migration corridors and have been shown to impede salmon spawning and displace other species (Sergeant et al. 2022). However, the impacts of roads on anadromous waters are regulated under Alaska statute (AS 16.05.871), which reduces potential conservation challenges associated with transportation corridors and helps ensure movement of anadromous fish is not blocked. Roads, trails, and railroads have also been implicated in introducing and spreading invasive plant species. Vehicle collisions are a source of direct mortality of wildlife. Compared with roads, railroads may have less severe impacts on wildlife because traffic is relatively infrequent; however, because of the volume and types of products carried, potential threats from spills may be higher.

Recent initiatives, such as the state's Roads to Resources and the proposed Alaska Long Trail project, could extend the current transportation network into undeveloped areas (DOT&PF 2024a, BLM 2025). New roads and trails can lead to increased hunting, trapping, fishing, recreational activities, resource extraction, and industrial and residential development. However, even with the addition of several new roads or trails, Alaska will still have the lowest density of transportation corridors of any state.

Utility lines under construction at Delta Junction, Alaska. ABR, used with permission.

Utility and Service Lines

The total land area directly affected by utility and service lines in Alaska is small; however, alteration of habitat structure and vegetation can change which species use these corridors for breeding, movement, and migration and increase the risk of predation for some species.

Impacts to wildlife from utility lines and corridors primarily consist of direct mortality (Bevanger 1998), habitat alteration, and changes in wildlife use and patterns of movement. An estimated 12–64 million birds are killed annually through collisions with or electrocution by powerlines in the rest of the United States (Loss et al. 2013). However, the density of utility lines and their corresponding risk to birds is substantially lower within Alaska. Towers associated with utility lines provide artificial structures for nesting and perching by raptors and ravens. Any resulting artificial increase

Shipping in the Inside Passage. ADF&G.

in predators may depress the nesting success of breeding birds, as well as populations of small mammals, along utility corridors. Similarly, pipelines and utilidors can alter habitat and vegetation composition (McDonald et al. 2020) and affect wildlife movement (Charlebois et al. 2023). In a recent 12-year study, factors such as pipeline height, pipeline corridor width, and vegetation type played a role in how likely boreal mammal species were to cross above-ground pipeline corridors during winter months (Charlebois et al. 2023).

Shipping Lanes

Aside from oil spills (see "Pollution: Water-borne and Other Effluent Pollution" below), threats to wildlife from shipping in Alaska are primarily related to marine shipping and vessel travel (Humphries and Huettmann 2014), although there is also substantial barge shipping on large river systems. For example, the North Pacific Great Circle Route is a globally important shipping corridor between North American and Asian ports, with around 1,000–3,000 vessel transits per year that cut through the ecologically rich Aleutian Islands (Sullender et al. 2021). In addition, approximately 57% of the 2.7 million tourists visiting Alaska each year use the cruise ship industry (Destination Analysts 2023), and the numbers of passengers and vessels have increased in recent years.

Snowy Owl resting on fishing vessel at sea. ABR, used with permission.

Increases in shipping in the Bering and Beaufort and Chukchi Sea biogeographic regions, which historically have experienced low levels of shipping activity, are occurring due to the reduction in sea ice in the Arctic. Between 2013 and 2023, there was a 37% increase in the number of ships entering Arctic waters worldwide, primarily due to a large increase in the number of gas tankers (PAME 2024). During the same time period, marine tourism in Arctic waters increased

from 58 vessels in 2013 to 96 in 2023 (PAME 2024). As the length of the ice-free season increases, shipping vessels traveling the Northern Route (between Europe and Asia along the northern coast of Russia) may be able to access the Great Circle Route (between western North America and Asia) via the Bering and Chukchi Seas. This could lead to increases in vessel traffic along the Aleutian Island chain and through Unimak Pass (Arctic Council 2021), an important migration corridor for wildlife (Sydeman et al. 2023). Voluntary measures, such as the designation of Areas To Be Avoided (ATBA) along shipping routes, can decrease the risk of impacts from shipping to fish and wildlife (Sullender et al. 2021).

Shipping activities and the maintenance of shipping lanes can result in habitat alteration and changes to water quality, which, in turn, can affect the numbers and types of wildlife using affected areas. Dredging and construction, as well as maintenance of boat docks and harbors, can degrade sensitive nearshore and intertidal marine habitats. Offshore dredging can degrade benthic habitats and result in the mortality of sessile marine invertebrates, such as bivalves, corals, and sponges.

Species of Conservation Need: Cook Inlet Beluga *(Delphinapterus leucas)*

Beluga whales are known as the "canaries of the sea" for their impressive repertoire of vocalizations. Adults can reach lengths of up to 16 feet and are bright white in coloration, whereas calves are born with a dark grey coloration that lightens as they mature. Belugas lack a prominent dorsal fin and instead have a dorsal ridge, which allows them to swim under sea ice more easily. There are five recognized stocks of beluga whales that inhabit Alaska waters. Of these, the Cook Inlet stock, recognized as a Distinct Population Segment (DPS), is the only stock listed under the Endangered Species Act (ESA). Surveys conducted by ADF&G in 1979 estimated that there were approximately 1,300 whales in Cook Inlet at that time. After decades of decline, the population was listed as endangered under the ESA. As of 2022, the abundance estimate for the Cook Inlet beluga stock was 331 animals. Many potential threats to the population have been identified, including catastrophic events (e.g., oil spills and mass strandings), noise, disease agents (e.g., harmful algal blooms, pathogens, and parasites), reductions in prey availability, habitat loss and degradation, predation, and pollution and contaminants. Cumulative effects, resulting from all or some of these impacts, may be responsible for the slow recovery of the species. Cook Inlet belugas appear to have some stark differences compared to other stocks that could be contributing to their decline. Their lifespan appears to be shorter than that of other Alaska populations; their age of first reproduction or calving is older than in other stocks; and strandings of calves are higher than expected. Reproduction is likely a limiting factor for the recovery of the population.

An adult Cook Inlet beluga (white) and a juvenile (gray) swim in silty water (NOAA permit #20465). H. Europe and J. Barbaro, NOAA Fisheries, used with permission.

These benthic animals provide habitat for other wildlife, including commercially harvested fish species. Ballast water exchange and hull fouling of ships and barges are potential vectors for aquatic invasive species, especially in the Arctic.

Vessel collisions and propeller strikes cause mortalities and injuries to marine mammals and birds. In Alaska waters, the number of vessel strikes for marine mammals is thought to be generally low, but many incidents likely go undetected or unreported, especially in remote areas (Neilson et al. 2012). The number and speed of vessels relate to collision severity for whales (Jensen and Silber 2003) and potentially other marine wildlife. Sea ducks, such as Spectacled and Steller's Eiders, typically fly low over the water at relatively high speeds and are at risk of collisions during periods of bad weather and impaired visibility. Some vessel lighting configurations, such as red steady-state lights and lighting that shines upward and outward from the vessel, are particularly disorienting to marine birds (USFWS 2025).

Atmospheric and Space Activities (Flight Paths)

In-state and international air traffic between Asia and North America commonly use numerous civilian and military flight paths over Alaska. The overall quantity of in-state civil air traffic is low relative to more populous states; however, the Ted Stevens International Airport in Anchorage is the most active cargo hub in the country (FAA 2024a). Within Alaska, the highest airport traffic rates occur in Anchorage, Fairbanks, Juneau, Bethel, and Ketchikan (FAA 2024b). The use of unmanned aerial systems (UAS; i.e., drones) for both civilian and military purposes has increased over the past decade, and the University of Alaska Fairbanks operates a national UAS test site (ACUASI 2024). Military flight paths are discussed in the "Human Intrusion and Disturbance" section.

Impacts of air traffic on wildlife include direct mortality due to collisions, disturbance from excess noise, and air pollution generated during low-elevation flight, take-off, and landing. Bird strikes are most common near major airports and areas of high air traffic. Collisions and other impacts associated with industry, military, and civilian aircraft activities in nonurban parts of the state are unlikely to have population-level effects on wildlife. Still, they can lead to localized effects, particularly for large congregations of individuals, such as resting walruses and staging or molting waterfowl and shorebirds.

Biological Resource Use and Control

The harvests of fish, wildlife, and all other replenishable resources in Alaska are managed for the beneficial use of all Alaskans and future generations under the sustained yield principle as required under the Alaska Constitution (Art. VIII, § 4). This mandate helps ensure that both the direct harvest of SGCN and the management of the indirect impacts of biological resource use on SGCN are conducted in a way that supports the long-term conservation of SGCN. The state supplies 60% of the wild seafood consumed in the United States, and the seafood industry contributed approximately $6 billion to the Alaska economy during 2021–2022 (MRG 2024). Hunting, fishing, and trapping are important practices for many Alaskans for consumption and recreation, and they are a particularly important source of food, cultural connection, and income for rural communities. While logging used to be a top contributor to the economies of Southeast Alaska communities, the industry has declined in recent decades.

Hunting, Collecting, and Controlling Terrestrial Animals

Hunting ptarmigan in the Kenai Mountains. ADF&G.

The harvest of wildlife is important to many Alaskans and occurs broadly across the state. A commonality shared by Alaskans in every community is the pleasure of putting a meal of wild game on the table. The highest levels of wild food harvest per capita in Alaska occur in rural communities in the Northern, Western, and Central biogeographic regions (ADF&G 2018). The State of Alaska is the primary manager of wildlife in Alaska and sets the harvest regulations across the state for all harvested wildlife, except marine mammals and migratory birds. Through the Federal Subsistence Board, the federal government can restrict harvest by nonrural residents in certain instances when a harvest limitation is necessary to safeguard subsistence uses. Subsistence harvests are the customary and traditional uses of fish and wildlife. Because of the importance of fish and wildlife to the people of Alaska, the sustainable management of renewable resources was incorporated into the Alaska Constitution (Art. VIII, § 4), which has resulted in management that is generally conservative. Therefore, hunting is unlikely to be a current threat to the sustainability of game populations, as evidenced by Alaska's successful management of game populations for more than a half-century, since statehood in 1959.

Hunting and trapping result in direct mortality of wildlife. Some of Alaska's bird species listed as SGCN are regularly harvested, particularly in rural communities. Species undergoing population declines, that are concentrated in small areas during various life stages, or that have a limited range can be vulnerable to overharvesting if their harvest is not adequately managed. When combined with other threats (e.g., climate change, resource development, and new infrastructure), hunting and trapping can potentially have an additive effect on local wildlife population mortality. Although hunting pressure in Alaska is generally low for migratory birds listed as SGCN, many species face threats outside the state from unregulated hunting and trapping practices at migratory stop-over sites and wintering grounds. This is particularly true for shorebirds migrating through and wintering in the Caribbean and northern South America (ASG 2019).

The use of lead ammunition and fishing tackle may result in the accidental poisoning of wildlife. For example, scavenger species, including eagles, may inadvertently consume lead fragments left behind in gut piles and carcasses harvested by hunters who used lead bullets, which has led to population-level impacts for eagles (Slabe et al. 2022). In 2024, ADF&G and partner organizations initiated a public education and incentive program to reduce the use of lead ammunition across the state to minimize the threat of accidental lead poisoning on wildlife (AK Copper Ammo Challenge 2025).

Logging, Harvesting, and Controlling Trees

Logging can impact SGCN by eliminating habitat for forest-dependent species; however, the limited geographic scope of current logging activities in Alaska, relative to the vast amount of available

habitat, is unlikely to result in population-level impacts. Additionally, the Alaska Forest Resources Protection Act (AS 41.17) ensures that impacts of logging to fish and wildlife are minimized in sensitive riparian areas, and ADF&G has proposed best practices for timber and wildlife in interior boreal forests (Paragi et al. 2020).

Logging and wood harvesting for commercial purposes occur in the Central, Southcentral, and Southeast biogeographic regions and target two major forest types: the interior boreal and coastal forests (DNR 2024c). Between 1990 and 2019, statewide timber harvest declined by 67.6% (Simmons et al. 2024). Historically, most logging and wood harvesting occurred in the Southeast region, particularly in the Tongass National Forest. Logging in the Central region's boreal forests targets productive stands of white spruce, found in both upland and riparian settings, for lumber, while birch, found in upland settings, is primarily harvested for fuelwood, including fuel pellets.

Most of the past logging in the Southeast region occurred on highly productive old growth sites, at lower elevations, in riparian areas, and near the coastline, resulting in disproportionate impacts to habitats of highest importance to fish and wildlife (Albert and Schoen 2013). Regionally, 11.9% of productive old growth forests have been logged. Within this logged proportion, large-tree stands were reduced by 28.1%, karst forests by 37%, and continuous old growth forests by 66.5% (Albert and Schoen 2013). Logging can affect terrestrial wildlife by causing habitat loss. Aquatic species may be impacted by increased sediment loads and changes to water quality and riparian habitat structure that result from logging operations. While levels of logging have declined substantially in the past decade and are not expected to return to historical levels, the impacts of historical logging will continue to affect wildlife habitat for decades, as forest stands take many years to resume their old growth characteristics. ADF&G will continue to monitor SGCN that may be affected by the 2025 reversal of the Roadless Rule. However, we are not aware of any resulting changes in timber development plans that could have population-level effects on SGCN.

Clearcut on Dall Island. ADF&G

The harvest of timber for biomass energy has the potential to impact boreal forests, particularly in the Central region. The Alaska Energy Authority's Biomass Energy Program has been developing wood-fired heating systems in Alaska, and there are currently 50 systems operating across the state (AEA 2024). Material for biomass systems can come from residual sawmill waste, slash from standard logging or thinning operations, or timber sales specifically targeting whole trees. When wood waste from mills is used, there is no additional impact on wildlife or wildlife habitat; however, 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 (Paragi et al. 2020).

Species of Conservation Need: Yelloweye Rockfish *(Sebastes ruberrimus)*

Yelloweye rockfish. ADF&G.

Yelloweye rockfish are among the most well-known of Alaska's 33 rockfish species. Named for the color of their eyes, these fish are most often found near rocky reef structures at depths exceeding 300 feet. Young yelloweye rockfish feed on algae, zooplankton, and crustaceans, but as adults, they are primarily piscivorous and can grow up to 36 inches, making them highly sought after by anglers. Yelloweye rockfish do not become sexually mature until they are between 20 and 30 years old. They commonly live to be over 100 years old and spend their entire lives on the same reef. Females give birth to live young between May and August. Their lengthy developmental period and very small home ranges make yelloweyes and other demersal rockfish extremely vulnerable to overfishing, requiring careful management efforts. Populations of yelloweye rockfish on the United States west coast (i.e., off the coasts of Washington, Oregon, and California) were declared overfished by the National Marine Fisheries Service in 2002. In 2010, the population in Puget Sound was listed as threatened under the Endangered Species Act. A contributing factor to rockfish vulnerability is a lack of swim bladder vents. This results in barotrauma injuries (bulging eyes or stomach protruding from the mouth) when fish are reeled up from depth, inhibiting them from resubmerging upon release. ADF&G has conducted extensive research to develop best practices for rockfish release, and anglers are now required to carry deep-water release mechanisms to safely return all unretained rockfish species to depth. In recent years, fishing restrictions for yelloweye rockfish have become more common to help ensure the conservation of this species.

Fishing and Harvesting Aquatic Species

Large harvests of fish occur in Alaska in commercial, subsistence, sport, and personal use fisheries throughout the state. All Alaska fisheries are managed to provide harvestable surpluses because of the constitutional requirement to ensure sustained yield. Subsistence and personal use fisheries are limited to Alaska residents. In contrast, sport and commercial fisheries include both in-state and out-of-state residents who purchase a sport fishing license or a commercial fishing permit. The most common fish harvested commercially are Alaska pollock and salmon species, which accounted for 75% of the ex-vessel volume during 2021–2022 (MRG 2024). For the most part, commercial fisheries in state-managed waters target salmon, groundfish, herring, and crabs; however, there are fisheries that target many other species of finfish and shellfish. Federally managed marine fisheries primarily target pollock, Pacific cod, Pacific halibut, and other groundfish species, as well as king, tanner, and snow crab under joint federal-state management structures in the Bering Sea and Aleutian Islands.

Subsistence fisheries harvest an estimated 28 million pounds of all species of fish annually, and sport fisheries harvested an estimated 2.9 million fish annually between 2004 and 2013. Subsistence and sport fisheries are managed by ADF&G to provide beneficial use for all Alaskans. These fisheries primarily target salmon, but many species of shellfish, groundfish, and resident freshwater species

of finfish are also harvested (ADF&G 2018). Traditional harvest of marine mammals, including seals, sea lions, walruses, and whales, by Alaska Natives accounts for 14% of all wild food harvested by local residents (ADF&G 2018).

Alaska salmon fisheries are managed by ADF&G, first to ensure adequate spawning escapement levels and then to provide harvestable surpluses (under the sustained yield principle). However, reduced run sizes in recent years, especially for Chinook and Western Alaska chum salmon, have resulted in considerable restrictions for commercial, recreational, personal use, and subsistence fisheries. The reasons for the decline of some aquatic species and species groups are complex. Warming ocean temperatures, changes in currents, invasive species, parasites, and disease possibly play a role in stock abundances to varying degrees. Other species groups, such as rockfish, may be impacted by incidental catch when targeting halibut and lingcod, resulting in conservation concerns and additional management measures (Hochhalter and Reed 2011, Hochhalter 2012).

Impacts from Bycatch and Trawl Gear in Commercial Fisheries

Alaska has large-scale federally managed commercial groundfish fisheries for pollock, Pacific cod, and flatfish. Comprehensive science and management programs have been established to minimize the impacts of these fisheries on other marine species and habitats. Minimizing the impacts of bycatch is a key focus area for the North Pacific Fishery Management Council, which has established bycatch limits and other incentives for fishing fleets to avoid bycatch (NPFMC 2025). Bycatch is defined as fish that are harvested in a fishery but not sold or kept. Fish are discarded in commercial fisheries because they are prohibited by regulation from being retained or are simply not wanted due to being a nonpreferred size, a less desirable species, or a lower value or unmarketable species. Alaska fisheries bycatch is relatively low compared to commercial groundfish fisheries in other areas. Of the 2,058,816 tons of fish caught in the Alaska halibut and groundfish fisheries in 2021, 97,083 tons (4.7%) were discarded (Witherell and Fey 2023). To ensure continued low levels of bycatch, federal fishery managers count and monitor all catch and bycatch using human observers and electronic technologies, and all bycatch accrues towards the annual catch limits for groundfish stocks and established bycatch limits for salmon, crab, halibut, and herring.

While bycatch in Alaska fisheries has not been identified as the primary cause of conservation concerns for specific species, fishery managers recognize the importance of continued work to further minimize bycatch in commercial fisheries. The Alaska Bycatch Review Task Force was formed in 2021 to evaluate fisheries bycatch and provide recommendations for continued work on incentives and methods to avoid and reduce bycatch (Alaska Administrative Order no. 326; November 18, 2021). The task force published a final report on December 8, 2022, containing recommendations on research, state engagement, and management measures related to bycatch (ABRT 2022). ADF&G uses these recommendations to support science and management priorities at the North Pacific Fishery Management Council. In addition, the Alaska Bycatch Advisory Council was formed in 2023 to maintain a focus on improving bycatch management by advising the ADF&G Commissioner on implementation of Alaska Bycatch Review Task Force recommendations (ADF&G 2025c).

The North Pacific Fishery Management Council also focuses effort on minimizing the impacts of trawl gear on other marine species and habitats. A large portion of Alaska's federally managed commercial harvest occurs on vessels that catch fish by towing a bottom or pelagic trawl net. As the name implies, bottom trawls are designed to catch fish at or near the seafloor. Pelagic trawls,

also known as mid-water trawls, are designed to fish higher than bottom trawls and are typically used to target a single species, primarily pollock in Alaska's fisheries. The best available information indicates that bottom trawls have a greater impact on seafloor habitat than pelagic trawls, and federal management programs have already closed large areas of the ocean off Alaska's coast to bottom trawling to minimize these impacts. Most trawling in Alaska fisheries occurs with pelagic trawl nets, which are designed to tow the net through the water column rather than on the seafloor. However, pelagic trawl gear is known to have contact with the seafloor, and efforts are underway to better estimate the impacts to benthic habitat and sensitive species (Rijnsdorp et al. 2016). This work is expected to inform the North Pacific Fishery Management Council's ongoing evaluation of the impacts of fishing on essential fish habitat for all managed marine species.

Human Intrusions and Disturbances

Recreational Activities

Alaska is known for its abundant recreational opportunities, and both residents and many of the approximately 2.7 million tourists who visit Alaska each year take advantage of these opportunities (Destination Analysts 2023). Outside of human population centers, most recreational activity in Alaska generally occurs at a low level of intensity. In addition, because Alaska has a limited road system, recreationists do not access much of the wildlife habitat in the state. Because of these factors, recreational activities are unlikely to have population-level effects on wildlife. Areas with greater localized impacts include popular river corridors, some accessible ocean shorelines, areas near population centers, and popular fish and wildlife viewing areas where human activity is often concentrated and can affect riparian and shoreline habitats important to some bird and aquatic species. Recreational vehicles can cause localized disruption of wildlife behavior and damage to habitats. However, these impacts are not likely to affect fish and wildlife at the population level. Recreation vehicles are also a potential pathway for spreading invasive aquatic and terrestrial species into remote ecosystems, where the costs of surveillance and eradication are high. However, there are regulations and a public outreach campaign designed to minimize this threat.

Fishing the Copper River. ADF&G.

Conflict, Civil Unrest, and Security Activities

The Joint Pacific Alaska Range Complex (JPARC) includes all land, air, and sea space used for military training in Alaska. The overall JPARC training area encompasses 65,000 square miles of airspace, 2,500 square miles of land space, and 42,000 square miles of ocean surface. Each year, JPARC hosts three to four major military exercises, such as RED FLAG, that involve thousands of personnel and hundreds of vehicles, aircraft, and facilities (JPARC n.d.). Ongoing military training occurs daily on a much smaller scale at home stations.

Paratroopers descend over the Donnelly drop zone near Fort Greely. M. S. Berry, U.S. Army, used with permission.

Potential effects of military activity on wildlife include localized direct mortality from munitions training and aircraft and vehicle collisions, alteration or elimination of habitat, increased air and water pollution from munitions and transportation (Racine et al. 1992), and behavioral effects related to noise pollution, particularly from low-level aerial training exercises (Lawrence et al. 2015). Large military exercises result in temporary increases in aircraft overflights (sometimes at low elevation and supersonic speeds), vehicle traffic, and live fire exercises in the training areas utilized. These activities may affect local wildlife populations, and with renewed focus on Arctic engagement by the military, the potential for wildlife disturbance is likely to increase (Bye 2024). 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 takes place at a significant scale is quite low and unlikely to have population- or landscape-level effects on fish or wildlife.

Other Human Disturbances

Scientific research and other nonrecreational and nonmilitary activities occur at a small scale across Alaska, and their effects on fish and wildlife are expected to be localized. However, small populations of animals that are frequently studied have experienced impacts from this threat (Meixell and Flint 2017). Possible impacts of researcher disturbance on fish and wildlife include injury or mortality, disturbance, displacement, and attraction of predators.

Natural System Management and Modifications

Fire and Fire Management

Wildfire plays an important role in the life history of many wildlife species in Alaska. It is one of many factors that maintain biological diversity (Smith et al. 2000): the natural cycle of habitat change caused by wildfire generally leads to more productive and diverse landscapes. However, fires can result in the immediate loss of individuals and the short-term loss of suitable habitat over large areas. Alaska has seen several major wildfire seasons over the past 20 years, including 2015, when 5.1 million acres burned (IARC 2025). As human recreation in nonurban areas increases, so does the potential for accidental wildfires. The frequency and intensity of wildfires have increased over the past few decades as a result of climate change and changing fire management strategies in Alaska.

Kanuti River and burned area. S. Hillebrand, USFWS, used with permission.

Dams and Water Management/Use

Alaska is fortunate to have relatively few water impoundments, and much of the state has abundant surface and groundwater availability. There are approximately 184 named dams in the state, primarily in the Southcentral, Southwest, and Southeast biogeographic regions. Of these, 50 dams are integral to utility-scale hydroelectric projects, whereas the remaining dams are relatively small and were built for community water storage or the treatment of water at mining operations (ASCE 2021). Potential impacts on wildlife from future dams and water withdrawals are most likely to come from large, utility-scale hydroelectric dams or those associated with large-scale mineral or oil and gas development.

Potential impacts of dams and water withdrawals on wildlife include permanent habitat loss and alteration, changes to water flow and characteristics, and blocking fish passage. Upstream of any river dam, large-scale flooding alters riparian and forest habitats important to wildlife, including forest birds and mammals. Dewatering of stream channels downstream of the dam or withdrawal results in reduced water flows, reduced transport of sediment and nutrients, and increased water temperature, all of which can degrade downstream wetland or estuarine habitats. Changes to habitat structure and function may alter wildlife communities that depend on these habitats and are most likely to affect fish, aquatic invertebrates, and bird species. Without fish passage structures, dams may prevent migrating salmonids from swimming upstream to spawn, and these fish may become the targets of predators who prefer slow-moving water.

Blue Lake Dam in Sitka. ADF&G.

In Alaska, the Anadromous Fish Act (AS 16.05.871–.901) and the Fishway Act (AS 16.05.841) both require consultation with ADF&G for any project that may have an impact on anadromous fish habitat or may obstruct fish passage. ADF&G evaluates project components and works with a project applicant to minimize the possible impacts on anadromous fish habitat and fish passage, which could include stipulations such as construction and operation timing windows, minimum flow releases, and project design, among other things. These statutes provide a mechanism for responsible management of anadromous waterways in Alaska that helps to mitigate impacts to these waters.

Invasive and Other Problematic Species, Genes, and Pathogens

As of 2024, an estimated 132 non-native animal species (fish, amphibians, reptiles, birds, mammals, invertebrates, parasites, and pathogens) have been reported in Alaska, and 24 of these are designated as highly invasive (USGS 2025, ADF&G 2025d). Potential invaders arriving by human-mediated pathways, including ships and cargo vessels, trailered watercraft, and fouled infrastructure, or through intentional or inadvertent introduction, are not included in that number. Some of these invasive and problematic species can have significant ecological and economic effects. Managing invasive, problematic, and pathogenic species is a priority because they can have significant negative impacts on habitat and native fish and wildlife. Due to the potential threat of invasive or problematic species introductions, Alaska has state laws and regulations aimed at preventing the introduction of potential invasive species. With diligent effort and sufficient resources, the introduction of these harmful organisms can be prevented or controlled.

Invasive Non-native and Alien Species

For this plan, an invasive species is defined using the language of the State of Alaska's Executive Order 13112: "an alien species whose introduction does or is likely to cause economic or environmental harm or harm to human health." Following Salafsky et al. (2024), this section also includes information on native species that have been transplanted outside their natural range, which can result in harm to SGCN, their habitats, or both.

The most serious effects of terrestrial invasive species, so far, have been felt on individual Aleutian Islands in the Southwest biogeographic region, where the establishment of exotic foxes, rats, livestock, and mice have wreaked havoc on some bird populations (ASG 2019, BPIF 2021). Efforts to eradicate these species have been successful on Hawadax Island, where rat eradication has resulted in recovery of terrestrial and marine birds (Croll et al. 2016; see "Invasive Species" in Chapter 8).

Aquatic habitats are especially vulnerable to threats from invasive species due to their rapid transport by flowing water or ocean currents (Gotthardt and Walton 2011). Marine colonial tunicates, including the didemnid tunicate *(Didemnum vexillum)*, are easily transported on vessel hulls, infested aquatic farm infrastructure, or in ballast water, and aquatic plant species such as *Elodea* are typically spread by floatplane or boat traffic. These organisms can spread rapidly, enabling them to outcompete native species, altering the habitat and reducing or concealing available fish or wildlife forage species (ADF&G 2024). *Elodea* can completely choke slow-moving river channels, slowing currents and increasing water temperatures. It can outcompete native aquatic plants and cover the entire bottom of shallow lakes, altering habitat structure. Additionally, it could pose a threat to several fish species and other aquatic organisms (DNR 2024b).

A number of invasive terrestrial plants can disrupt native plant communities by directly competing for resources, displacing native vegetation, and ultimately degrading natural habitats that Alaska wildlife depend on (DNR 2011). European bird cherry *(Prunus padus)* contains cyanogenic glycosides and has, in rare circumstances, resulted in cyanide poisoning of moose. European bird cherry also outcompetes native vegetation and supports fewer terrestrial insects, reducing prey availability for salmon (Roon et al. 2016). Other plants, such as Japanese knotweed *(Fallopia japonica)*, can outcompete willow and native grasses, which are food and habitat for wildlife. When introduced to estuarine habitats, cordgrasses (*Spartina* spp.) fill in mudflats important to bivalves, crabs, and fish species, transforming them into dense meadows (DNR 2025).

While Alaska's remoteness and challenging physical environment were once thought to prevent many potential invasive species from becoming established, the state's relatively low level of natural biodiversity actually increases the risk that an invasive species could cause the decline of a native species or destroy important habitats. Invasive species can negatively impact fish, wildlife, and their habitats through predation and competition for resources, and they can serve as potential vectors for novel animal and plant pathogens. Landscape-scale changes caused by climate change, including rising ocean temperatures, are increasing habitat suitability for many non-native species. This has been the case with the detection of invasive European green crabs *(Carcinus maenas)* in the Southeastern region in 2022 (Lutto 2022). The European green crab has depleted shellfish beds and affected aquaculture in other states and is capable of causing widespread and rapid damage to eelgrass beds, which are important to many marine species. Dreissenid (zebra and quagga) mussels are aquatic invasive species that are not currently present in Alaska but potentially will be within the

European green crab. E. Grason, NOAA, used with permission.

next decade. Dreissenid mussels are filter feeders that have had extreme impacts on food webs outside of Alaska (Miller and Watzin 2007), and resources to control their spread in Alaska are currently scarce.

Increases in human travel and development, particularly new roads and other transportation corridors, may facilitate the spread and establishment of invasive species in otherwise remote areas. Higher rates of interstate and international shipping traffic could result in accidental introductions of invasive species. Both the state and federal governments and nongovernmental organizations (NGOs) have engaged in public education efforts regarding the dangers of introducing non-native species.

Desirable native fish, furbearer, and game species such as northern pike and mink have been intentionally transplanted in Alaska, including to islands and waters outside their native range, and have thrived (Paul 2009, Sepulveda et al. 2013). Intentional transplants may have been done to augment an existing wildlife population, create economic, hunting, and angling opportunities, reduce human-wildlife conflicts, increase food security, or rebalance predator and prey levels (Paul 2009). For example, invasive northern pike illegally released in lakes of the Southcentral region have caused population declines of salmonids due to predation (Dunker et al. 2022). Managing invasive species through methods such as netting, trapping, or pesticides can also have bycatch and nontarget effects on some SGCN species; however, precautions are taken to minimize this bycatch during pike removal. Mink were transplanted to some islands in the early twentieth century for ranching, and these populations have had significant negative effects on breeding seabirds, such as Pigeon Guillemots in Prince William Sound (USFWS 2024). Successful removal of mink from the Naked Islands group in Prince William Sound by 2017 led to population rebounds by Pigeon Guillemots.

Problematic Native Species

Native species in terrestrial or aquatic environments can become harmful to other wildlife and their habitats when they become overabundant or spread beyond their natural ranges due to human activities (Salafsky et al. 2024). They can also become overabundant without human translocation and negatively affect other native wildlife and their habitats. For example, warmer temperatures and milder winters have led to an increase in the severity of spruce beetle *(Dendroctonus rufipennis)* outbreaks (Dell and Davis 2019), negatively impacting habitat quality and suitability for some forest-dwelling species but possibly benefitting wildlife species that prefer early successional habitats. As of 2024, at least 2.3 million acres of forest have been affected by spruce beetle outbreaks in the Southcentral region (Spruce Beetle in Alaska's Forests 2025). Due to the availability of artificial nest structures in the oilfields, Common Ravens have become more common in Alaska's Northern region, where they prey on tundra-nesting birds, their eggs, and their young (Backensto 2010).

Introduced Genetic Material

Unlike hatchery development practices used elsewhere in North America, Alaska has always prioritized conserving local salmon populations in the vicinity of hatcheries (Evenson et al. 2018). A few studies have indicated that hatchery salmon can effectively spawn with wild salmon in streams (McConnell et al. 2018, Shedd et al. 2022), which may decrease genetic diversity of wild populations (Jasper et al. 2013). A key research question is whether potential effects are transitory (short-term) or heritable (long-term).

Pathogens

Disease-causing microorganisms such as bacteria, viruses, fungi, and prions can cause injury and mortality of Alaska's fish and wildlife. Much of the research and surveillance conducted in Alaska has centered around pathogens found in fish and wildlife species that may pose a risk to human health. Additionally, in recent decades, several pathogens have been detected in wild bird, mammal, and marine invertebrate populations that have the potential to impact some species on a population level. Some emerging infectious diseases in wildlife are linked to climate change, and there is evidence that the spread and prevalence of some diseases is increasing (Van Hemert et al. 2014). Warming ocean waters and marine heat waves, such as the one that affected the North Pacific Ocean during 2014–2016, have facilitated the spread of diseases. For example, a Sea Star Wasting Syndrome pandemic began in 2013 and led to population crashes of several species of sea stars. This outbreak decimated most populations of the sunflower sea star in the southern portion of its range, while in Alaska, the largest portion of the species' range, declines were less severe, and there has been some evidence of recovery (Lowry et al. 2022).

Migratory bird and mammal species play an important role in the spread of diseases, and increased monitoring efforts are needed in Alaska (Van Hemert et al. 2014, Droghini et al. 2022). For example, Highly Pathogenic Avian Influenza (HPAI) has been detected in both domestic and wild bird populations as well as in some mammals in Alaska (ADF&G 2022). Waterfowl and raptors appear to be particularly susceptible to HPAI (ADF&G 2022); waterfowl and seabirds constitute the majority of reported cases in Alaska (APHIS 2024).

Avian keratin disorder, a recently described disease that may be caused by a novel picornavirus, has been detected in Alaska landbird populations, particularly Black-capped Chickadees and American Crows (BPIF 2021). The disease causes abnormal beak growth, which prevents infected birds from feeding and properly maintaining their feathers, often leading to death. Currently, the prevalence of this virus is low, and it is not having population-level impacts on Alaska's birds.

White-nose syndrome (WNS), a disease caused by the fungus *Pseudogymnoascus destructans*, has not yet been detected in Alaska. This disease has been decimating bat populations in eastern North America since at least 2006 and was first detected in a western state in 2016. WNS is highly contagious and lethal for bats that congregate in large numbers, as they do in the East and Midwest, where bats hibernate in caves and mines. It has resulted in the deaths of more than six million bats outside of Alaska, and mortality at individual caves and mines can be as high as 90–100% of the colony (Cheng et al. 2021). In Alaska, western little brown myotis hibernate in small groups in dispersed hibernacula on talus slopes rather than in large groups in caves and mines (Neubaum 2018, Blejwas et al. 2021). Their different hibernation strategy, habitat use, and greater genetic

Species of Conservation Need: Little Brown Bat *(Myotis lucifugus)*

Little brown bat. ADF&G.

The little brown bat is the most common and widespread bat species in Alaska and the only one found outside Southeast Alaska. Bats sleep during the day and hunt and feed at night, using echolocation to navigate and catch their prey. Little brown bats mate in the fall, but fertilization does not occur until the following spring, after the females emerge from hibernation. Females give birth to a single pup in June or July, clustering together in large, warm roosts to speed the growth and development of their young. Most known maternity roosts in Alaska are located in buildings, but such roosts have also been found in trees and even at hot springs in Southeast Alaska. Male bats and nonreproductive females usually roost singly or in small groups in various roost types, including snags, live trees, rock crevices, caves, logs, stumps, and buildings. The little brown bat hibernates for the winter, usually entering hibernation in September or October and emerging in April or May. Little brown bats east of the Rocky Mountains hibernate in caves and mines, where they often cluster in large groups. This has made them vulnerable to a deadly fungal disease called white-nose syndrome, which has killed millions of bats in the eastern and midwestern United States. In the western United States, little brown bats hibernate locally in small groups in the spaces between rocks on talus slopes or boulder fields, which has slowed the spread of the disease and resulted in much lower levels of mortality. White-nose syndrome has not been detected in Alaska, where bats are likely at lower risk of the disease than bats in the continental United States due to their use of dispersed hibernacula, among other variables.

structure suggest that western bats may not experience the same high levels of mortality as their eastern counterparts (Blejwas et al. 2023). Furthermore, based on the current rate of spread in Washington State, it could take decades for WNS to reach Alaska, although accidental translocation of infected bats remains a possibility.

Pollution

The quantity of human-caused pollution that enters Alaska's waters and air from in-state sources is low relative to the state's size and is typically associated with localized development (e.g., military bases, airports, oil and gas fields, mines, household sewage). Pollution (not limited to in-state sources) has been identified as a top conservation threat for some species groups, such as shorebirds (ASG 2019) and marine mammals, as well as sensitive marine ecosystems that directly and indirectly support large numbers of fish and wildlife.

Water-borne and Other Effluent Pollution

Household Sewage and Urban Wastewater

Excess nutrients, toxic substances (e.g., pharmaceuticals, heavy metals, and household chemicals), and sediments from waterborne sewage and nonpoint runoff can impact the health and survival of wildlife and alter wildlife habitats. Most wastewater in larger urban areas in Alaska is collected and

treated in sewage treatment plants before being discharged into rivers or directly into the ocean; however, sparsely populated and small villages in rural areas often lack this infrastructure. An estimated 3,300 houses in Alaska lack water and sewer service, most occurring in rural, underserved communities in the Western and Northern biogeographic regions. In addition, approximately 4,500 rural homes are connected to community-wide piped systems that have surpassed or are nearing the end of their design life (ADEC 2023).

Household sewage and the unregulated dumping of effluent from large cruise ships can be detrimental to nearshore ecosystems such as eelgrass beds; high nutrient input from waste streams can result in excess growth of algae and other epiphytes on eelgrass blades, blocking light and interfering with photosynthesis. 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.

Pollution from roads is also part of the urban wastewater stream and may impact fish and wildlife at a local scale. Salt brine (a solution composed of sodium chloride and water) is frequently used in urban areas in Alaska to prevent and remove ice on roadways (DOT&PF 2014). Bird mortalities associated with salted roads may be more widespread and frequent than indicated by documented reports alone (Mineau and Brownlee 2005). Applying calcium chloride to unpaved roads for dust control has been shown to alter soil chemistry and, subsequently, plant health (Stehn and Roland 2018). Runoff from calcium chloride application, as well as other contaminants such as road salt, tire residue, and vehicle fluids, is toxic to fish (Barnes and Conner 2014) and wood frog larvae (Harless 2012) and may have other direct and indirect effects on aquatic invertebrate and fish species. When sedimentation and water quality in nearshore marine environments are altered due to runoff or other pollution sources, overgrowth of native epibenthic algae can be a problem (Hughes et al. 2004).

Industrial and Military Effluents

Contaminated sites are present at discrete locations across Alaska, and hazardous materials that have been released into the environment include oil, fertilizers, heavy metals, polychlorinated biphenyls (PCBs), and polyfluoroalkyl substances (PFAS), as well as short-lived climate pollutants such as black carbon and methane. During 2015–2024, the Alaska Department of Environmental Conservation recorded 645 spills of at least 500 gallons, the majority of which originated from oil production, mining operations, military installations, and vessels (ADEC 2024). Of these, most spills occurred in the Northern, Central, and Western biogeographic regions. The Department of Defense has over 500 Formerly Used Defense Sites (FUDS) in Alaska (USACE 2024) and seven active Superfund sites (EPA 2024), all of which are polluted with a variety of toxic contaminants. There are nine active military installations in the state, portions of which are contaminated by used munitions and other toxic materials. Alaska currently has a limited manufacturing industry (i.e., 4% of state gross domestic product [GDP]), but there are ongoing efforts to expand this sector. Alaska's seafood processing industry, with over 166 shore-based plants, 49 catcher-processor vessels, and 10 large floating processors, accounts for 70% of Alaska's manufacturing employment (ARC 2021). Additionally, Alaska has several oil refineries and one fertilizer plant (not currently operating).

Spills and releases of oil, gas, produced water, and other contaminants can destroy habitat, contaminate groundwater aquifers and surface water, and introduce dissolved metals and

Species of Conservation Need: Spectacled Eider *(Somateria fischeri)*

Male Spectacled Eiders. T. Bowman, USFWS.

The Spectacled Eider is a large sea duck with distinctive plumage—both males and females have eye patches resembling spectacles. It is an Arctic and subarctic species found only in Alaska and Russia. In Alaska, Spectacled Eiders breed in marshy tundra, most commonly in the Yukon-Kuskokwim Delta and along the Beaufort Sea coast. The entire population has been known to winter south of St. Lawrence Island in the Bering Sea. They are currently listed as threatened under the Endangered Species Act—in 1993, researchers found a 96% decline in the breeding population along Alaska's western coast. Lead poisoning from ingestion of lead shotgun pellets was considered an important threat, but lead shotgun pellets are now banned for waterfowl hunting by ADF&G regulations. Decreased winter sea ice cover in the Bering Sea due to climate change is likely to affect populations of these eiders over the next two decades. ADF&G and partners are conducting research to understand the effects of the changing climate on this SGCN. Spectacled Eiders feed primarily on invertebrates; during the breeding season, they feed on plentiful insect life and larvae, and in the winter, they will dive up to 250 feet underwater to feed on marine invertebrates such as clams, snails, and crustaceans.

radio-active elements to surface waters. Effects from small spills are generally limited to direct damage to local fish and wildlife populations and their habitats. PFAS, known as "forever chemicals," do not naturally degrade in the environment but must be incinerated at very high temperatures to remove them from soils and other substrates (Verma et al. 2023). Live fire exercises for military purposes, as well as fire and airport trainings, are of concern because they use Aqueous Film Forming Foam (AFFF), a substance containing PFAS, to put out fires.

Oil spills in or near marine or freshwater habitats, especially in flowing water, can spread more easily and have an increased impact because spilled oil is much more difficult to control and recover in these environments. Such spills can have much broader impacts on wildlife, particularly invertebrates (Miller et al. 1986), fish (Moles et al. 1979), and other aquatic species that depend on the impacted system. Of particular concern is the potential for spills in remote areas where oil is difficult to contain and remove, such as Arctic waters with sea ice and locations critical to large numbers of marine animals.

The risk of a large marine oil spill has been reduced to some extent by the use of double-hulled tankers and real-time monitoring of cargo and other vessels; however, even small marine oil spills can cause mortality of seabirds, shorebirds, marine mammals, fish, and marine invertebrates. Depending on the size of the spill (Peterson 2001) and the location, mortality can be widespread and can potentially have population-level effects on fish and wildlife. An oil spill affecting important coastal and nearshore areas, such as Izembek Lagoon, the Copper River Delta, or Ledyard Bay, could expose millions of birds and marine mammals, fish, and other aquatic species to harm. In addition

to the immediate effects of oil spills on wildlife, long-term oil exposure has been shown to decrease reproductive success in seabirds for up to 10 years after a spill event (Barros et al. 2014).

The potential failure of containment dams holding tailings and effluents from mineral processing could expose a large downstream area to toxic pollutants, resulting in direct mortality of fish and other aquatic organisms; contamination of wildlife that depend on aquatic organisms for food; and alteration of habitat through toxin exposure, sedimentation, and channel modification. In January 2024, a pipeline leak at a mine near Juneau spilled over 105,000 gallons of tailings slurry containing sediments and elevated concentrations of heavy metals into a nearby creek and marine waters (Canny 2024). Disposal of water used in leaching or other ore reduction operations generally requires treatment, which requires impoundment facilities. These facilities can alter habitats and negatively affect fish and wildlife on a local scale. Wet impoundments may also leak or fail over time, sometimes resulting in catastrophic failure, which can impact fish and wildlife (Davies 2002).

Oiled birds from the Exxon Valdez oil spill in Prince William Sound. NOAA, used with permission.

Acid mine drainage has long been recognized as detrimental to wildlife (Hoffert 1947, Higman et al. 2019). Mineral extraction often results in the exposure of metal sulfides to oxygen and water, leading to the formation of sulfuric acid, which can leach metals from rocks that come in contact with the acid. This runoff can be toxic to aquatic organisms (Koryak et al. 1972; Jennings et al. 2008) in both freshwater and marine environments (Grout and Levings 2001). These threats can be a significant concern, given the persistence of such runoff over time and the difficult, often prohibitive mitigation costs. Unremediated, abandoned mine sites can continue to have localized negative effects on fish and wildlife decades after mine operations have ceased. For example, ongoing acid mine drainage into the Taku River in Southeast Alaska continues to be a risk to the river's important fish and wildlife populations, despite a nearby mine being closed since 1957.

Agricultural and Forestry Effluents

Because there is so little agricultural land in the state, there is very little risk that agricultural effluents would cause any population-level effects on wildlife. Discharges from the forest products industry in the state currently include increases in natural runoff from clearcutting and sedimentation due to landslides. Sedimentation from road building and logging-related operations is monitored and regulated by the Alaska Department of Natural Resources and by the Department of Environmental Conservation under the Alaska Forest Resources Protection Act (FRPA; AS 41.17). There are no longer any pulp mills operating in the state. Herbicide use for right-of-way maintenance has the potential to impact both terrestrial and aquatic habitats through runoff; this is most likely to be problematic in urban areas of Alaska. Pesticides used in mariculture operations have the potential

This Laysan Albatross chick died from ingesting plastic garbage picked up while foraging. Claire Fackler, NOAA, used with permission.

for localized impacts to nearshore and intertidal habitats such as eelgrass beds and salt marshes.

Garbage and Solid Waste

Unsecured garbage in developed areas is an attractant to wildlife, such as bears (Peirce and Van Daele 2006). Garbage can provide a nutritional subsidy to avian and mammalian predators, potentially skewing the population balance among some species (Weiser 2010, Ripple et al. 2014).

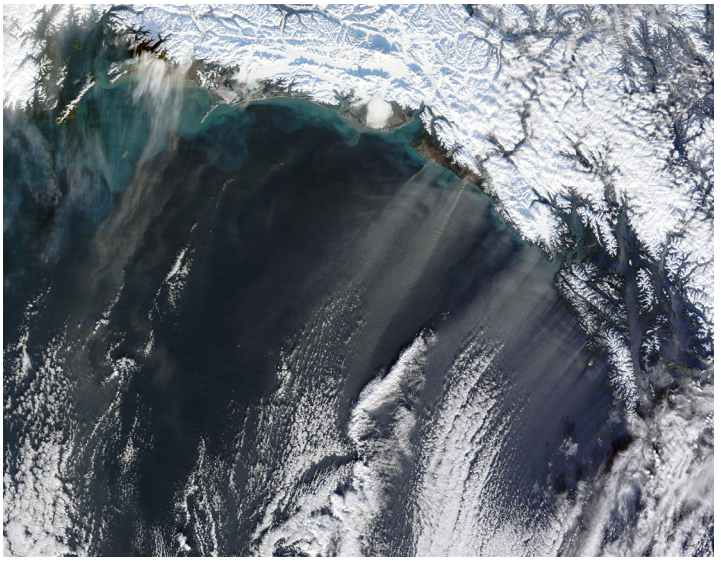
Plastic waste pollution primarily threatens developed terrestrial areas and the marine environment, though the magnitude of impacts on individual fish and wildlife species is unclear. Worldwide, improperly disposed of plastic waste affects all terrestrial, freshwater, and marine habitats and has been implicated as a driver of biodiversity loss and ecosystem degradation (IUCN 2024). The majority of plastic waste consists of macroplastics, much of which is from single-use containers. Discarded fishing gear is particularly problematic in marine environments and can result in entanglements and ingestion, with associated harmful effects on seabirds and marine mammals (Manville 1990; Raum-Suryan et al. 2009). Microplastics and nanoplastics, as well as synthetic textile fibers, can enter living organisms and, in the case of nanoplastics, cross cell walls (IUCN 2024). Microplastics have been found in the blubber of many marine mammal species, including a subsistence-harvested bearded seal from Alaska, suggesting translocation throughout the body (Merrill et al. 2023). Ongoing studies (unpublished) are finding microplastics in other marine mammal tissues (i.e., muscle, liver, kidney, placenta) and in amniotic fluid and fetal tissue.

Alaska lacks adequate facilities and infrastructure to manage plastic waste. The most noticeable impact of plastic waste on wildlife is mortality from ingestion, entanglement, or suffocation; however, floating plastics can also be a transport mechanism for invasive species. In addition, contaminants may leach from plastics or be deposited from airborne sources into surrounding habitats, where they may affect soil processes and plant production (IUCN 2024).

Airborne Pollutants

The Alaska Department of Environmental Conservation regulates airborne pollutants under the federal Clean Air Act. Airborne pollutants from point and nonpoint sources, such as vehicle emissions, wood smoke, and industrial development emissions, may impact the health and survival of Alaska wildlife. Air pollution from vehicle exhaust, electricity generation, and the heating of buildings (e.g., wood, coal, natural gas, and heating oil) is more common around urban population centers in the Southcentral and Central biogeographic regions. Due to prevailing wind patterns and ocean currents, the Northern biogeographic region and other parts of the global Arctic act as a sink for airborne pollutants from distant sources, which degrade very slowly in cold temperatures. Heavy metals (e.g.,

mercury) and persistent organic pollutants (e.g., PCBs) can bioaccumulate, as observed in Alaska birds (Evers et al. 2014, Kaler et al. 2014, Perkins et al. 2016), whales (Hoguet et al. 2013), and fish (Kenney et al. 2014).



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

Energy Emissions

Artificial light has been shown to alter the behavior and movement of wildlife in terrestrial, freshwater, and marine environments and can ultimately impact an animal's productivity, movement, and survival (Rich and Longcore 2006). Behavioral changes in aquatic invertebrates can alter their population dynamics and ultimately cause changes to an ecosystem's structure and function, affecting wildlife at higher trophic levels (Ganguly and Candolin 2023). Artificial light can cause collisions with human structures such as residential and commercial buildings, communication towers, wind turbines, fishing vessels, offshore oil rigs, and others (Day et al. 2015, Cabrera-Cruz et al. 2018). Emission of artificial light is generally restricted to developed areas and transportation corridors and therefore is not expected to have population level impacts on SGCN.

Noise pollution from traffic, industrial and urban sources, seismic exploration, SONAR use, and human recreation can make it difficult for wildlife to communicate, forage, mate, and avoid predators. It may also deflect and deter wildlife from using particular areas (Shannon et al. 2016). Sound transmission decreases with distance, and the effects of loud, stationary sources are typically confined to developed areas and transportation corridors. However, in-water noise is typically transmitted over much longer distances, resulting in a larger disturbance area than terrestrial sources of noise. Seismic airguns used in oil and gas exploration emit high-energy, low-frequency bursts of sound that can travel long distances, disrupt marine mammal behaviors, and, at close range, cause physical injury (MMC 2021). Changes to the acoustic landscape in marine environments can impact foraging success and cause mortalities of marine mammals (Bejder et al. 2006, Blair et al. 2016). For example, in Cook Inlet, one study found that daily anthropogenic noise sources may be masking beluga whale communication and hearing (Castellote et al. 2018).

Natural Disasters

Geologic Events

Threats to wildlife populations in Alaska from geologic events, including volcanoes, earthquakes, tsunamis, avalanches, and landslides, are unpredictable and have the potential to significantly alter fish and wildlife habitats. The state is located in the most tectonically active region of the country, with a significant portion of its coastline located at the intersection of two major tectonic plates.

Volcanoes

A major volcanic eruption would likely cause some direct loss of wildlife and habitat in the immediate area of the volcano, but widespread ash fall is the most common volcanic hazard (USGS 2000). Volcanic ash can harm wildlife health, causing direct mortality from inhalation, increased sedimentation, radical change of the pH of waterbodies, and the death of vegetation that wildlife depend on. These effects can last for months to years or more.

Mount Redoubt. ADF&G.

Earthquakes and Tsunamis

Earthquakes and associated tsunamis can cause widespread damage to coastal, marine, and inland habitats, as well as habitat loss or alteration from uplift or subsidence. Breaches of industrial facilities, such as pipelines, mining ponds, holding facilities, or similar infrastructure, could also threaten wildlife and habitats by discharging toxic substances. Shallow, nearshore marine habitats are extremely productive and are important for seabirds, juvenile fish, and shellfish. Catastrophic damage from earthquakes and tsunamis could impact wildlife on a regional population level.

Avalanches and Landslides

In recent decades, there have been an increasing number of landslides, avalanches, and coastal tsunamis in Alaska due to warming temperatures, thawing permafrost, glacial retreat, and high levels of precipitation. Many recent events have occurred in the Southeast biogeographic region, including Icy and Glacier bays, Haines, Sitka, Juneau, Wrangell, and Ketchikan. Landslides are becoming more frequent in Alaska's other biogeographic regions as well. In addition to human and economic costs, debris flows may cause localized mortality and habitat loss for wildlife in the area.

Climate Change

Climate change is a potential threat to fish and wildlife in Alaska at regional and statewide scales. Adequate planning for the future of fish and wildlife management in Alaska will require consideration of future changes in climate and resulting impacts on species and habitats. As this plan guides Alaska conservation efforts over the next decade, this section focuses on climatic changes occurring presently and predicted changes within the next two decades. Robust monitoring will be essential during this time period to identify which species are likely to be resilient to climate change and which will require additional management to support their resilience.

Owing to the high connectivity of habitats, wildlife in Alaska may be more resilient to climate change than wildlife in other parts of the United States where habitat fragmentation by human activities is more extensive (Vynne et al. 2021). For example, wildlife in Alaska may be able to more easily move to higher elevations or latitudes (e.g., Tape et al. 2016, 2018, Mizel et al. 2016) as their habitats change

because there are fewer anthropogenic barriers to dispersal. Climate-related shifts in distribution or abundance may have ecosystem-wide effects, especially as new species immigrate or emigrate. Wildlife managers, therefore, need to adapt management strategies to account for the effects of a changing climate, combining past experience and knowledge with new information to assess or modify management strategies. While climate change may have neutral or even positive effects on some species, this section focuses on SGCN that are currently—or are projected to be—negatively impacted, since supporting resilience of these species will avoid the need to list additional species under the ESA.

Alaska Wildlife and Fish in a Changing Climate

Climate dynamics strongly affect terrestrial, aquatic, coastal, and marine species and environments in Alaska (Markon et al. 2018, Huntington et al. 2023). Climate can directly impact wildlife by influencing species' ranges, seasonal timing (phenology), or productivity. Complex or indirect effects of climate on wildlife and fish include habitat changes, disturbances (such as fire, wind, or insect outbreaks), and influences on competition, predator-prey interactions, community structure, and food webs. As a result, changes in climate are expected to affect fish and wildlife species in complex ways.

Wood frog. NPS, used with permission.

Changes in global and regional climate, such as increasing temperature and altered precipitation patterns, can trigger a series of processes that may ultimately affect wildlife and fish in both positive and negative ways. In northern systems, changes in temperature and precipitation interact to affect characteristic patterns of snowpack, permafrost, glaciers, and sea ice (Figure 7.1). For example, throughout much of the Southwest, Southcentral, and Southeast biogeographic regions, cold season temperatures typically hover around freezing. As a result, small temperature changes can have large effects on snow accumulation and melting, even if the amount of precipitation does not change. In these places, hydrologic and habitat changes that are important to fish and wildlife species can thus be disproportionate to air temperature changes.

Current Climate Trends

Temperature and Precipitation

Alaska's climate is characterized in part by its inherent variability, both in terms of expected conditions across the large geographic span of the state and the interannual and interdecadal variability stemming from the region's position in Arctic and North Pacific climates. Climate change in Alaska is driven by global trends, but Alaska is warming at two to three times the global average (Markon et al. 2018, Ballinger et al. 2023), and the Arctic is warming at four times the global average (Rantanen et al. 2022). Annual average temperatures since 1971 have increased by approximately 2.4°F in the Southeast biogeographic region to approximately 6.2°F in the Northern biogeographic region (Ballinger et al. 2023).

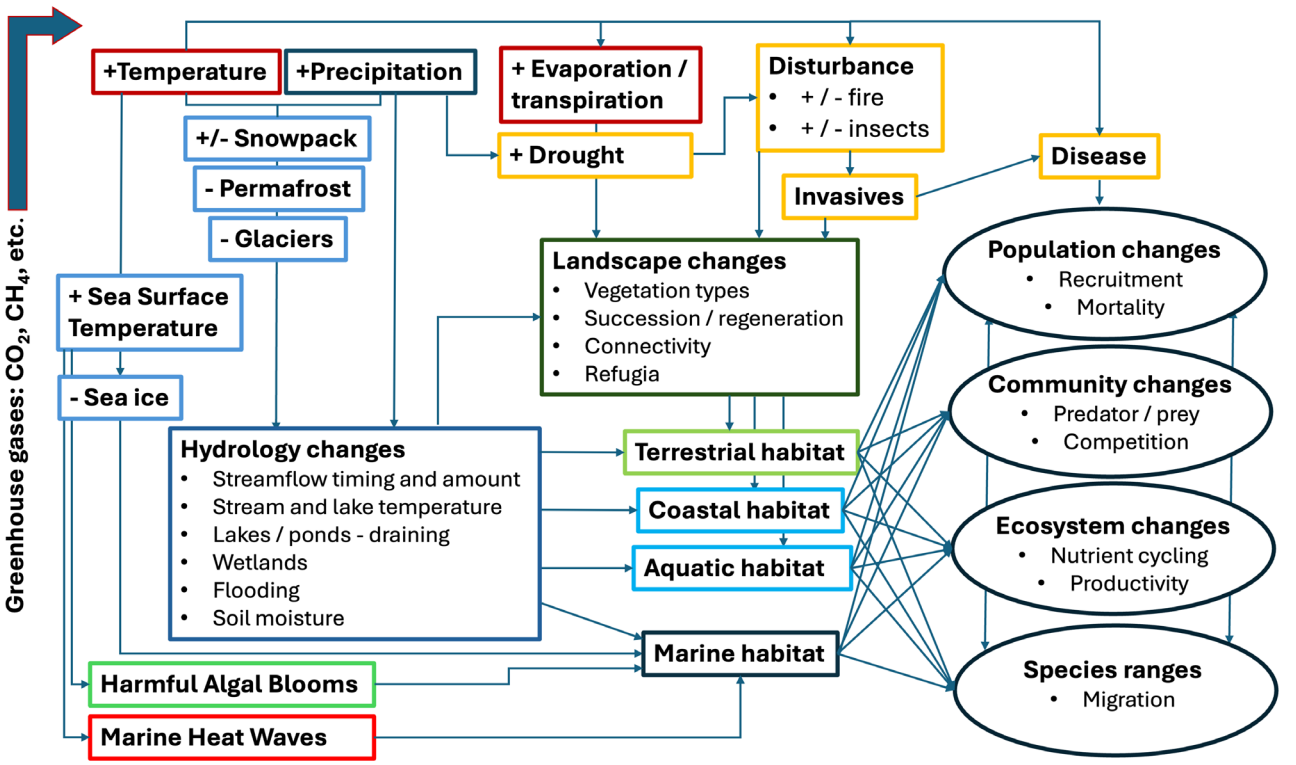


Figure 7.1. Climate change effects on processes that influence species, habitats, populations, communities, and ecosystems in boreal and Arctic systems. Climate changes and variability interact in complex ways with these systems, affecting species of concern and their habitats.

Heat waves are also increasing in the Arctic (Dobricic et al. 2020). A 2019 summer heatwave brought record-high temperatures to the Southcentral biogeographic region (Bhatt et al. 2021). Daily high temperatures exceeded normal temperatures by more than 20°F, resulting in uncharacteristically severe disturbances, such as the Swan Lake Fire on the Kenai Peninsula (Jandt and York 2021) and fish kills from thermal stress in multiple areas of the state including Norton Sound, Yukon River, Kuskokwim River, Bristol Bay, Matanuska-Susitna area, Cook Inlet, and Prince William Sound (von Biela et al. 2022).

Precipitation in Alaska has generally been increasing since the late 1950s, but trends vary by region, observation source, season, and statistical method. The largest precipitation trend is on the North Slope, with increases in annual average precipitation of 2.5% to 3.5% per decade since the 1950s (Ballinger et al. 2023). Recent unprecedented extreme rainfall and seasonal precipitation events have presented challenges in multiple parts of Alaska. For example, an atmospheric river (an atmospheric flow that causes extreme precipitation) in December 2020 broke all-time extreme 24-hour precipitation records (Lader et al. 2022) in 11 Southeast Alaska locations (National Weather Service Juneau 2021).

Snow, Permafrost, Sea Ice, and Glaciers

Temperature increases are driving a shortened period of snow cover during the winter season, resulting in melting glaciers, thawing permafrost, and less predictable sea ice extent (Meredith et al. 2022, Ballinger et al. 2023). Snowfall has also decreased in 12 of 13 Alaska climate divisions in both spring and autumn (Ballinger et al. 2023). Midwinter snowfall has increased except in the

central and southern panhandle of Southeast Alaska, particularly in the Southcentral and Central biogeographic regions (Ballinger et al. 2023). In recent years, uncharacteristic rain-on-snow events across the Arctic have been observed, negatively impacting forage and habitat availability for mammals and resident birds (Serreze et al. 2021). Permafrost thaw is increasing and is associated with thermokarst (ground slumps or cave-ins), lake drainage, and surface pooling, depending on the ice content of the ground and continuity of permafrost (Lara et al. 2016, Nitze et al. 2020, Chen et al. 2021, Lara et al. 2021, Lindgren et al. 2021). Depending on local topography, these effects also contribute to accelerating erosion of river and coastal systems, changing sediment patterns, and destabilizing ground. Collectively, these changes are projected to affect wildlife habitats and hydrology in the Arctic (Jones et al. 2022).

Even though sea ice can be highly variable from year to year, the overall sea ice season is becoming shorter in the Bering, Chukchi, and Beaufort seas. Also, sea ice structure is less predictable when there are novel extremes (Stabeno and Bell 2019). In March, historically the month of maximum sea ice extent, the Bering Sea ice extent has decreased by about 20,000 square miles per decade since 1957 (Meredith et al. 2022), and record minimums in 2018 and 2019 were associated with warm ocean temperatures (Thoman et al. 2020). For September, historically the month of minimum sea ice extent, the Chukchi and Beaufort ice extents have decreased by about 27,000 square miles per decade and 31,000 square miles per decade, respectively (Meredith et al. 2022).

The majority of glaciers across Alaska are retreating and thinning rapidly, which is having complex effects on rivers and coastal systems (O'Neel et al. 2015). Increased glacial contributions to streamflow and coastal systems have the potential to alter nearshore food webs, which would affect coastal fish and wildlife species (Arimitsu et al. 2016). Glacial retreat is also creating notable new salmon habitat in the Southcentral and Southeast biogeographic regions (Pitman et al. 2021).

Species of Conservation Need: Harbor Porpoise *(Phocoena phocoena)*

Harbor porpoise, NOAA Fisheries/Northeast Fisheries Science Center, used with permission.

The harbor porpoise is a small, elusive cetacean distributed throughout coastal and offshore waters of the Northern Hemisphere. It is the second smallest cetacean species, with adults averaging five feet long and weighing between 130 and 170 pounds. Described as "living in the fast lane," harbor porpoises reach sexual maturation early (females at three years and males at three to four years) and give birth every one to two years. Harbor porpoises can live up to 24 years, with a mean lifespan of 12 years. Despite their long-distance dispersal capabilities, harbor porpoises seldom make long-distance movements and are typically observed in shallow waters less than 100 meters deep and within 10 kilometers of shore. One of the main potential threats to harbor porpoise populations is entanglement in fishing gear. The National Marine Fisheries Service has recently raised conservation concerns and taken management actions for harbor porpoises in Southeast Alaska based on inadequate information. To understand if there is a true conservation concern and need for those management changes, ADF&G has begun multiple extensive studies of harbor porpoise in Southeast Alaska.

Hydrology

The changes in temperature, precipitation, and snowpack described above affect the timing and magnitude of streamflow. Across most of Alaska, the duration of the snow cover season has decreased due to earlier melt and runoff. For river systems where seasonal streamflow patterns were historically dominated by snowmelt, warming since the 1970s is driving a shift from snow-dominated hydrology toward transitional (mix of rain and snow) hydrology or even rain-dominated hydrology (Littell et al. 2018). These changes in the timing of peak streamflow and the role of snow versus rain affect individual streams and rivers in different ways. In river systems where glacial melt subsidizes summer streamflow, the effects of climate change on streamflow and temperature may be buffered in comparison to nonglacial systems, or it can result in increased streamflow. Streamflow changes can impact stream temperatures that affect salmon growth, migration, and spawning (Shaftel et al. 2020). For example, high summer air temperatures can increase glacial melt, increase summer stream flows, and decrease stream temperatures in glacial systems. By contrast, elevated air temperatures can increase stream temperatures in nonglacial streams, sometimes to lethal levels (von Biela et al. 2022), affecting anadromous fish migration.

Marine Systems

In recent decades, Alaska marine ecosystems have experienced several substantial changes including rapid ocean warming, (Huntington et al. 2020, Stabeno and Bell 2019, Thoman et al. 2020, Walsh et al. 2018), the highest global rates of ocean acidification (Qi et al. 2017), and an increasing frequency (Carvalho et al. 2021) of extreme climate events such as Marine Heat Waves (Bond et al. 2015, Walsh et al. 2018). These physical changes have caused large perturbations to the marine system such as reduced productivity, shifting seasonal timing of productivity, altered food web dynamics, and steep declines in prey availability for some species (Hunt et al. 2020, Siddon et al. 2021).

Ocean acidification describes decreases in marine pH and carbonate ion concentrations and occurs due to oceanic uptake of anthropogenic carbon dioxide (CO_2) in the atmosphere (Mathis et al. 2015, Hauri et al. 2021). Although ocean acidification is a global phenomenon, ocean water in Alaska is more susceptible to the acidification effects of increased atmospheric CO_2 because of its colder temperatures (Steinacher et al. 2009). Some of the most abundant and productive species of marine plankton, shellfish, and other benthic arthropods in the marine waters of Alaska form shells using carbonate minerals, and ocean acidification has already reached threshold levels that negatively affect the development of these organisms (Mathis et al. 2011, Fabry et al. 2008). This group of animals is often a critical component of the marine trophic systems that produce much of the forage relied on by seabirds, marine mammals, and many species of commercially harvested fish (Fabry et al. 2009). More recently, modeling efforts predict that under certain climate scenarios, the months in which ocean acidification events occur are expected to increase (Pilcher et al. 2022).

Ocean acidification is predicted to have negative impacts on many aspects of marine ecosystems and the people that rely on them for economic, subsistence, cultural, personal, and recreational uses. A risk assessment for Alaska's commercial and subsistence fisheries found that southeastern and southwestern Alaska communities faced the highest risk from ocean acidification (Mathis et al. 2015). These locations rely most highly on fisheries harvests and co-occur in regions where increased ocean acidification is expected to occur (Mathis et al. 2015). Another study that used hindcast simulations found that local wind stress influenced upwelling in areas of the Gulf of Alaska

As ice cover declines in the Arctic, the darker water absorbs more heat from the sun and accelerates ice melting. C. Michel, used with permission.

and caused extreme acidification events (Hauri et al. 2021). After these extreme ocean acidification events, the Gulf of Alaska then experienced the unprecedented marine heatwave in 2014–2016 known as "the Blob," which is the largest and longest global marine heat wave to date (Hauri et al. 2021). Other areas of Alaska waters are also expected to experience ocean acidification events and continued warming. An analysis in the Bering Sea found that the southeastern Bering Sea shelf and outer shelf regions were projected to experience the greatest increases in ocean acidification (Pilcher et al. 2022). Ocean acidification events and marine heatwaves affect important components of the current marine ecosystem, and these events may continue to increase in frequency.

Many arctic seabird and marine mammal species are likely to be negatively impacted by climate change and require conservation and management to support their resilience. Ocean warming and record-low sea ice in the Chukchi Sea have impacted the food web (Huntington et al. 2020, Romano et al. 2020). An observed shift from large-bodied, lipid-rich arctic zooplankton species to small-bodied, lipid-poor subarctic species (Mordy et al. 2022, Ershova et al. 2017) corresponds with the reduced energy content of zooplanktivorous fish such as Arctic cod, saffron cod, sandlance, and capelin (Copeman et al. 2022). Subsequently, seabirds and marine mammals preying on these fish may have a nutritionally poor diet, which could result in reproductive failures and mortality. Indeed, emaciated seabird carcasses were found on beaches during mortality events in the Bering and Chukchi Seas (Romano et al. 2020), with evidence suggesting starvation was the underlying cause. Similarly, Renner et al. (2024) attributed the mortality of half of Alaska's Common Murre population (four million birds) to the 2014–2016 marine heatwave, demonstrating persistent effects of climate change on top predators in these systems.

Marine mammal and seabird health may become increasingly affected by toxic harmful algal blooms (HABs) in Alaska (Hendrix et al. 2021; Lefebvre et al. 2016; Van Hemert et al. 2021, 2020). HABs produce the neurotoxins saxitoxin and domoic acid, both of which can result in illness and mortality among wildlife. The largest bed of resting cysts of HAB species in the world has been discovered in the Chukchi Sea (Anderson et al. 2021). Warming ocean temperatures and loss of sea ice may mean these cysts will hatch into recurring toxic algal blooms (Anderson et al. 2021).

Current and Projected Impacts of Climate Changes on Wildlife

Habitat Changes

Recent changes in the physical environment have been attributed to climate change (Figure 7.2), which can impact fish and wildlife species in positive or negative ways (Figure 7.3). Ongoing warming is associated with rapid changes in vegetation; depending on each species' habitat preferences, vegetation changes may increase or decrease habitat availability for fish and wildlife (Marcot et al. 2015). Unusually high midsummer tundra productivity (greening) has been observed on the North Slope of Alaska, but lower productivity (browning) has continued in the Southwest biogeographic region (Frost et al. 2021a, b). Shrub expansion in arctic tundra has been widely observed in these greening areas, partly due to temperature increases. As a result, moose and beaver are colonizing previously inhospitable Arctic areas (Tape et al. 2016, 2018). Lapland Longspur prefer sedge-dominated tussock tundra for nesting and could plausibly lose habitat as shrubs invade, while White-crowned Sparrows could gain habitat (Boelman et al. 2015). Shrub expansion is also occurring at higher elevations than in previous decades. In a long-term study in Denali National Park, passerine species shifted to higher elevations in response to advancing treeline (Mizel et al. 2016). Herbivores

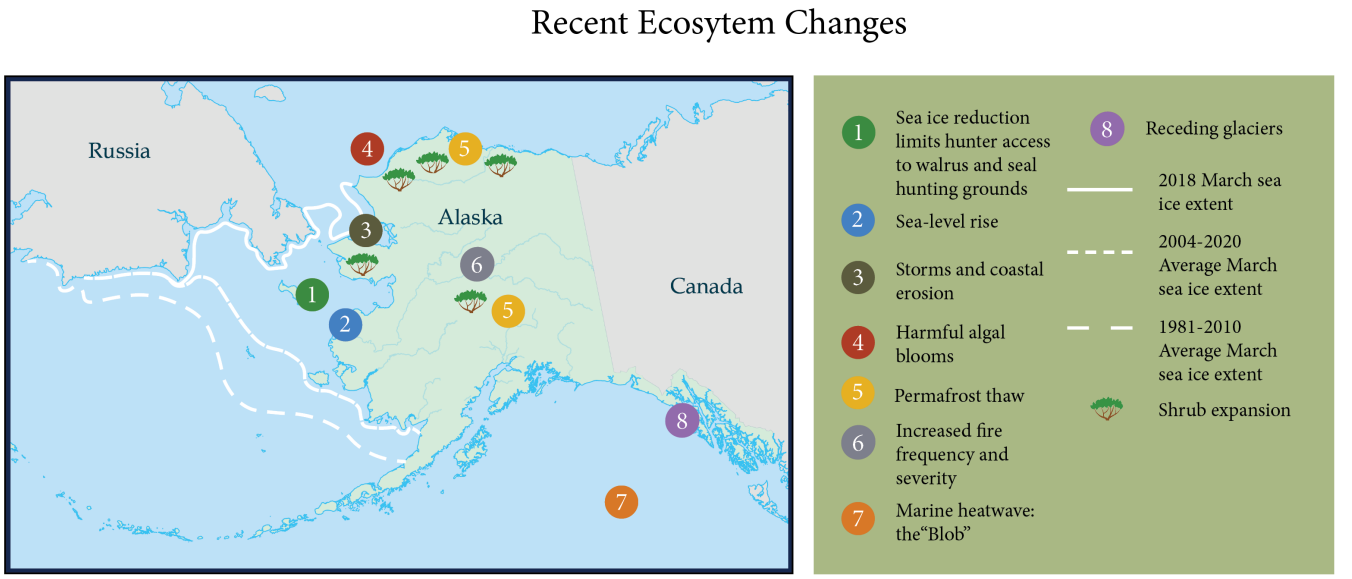


Figure 7.2. Recent observed changes in the physical environment related to climate change. A wide range of climate-driven changes to Alaska's ecosystems have implications for the species that depend on them. Data sources: 1. Larsen Tempel et al. 2021; 2. Arendt et al. 2022; 3. Kettle et al. 2020, Overeem et al. 2011; 4. Osborne et al. 2018, Gobler et al. 2017, Anderson et al. 2022; 5. Smith et al. 2010, Jorgenson et al. 2020; 6. Kasischke and Turetsky 2006; 7. Gobler et al. 2017, Quan et al. 2018; 8. Arendt et al. 2021; Sea ice extent: Historical Sea Ice Atlas for Alaska and the Arctic, 1850–2022; Shrub expansion: Mekonnen et al. 2021.

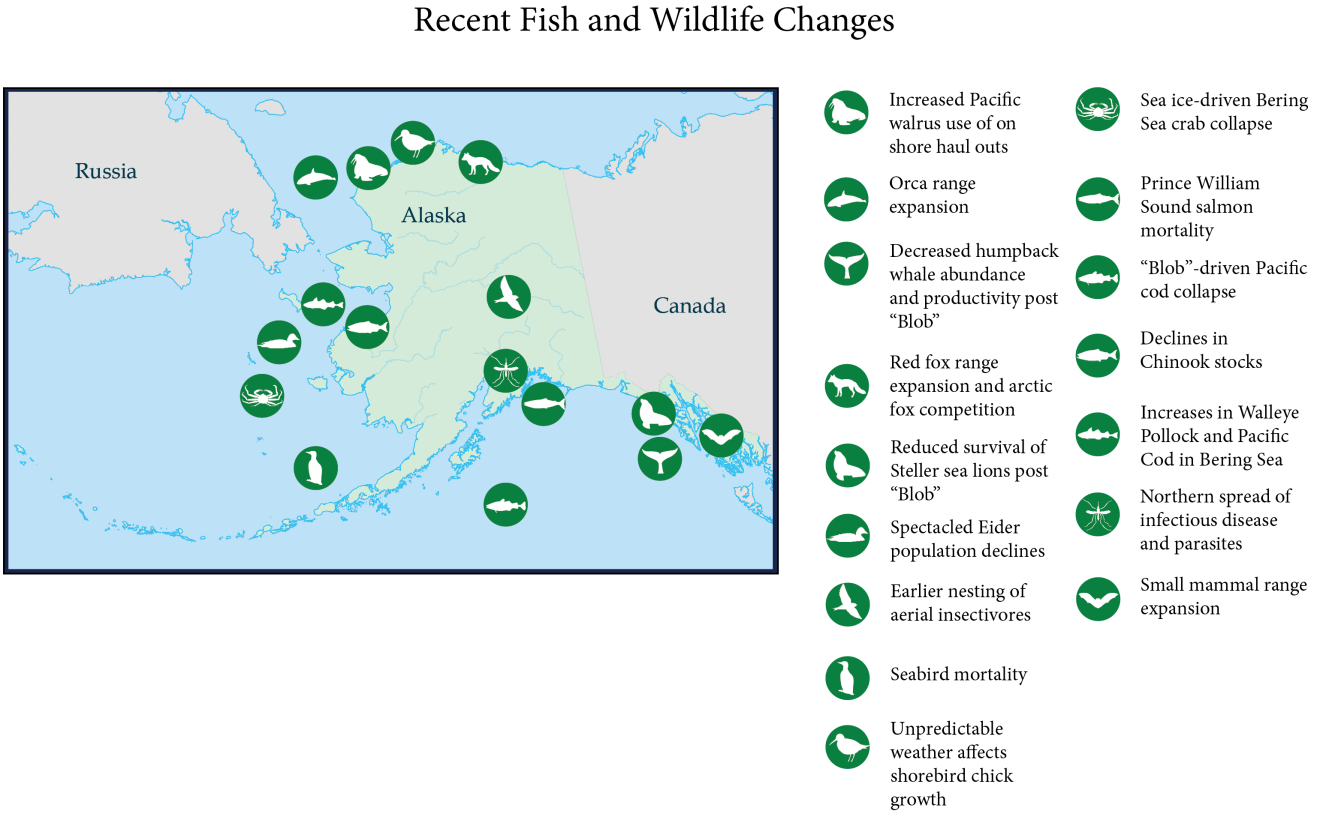


Figure 7.3. Recent observed changes in fish and wildlife species related to climate change. Fish and wildlife species are experiencing a wide range of impacts related to climate change. Data sources: Walrus, Fishbach et al. 2022; Orca, Stafford et al. 2019; Humpback whale, Gabriele et al. 2022; Red fox, Elmhagen et al. 2017; Steller sea lion, Hastings et al. 2023a,b, Maniscalco 2023; Spectacled Eider, Dunham et al. 2021; Aerial insectivores, Irons et al. 2017; Seabirds, Jones et al. 2019, Piatt et al. 2020, Van Hemert et al. 2021; Shorebirds, Saalfeld et al. 2019; Bering Sea crab, Szuwalski et al. 2023; Salmon, von Biela et al. 2022; Pacific cod, Laurel et al. 2020; Chinook, Eiler et al. 2014; Walleye Pollock and Pacific Cod, Larsen Tempel et al. 2021; Small mammals, Baltensperger et al. 2024.

have the capacity to moderate the rate of shrub expansion in tundra environments, at least on a local scale (Olofsson et al. 2009, Ravolainen et al. 2014), but the degree to which this phenomenon may forestall landscape-level changes is unknown.

Increases in temperature and evapotranspiration are projected to increase the area burned by wildfire, despite increased precipitation (McGuire et al. 2018). Tundra fires are increasing in frequency (Hu et al. 2015), and boreal forest fires are increasing in frequency and the amount of biomass burned (Kasischke and Turetsky 2006, Kelly et al. 2013). Projected fire-driven transitions from conifer- to deciduous-dominated boreal forest (Mann et al. 2012) already appear to be occurring at a regional scale. Wildfires in 2015 (Central biogeographic region; Partain et al. 2016), 2019 (Southcentral biogeographic region; Bhatt et al. 2021), and 2022 (Southwest biogeographic region; Thoman 2022) burned large areas with atypical severity or occurred in places where fire was previously rare (Jandt and York, 2021). Alaska has experienced an increase in overwintering or "zombie" fires, which occur when uncharacteristically severe burning during hot, dry summers results in burning during the following fire season (Jandt and York 2021).

Temperature increases, combined with changes in precipitation, glacial melt, snowmelt, and runoff, can change streamflow timing and affect stream and lake temperatures. These changes are complex and may be positive or negative for anadromous and resident fishes, depending on the circumstances. Continued monitoring is essential for determining whether management actions are necessary to promote resilience of these species. Projections for the Southeast biogeographic region include decreases in precipitation as snow (Littell et al. 2018) and increases in rainfall, glacial melt, and snowmelt during fall and winter months. This would result in changes to the region's freshwater hydrology, including greater stream flow rates in fall and winter and reduced rates in spring and summer. Fall flow increases may benefit parr-to-smolt survival, but decreases in summer flow may lower survival during the juvenile rearing period (Crozier et al. 2021). In Southcentral Alaska, a watershed-specific analysis found above-average precipitation had a positive corollary effect on juvenile Chinook salmon and a negative effect on spawning adults (Jones et al. 2020).

Changes in freshwater flow rates can also impact adult salmon. Low summer discharge with high spawning return rates can create hypoxic conditions leading to adult mortality, as observed previously in the Southeast biogeographic region (Sergeant et al. 2017). Yet, increased glacial melting may also provide additional salmon habitat in the region, buffering these effects. By modeling glacial retreat driven by temperature and precipitation projections, Pitman et al. (2021) mapped potential increases in salmon-accessible streams created by glacial runoff in Alaska. In general, salmon stream habitat was predicted to increase by approximately 6% in northern Southeast Alaska, 5% in the Prince William Sound area, and the largest gains were expected to occur in the Gulf of Alaska region (approximately 27% increase), demonstrating the potential for climate resilience among salmonids. Anadromous fish have additional stressors from marine conditions during their life history, which can be impacted by increasing marine temperatures, heat waves, and ocean acidification effects on their prey.

Range Expansion, Pathogens, and Problematic Insects

With temperature increases and climate-induced habitat alterations, Alaska is becoming more habitable for southern species that were previously limited by factors characteristic of cold environments in boreal and Arctic regions. This trend allows "leading edge" species—historically rare or absent species (e.g., mule deer, mountain lions, or some marine fishes)—to expand their ranges into the state. Similarly, invasive species whose climatic tolerances are met in a warming Alaska could become established more easily. Bird species that were historically migratory could become resident (Wu et al. 2018).

Other changes are more complex, such as the increased frequency and magnitude of insect outbreaks. Spruce beetle outbreaks are influenced by a combination of factors, which can include warm temperature-synchronized life cycles and the frequency of cold temperatures sufficient to limit beetle overwinter survival. Since 2016, the rapid expansion of an ongoing spruce beetle outbreak in the Southcentral region has caused extensive spruce mortality across 2.25 million acres (see above section on Problematic Native Species).

In the Southeast biogeographic region, a hemlock sawfly outbreak followed by a western blackheaded budworm outbreak resulted in 1.4 million cumulative acres of defoliation and caused hemlock mortality on over 218,000 acres between 2018 and 2024 (J. Moan, DOF pers. comm.). These outbreaks

affected forests throughout the region, with damage primarily occurring on western hemlock and, to a lesser extent, Sitka spruce (Howe et al. 2024). Outbreaks of these defoliator species were best explained by host tree availability, a limited range of spring, summer, and winter temperatures, and low precipitation (Howe et al. 2024).

While climate change may negatively impact some species across their entire range, other resident species will demonstrate resilience through mechanisms such as dispersal, behavioral and phenological shifts, and changes in microhabitat use, among others. Salmon have recently colonized streams where they were previously absent (Dunmall et al. 2022). Other species, such as walruses, are showing adaptability to climate change in their increased use, in recent years, of terrestrial haulouts when sea ice margins are not near suitable feeding grounds (Fischbach et al. 2022).

Mismatched Phenology and Food Webs

Climate change can have complex effects on wildlife because interactions among many variables, such as temperature, precipitation, habitat availability, ecosystem processes, and species interactions, are complicated and difficult to predict. For example, combined with the changes in habitat and seasonality described above, changes in the timing of spring leafout of vegetation or other historically reliable indicators can create a "mismatch" for migratory bird flight timing and food availability. These changes can result in reduced adult, nest, and brood survival (Kwon et al. 2019). Dates of first arrival for 16 migratory bird species that breed in Alaska's northern biogeographic region correlate with temperature, and species appear to adapt to changing temperatures differently (Ward et al. 2016). A study using six years of citizen science data found the most common migratory timing changes observed with increasing temperatures in Alaska were later arrivals, earlier departures, and shorter stopovers (Zaifman et al. 2017).

A species' dependence on specific ecological conditions or on other species affected by climate change increases its likelihood of being negatively impacted. For example, Liebezeit et al. (2012) identified Common Eiders as being highly vulnerable to climate change due to their dependence on barrier-island nest sites that are threatened by inundation and erosion due to increased storm frequency (Jones et al. 2009). Likewise, Pomarine Jaegers are diet specialists and appear to nest successfully only in years when their primary prey, brown lemmings, are abundant. Changes in climate are shifting lemming population cycles (Ims and Fuglei 2005) and thus could affect jaeger breeding potential (Liebezeit et al. 2012). By contrast, generalist species, such as Glaucous Gulls and Common Ravens are expected to be more resilient to the impacts of climate change (Liebezeit et al. 2012).

As sea ice thins and retreats earlier in the season, food webs under the ice are anticipated to switch from a benthic-dominated to a more pelagic-dominated marine ecosystem (Moore and Stabeno 2015). As relatively larger organisms (e.g., zooplankton) become more abundant, they can efficiently graze on the smaller plant organisms (such as phytoplankton) and reduce the amount of food supplied to benthic communities. These changing conditions create competitive advantages for species favoring warmer water, such as saffron cod and pollock, and have potential negative impacts on cold water species such as Arctic cod. Changes in productivity pathways have the potential to have cascading effects due to those effects propagating across multiple levels of ecological hierarchy that result in a reshuffling of energy flow throughout the food web.

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