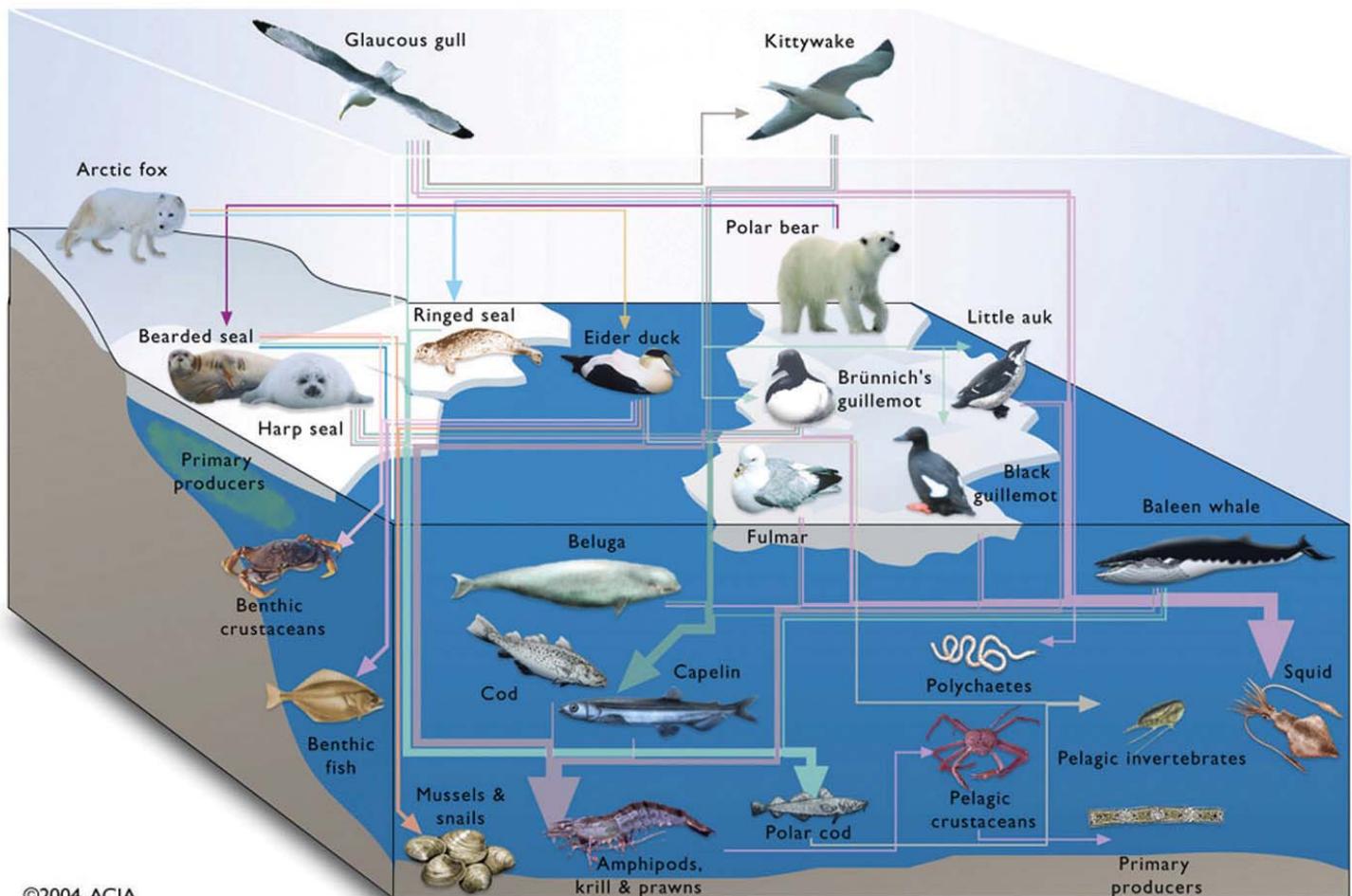


# Climate Change Effects on Arctic Ecosystems and Species

Because arctic ecosystems have extremes in temperature and sunlight that fluctuate with seasons, the species that can inhabit them are limited. And as most of the Arctic region is ocean, studying arctic species—particularly marine species—is difficult. While some expeditions occurred in the 19th century, the long-term studies needed to understand

species and ecosystems did not really get underway until the last 50 years. Therefore, we still lack basic information about many arctic species. Although this makes predicting the effects of climate change on these species challenging, virtually all arctic ecosystems show shifts and alterations that can be attributed to a changing climate.



Loss of species at the base of the marine food web, such as ice-dependent algae and ocean bottom-dwelling krill, will have cascading effects throughout, as one species is tied to many others.

## Changes in Species Communities

Many native arctic species are limited in how far north they can move to adapt to rises in arctic air and sea temperatures and declines in sea ice extent. The encroachment of more southerly species northward makes these northern species even more vulnerable. The combination of limitations in northern movements and competition with other species may drastically reduce some species' populations, increasing their likelihood of extinction.

**Aquatic Invertebrates and Fish.** Changes in the ocean and arctic lakes will lead to the loss of some invertebrates and new species becoming dominant. For example, the species found in some arctic lakes are no longer primarily those that dwell on lake bottoms but those that are more commonly found at the surface and associated with warmer waters. The blue mussel has reappeared in Svalbard after an absence of about 1,000 years, and a variety of Pacific invertebrates now reproduce and overwinter in the Chukchi Sea. Arctic species have declined in the eastern North Atlantic, while warmer-water species have shifted northward by more than 10 degrees latitude.

Lakes, ponds, wetlands and other fresh waters could warm beyond the temperature in which some freshwater species can survive. As the water warms, the body processes of species will accelerate and they will require more food—perhaps more than is available. Most vulnerable will be species with low population numbers that have specific habitat and temperature requirements. A variety of freshwater species, such as fish and invertebrates, are expected to be lost completely in a number of areas.

**Seabirds.** As sea ice pulls further off shore earlier in the year, seabirds that rely on fish living near the ice edge will have an increasingly difficult time finding preferred prey during the breeding season. This will be particularly problematic when fatty fish adapted to colder waters are replaced with leaner species. For instance, black guillemots, birds nesting on Cooper Island north of Barrow, Alaska, can't always find the fatty arctic cod during all of their breeding season. This has coincided with horned puffins, a more southerly seabird that does not require as much food, colonizing the island and competing for nesting sites.

**Marine Mammals.** Changes in the extent and character of sea ice will have significant effects on marine habitats and the various mammals that depend upon them. Impacts on ice-associated cetaceans—bowhead, narwhal and beluga—are currently difficult to predict, as their affiliations with sea ice are poorly understood. However, abundances of most seals and walrus that use ice platforms for pupping, molting and resting are expected to decline. Indeed, ringed seals in some regions are already exhibiting downward trends in reproduction and survival of young, likely related to changes in sea ice and other ecosystem changes.

Declining sea ice poses a severe threat for polar bears. The disappearance of summer sea ice may ultimately



As climate conditions change, some sea birds (such as these puffins) have difficulty finding prey and many in the Arctic region have starved. U.S. Fish and Wildlife Service

mean the extinction of the species. The beginning signs are ominous. Earlier break-up of sea ice is reducing polar bear cub and juvenile survival in some areas. Scientists at the Canadian Wildlife Service and NASA have found it is also forcing polar bears in western Hudson Bay to abandon seal hunting at progressively earlier dates. Because they are eating less, pregnant females today weigh, on average, 135 fewer pounds than others did in 1980.

**Species on Land.** Changes in arctic vegetation on land are gradually altering the habitat of migratory birds and grazing animals. Encroaching shrubs and trees from the south and rises in sea level from the north will reduce or eliminate important tundra and other treeless arctic habitats. The Arctic Monitoring and Assessment Programme projected in 2005 that a large number of bird species, including some that are globally endangered, will lose more than 50 percent of their breeding area by 2100. Many arctic land animals will face an influx of more southerly species while being barred from moving further north by the Arctic Ocean.

## Disruptions to Arctic Food Webs

As water and air temperatures in the Arctic rise, its species will need to overcome several changes to their environment to survive. Each of the following changes could upset the Arctic food web and could have cascading effects.

### **Match-Mismatch Between Predators and Prey.**

This will be the primary impact of climate change on many species. Simply, a *match* occurs when a predator occurs in the same space and time as its prey, whereas a *mismatch* is when they do not, reducing a predator's attraction to an area and its survival in it. Shifts in oceanographic conditions, such as temperature, salinity and currents, can alter matches throughout arctic food webs, with potentially severe effects on species. For example, many hundreds of thousands of migrating seabirds called short-tailed shearwaters starved in the

Bering Sea in 1997 when a change in weather patterns kept the krill they eat from inhabiting the area in which the shearwaters forage. Species are also emerging in areas sooner, stressing some food sources while boosting others. The earlier onset of spring is causing key ecological events to occur earlier—in some cases in Greenland by more than 30 days than they did during the last decade. This includes the blooming of plants, the emergence of insects and nest building by birds.

**Reductions in Sea Ice.** One of the most notable changes occurring is the loss of Arctic sea ice that covers the ocean and serves as crucial habitat to so many arctic species. This will dramatically alter arctic marine and terrestrial ecosystems. It will change the forage base of arctic marine mammals, including shifting the density and distribution of prey and, possibly, leading to the loss of preferred prey. Walrus are particularly sensitive to sea ice loss as they dive from it to hunt animals on the seafloor. As sea ice has withdrawn from areas shallow enough for walrus to dive into, they have formed large congregations on land. Such large numbers of walrus in one location can lead to them using up their food supply in that area and crushing juvenile walrus on land.

**Ocean Acidification.** As people have been releasing more and more carbon dioxide into the atmosphere, the ocean has served to limit the increase of atmospheric concentrations by dissolving about 50 percent of that carbon dioxide. However, carbon dioxide dissolved in water acidifies it, decreasing the water's calcium carbonate. Many major groups of marine organisms—coral, clams, sea stars and other

invertebrates—use this mineral to form their supportive and protective structures. The greatest impacts will be at the lowest levels of the food webs, potentially disrupting their very base. Increased carbon dioxide in surface waters may also impair vital physiological functions such as skeleton formation, respiration, circulation and metabolisms of fish and other aquatic species.

Recent research has found that increasingly acidic oceans will have an unexpected side effect: they can increase the distance sound can travel underwater. Conservative projections indicate that by 2050, this distance could grow up to 70 percent in some areas in the ocean. This is likely to have impacts on marine mammals, which already are contending with dramatically increased levels of underwater sound from human activities.

**Increased Ultraviolet Radiation.** Decreasing stratospheric ozone levels leads to higher levels of ultraviolet radiation that can have far-reaching impacts on food chains. Phytoplankton at the base of the marine food web and many fish in early larval stages are sensitive to ultraviolet radiation. Such radiation alters the fats that algae produce, reducing their nutritional quality for other organisms, and increase cod and anchovy larvae mortality rates.

### Introduction of Disease and Parasites

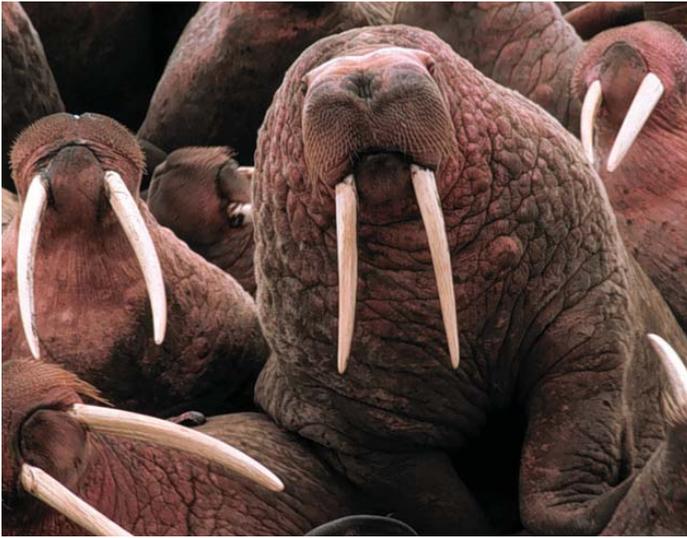
In addition to changes that particular groups of species and the food web in the Arctic might encounter, species across the region may be at great risk of being contaminated with emerging diseases and parasites. Even slight changes in temperature can encourage pathogens and parasites to thrive. Furthermore, elevated ultraviolet radiation exposure can compromise the immunity of fish and other marine animals, making them more susceptible to disease.

A warmer climate will also allow southern animals to move north, bringing diseases and parasites with them. Stress induced by environmental change can also reduce host resistance and increase the frequency of opportunistic diseases. Domestic animal diseases are also likely to pose a significant risk as increasing numbers of people and their animals inhabit arctic environments. For example, distemper, a viral disease in domestic dogs, is thought to have infected and caused high mortalities in both crabeater seals in Antarctica in 1955 and Russian Baikal seals in the late 1980s. In east central Alaska, blood tests suggest that parainfluenza 3 virus was transmitted by cattle to bison in the early 1980s.

Reports of a warming climate leading to diseases in marine species have increased worldwide, though no such trends have yet been reported for the Arctic. Nonetheless, many possibilities for this exist. Declines in sea ice, for example, have forced Pacific walrus to shift their eating patterns and prey more frequently on ringed seals, increasing contact with those prey infected with parasites. This could lead to a higher prevalence of trichinellosis (a disease caused by



Certain marine organisms (such as this shelled pteropod) may not be able to build their external skeletons if ocean acidification increases. *Russ Hopcroft/UAF*



Walrus are in danger of passing diseases and parasites among each other as the sea ice on which they can rest melts. *U.S. Fish and Wildlife Service.*

parasitic worms) in walrus. Declines in sea ice could also reduce the number of suitable ice platforms for seals and walrus, leading to crowding in remaining sites and increasing transmission of diseases there.

Changes to habitats, such as decreased food availability or other factors that affect nutrition, behavior, immune function and distribution of species, can spread disease among those infected.

### Increased Environmental Contaminants

Besides infectious disease, arctic animals, particularly top predators, are exposed to industrial pollutants such as PCBs and DDT that air and ocean currents and other animals carry into the Arctic. Marine mammals such as beluga whales and polar bears have shown elevated levels of these toxins in their tissues as well as associated problems such as cancer and weakened immune systems. While significant amounts of industrial chemicals are already in the marine environment, an unknown quantity was deposited in snow, which later became part of multiyear ice. As this ice melts, chemicals will be released into the waterways, adding to the toxic burden on the system. This will further stress arctic animals, making their adaptation to a changing climate more difficult.

### Upsetting the Balance of a Complex Web

Climate change is just one of several drivers of environmental change, occurring alongside habitat destruction, pollution and unsustainable resource extraction. Because arctic species will respond

differentially to these changes, significant difficulties remain in attempting to predict the responses of species, communities and ecosystems. Nonetheless, evidence is rapidly accumulating that many arctic species and habitats are highly vulnerable to such alterations to their environment.

## Governance Mechanisms and Governing Bodies

### Controlling Carbon Emissions

Kyoto Protocol, United Nations Framework Convention on Climate Change (Global)

### Impacts on Arctic Marine Mammals and Endangered Species

Convention on the Protection of the Marine Environment of the Northeast Atlantic (Global)

Convention on Biological Diversity, United Nations (Global)

Convention on International Trade in Endangered Species of Flora and Fauna (Global)

International Convention on the Regulation of Whaling, International Whaling Commission (Global)

Jakarta Mandate on Marine and Coastal Biological Diversity (Global)

Ramsar Convention on Wetlands (Global)

Beluga whale management, Canada and United States (Regional)

Beluga whale management, North Atlantic Marine Mammal Commission, Iceland, Norway and Greenland (Regional)

Migratory narwhal and beluga whale management, Canada and Greenland (Regional)

Indigenous hunting of polar bears, Russia and United States (Regional)

International Agreement for the Conservation of Polar Bears, Arctic States (Regional)

Working Group on the Conservation of Arctic Flora and Fauna, Arctic Council (Regional)

National Invasive Species Act of 1996, United States  
Nonindigenous Aquatic Nuisance and Prevention and Control Act of 1990, United States

U.S. Endangered Species Act, United States

U.S. Marine Mammal Protection Act, United States

**Additional information available in *Appendix 1: Governing a Warming Arctic***