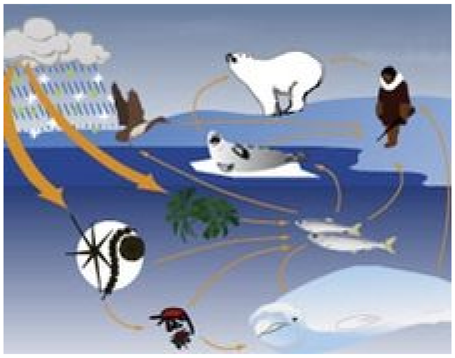
ARCTIC MARINE ENVIRONMENTS

http://www.earthtimes.org/conservation/human-activity-threatening-unique-antarctic-marine-ecosystem/651/)



The arctic marine environment covers about 13 million km^2, of which about 45% is a permanent ice cap that covers part of the Arctic Ocean. Seasonal sea ice forms during winter, and recedes during the short arctic summer, exposing large areas of open water. The marine environment is thus dominated by sea ice and by the dynamics of that ice and especially the location of the ice edge. The transition zone between the sea ice and the open water has intense algal growth in spring and summer, and it is the primary production by these phytoplankton that supports the arctic marine food webs. Only in exceptional cases can the energy that drives the marine food webs be obtained from other sources. Discoveries of “hot vents” and “cold seeps” in the Arctic have been recently recorded. At these sites, bacteria are capable of deriving energy from methane (CH_4) or hydrogen sulfide (H_2S) gases that emerge as bubbles or in solution from the vents and seeps. These bacteria are then fed on by other organisms and so form the basis of some very specialized and localized food webs. Research on marine biodiversity is usually expensive, which is probably why comparatively less is known about marine biodiversity than terrestrial biodiversity.

Projected changes in sea ice, temperature, freshwater, and wind will affect nutrient supply rates through their effects on vertical mixing and upwelling. These will in turn result in changes in the timing, location, and species composition of phytoplankton blooms and, subsequently, in the zooplankton community and the productivity of fishes. Changes in the timing of primary production can affect its input to the pelagic community as well as the amount exported to and taken up by the benthic community. The retention: export ratio also depends on the advection of plankton and nutrients within the water body and on the temperature preferences of the grazing zooplankton; these both determine the degree of match or mismatch between primary and secondary production.

The projected disappearance of seasonal sea ice from the Barents and Bering Seas, and so the elimination of ice-edge blooms, would result in these areas having blooms resembling those presently occurring in more southerly seas. The timing of such blooms will be determined by the onset of seasonal stratification, again with consequences for a match or mismatch between phytoplankton and zooplankton production. If a mismatch occurs, due to early phytoplankton blooms, the food webs will be highly inefficient in terms of food supply to fish. Both export production and protozoanbiomass is likely to increase. However, both the areal extent of export production and grazing by copepods are projected to increase slightly because of the larger ice-free area.

Future fluctuations in zoobenthic communities will be related to the temperature tolerance of the animals and to the future temperature of the seawater. Whereas most boreal species have planktonic larvae that need a fairly long period to develop to maturity, arctic species do not. Consequently, boreal species should be quick to spread with warm currents during periods of warming, while the more stenothermal arctic species (i.e., those only able to tolerate a small temperature range) will quickly perish. Shifts in the distribution of the fauna are likely to be quicker and more noticeable during periods of warming than periods of cooling. Change in the abundance or biomass of benthic communities is most likely to result primarily from the impact of temperature on the life cycles and growth rates of the species concerned. If warming occurs, thermophilic species (i.e., those tolerating a wide temperature range) will become more frequent. This will force changes to the zoobenthic community structure and, to a lesser extent, to its functional characteristics, especially in coastal areas.

Climate change affects fish production through direct and indirect pathways. Direct effects include the effects oftemperature on metabolism, growth, and distribution. Food web effects could also occur, through changes in lower trophic level production or in the abundance of top-level predators, but the effects of these changes on fish are difficult to predict. However, generalist predators are likely to be more adaptable to changed conditions than specialist predators. Fish recruitment patterns are strongly influenced by oceanographic processes such as local wind patterns, mixing, and prey availability during early life stages; these are also difficult to predict. Recruitment success could be affected by changes in the timing of spawning, fecundity rates, larval survival rates, and food availability.

Poleward extensions of the range of many fish species are very likely under the projected climate change scenarios. Some of the more abundant species that are likely to move northward under the projected warming include Atlantic and Pacific herring (*Clupea harengus* and *C. pallasi respectively*), Atlantic and Pacific cod (*Gadus morhua* and *G. macrocephalus* respectively), walleye pollock (*Theragra chalcogramma*) in the Bering Sea, and some of the flatfishes that might presently be limited by bottom temperatures in the northern areas of the marginal arctic seas. The southern limit of colder-water fish species, such as polar cod (*Boreogadus saida*) and capelin (*Mallotus villosus*), are likely to move northward. Greenland halibut (*Reinhardtius hippoglossoides*) might possibly shift its southern boundary northward or restrict its distribution more to continental slope regions. Migration patterns are very likely to shift, causing changes in arrival times along the migration route. Qualitative predictions of the consequences of climate change on fish resources require good regional atmospheric and ocean models of the response of the ocean to climate change. There is considerable uncertainty about the effects of non-native species moving into a region in terms of their effects on the “balance” within an ecosystem.

The impacts of the projected climate change scenarios on marine mammals and seabirds in the Arctic are likely to be profound, but are difficult to predict in precise terms. Patterns of change are non-uniform and highly complex. The worst-case scenarios for reductions in sea-ice extent, duration, thickness, and concentration by 2080 threaten the existence of entire populations of marine mammals and, depending on their ability to adapt, could result in the extinction of some species.

Polar bears, "Ursus maritimus". (Photo credit: WWF-Norway 2002)

Climate change also poses risks to marine mammals and seabirds in the Arctic beyond the loss of habitat and forage bases. These include increased risk of disease for arctic-adapted vertebrates owing to improved growing conditions for the disease vectors and to contact with non-native species moving into the Arctic; increased pollution loads resulting from an increase in precipitation bringing more river borne pollution northward; increased competition from the northward expansion of temperate species; and impacts via increased human traffic and development in previously inaccessible, icecovered areas. Complexity arising from alterations to the density, distribution, or abundance of keystone species at various trophic levels, such as polar bears (*Ursus maritimus*) and polar cod, could have significant and rapid consequences for the structure of theecosystems in which they currently occur.

Although many climate change scenarios focus on the potentially negative consequences for ecosystems, environmental change can also bring opportunities. The ability of some species to adapt to new climate regimes is often considerable, and should not be underestimated. Many marine vertebrates in the Arctic, especially mammals and birds, are adapted to dealing with patchy food resources and to a high degree of variability in its abundance.

Ice-living seals are particularly vulnerable to changes in the extent and character of the sea ice because they use it as a pupping, molting, and resting platform, and some species also forage on ice-associated prey. Of the arctic pinnipeds,ringed seals (*Phoca hispida*) are likely to be the most affected because so many aspects of their life history and distribution are tied to sea ice. They require sufficient snow cover to construct lairs and the ice must be sufficiently stable in spring for them to rear young successfully. Early breakup of the sea ice could result in premature separation of mother–pup pairs and hence increased neonatal mortality. Ringed seals do not normally haul out on land and to do this would be a very dramatic change in their behavior. Land breeding would expose ringed seal pups to much higher predation rates.

Changes in the extent and type of sea ice affect the distribution and foraging success of polar bears. The earliest impacts of warming will occur at their southern limits of distribution, such as at James and Hudson Bays. Late sea-ice formation and early break-up also mean a longer period of annual fasting. Reproductive success in polar bears is closely linked to their fat stores. Females in poor condition have smaller litters, as well as smaller cubs that are less likely to survive. There are also concerns that direct mortality rates might increase. For example, increased frequency or intensity of spring rains could cause dens to collapse, resulting in the death of the female as well as the cubs. Earlier spring break-up of sea ice could separate traditional den sites from spring feeding areas, and if young cubs were forced to swim long distances between breeding areas and feeding areas this could decrease their survival rate. The survival of polar bears as a species is difficult to envisage under conditions of zero summer sea-ice cover. Their only option would be to adopt a terrestrial summer lifestyle similar to brown bears (*Ursus major*), from which they evolved. But competition, risk of hybridization with brown and grizzly bears (both *U. major*), and an increase in human interactions, would also pose a threat to their long-term survival.

The effects of climate change on seabird populations, both direct and indirect, are very likely to be detected first near the limits of the species range and the margins of their oceanographic range. The southern limits of many arctic seabirds are likely to retract northward, also causing breeding ranges to shift northward. Changes in patterns of distribution, breeding phenology, and periods of residency in the Arctic are likely to be some of the first observed responses to climate change. Seabirds will also be affected by changes in prey availability and so can serve as indicators of ecosystem productivity. Since warmer (or colder) water would affect the distribution of prey species, the distribution of individual seabird species is likely to reflect changes in the distribution of macrozooplankton and fish populations. Changes in sea level may restrict the use of current breeding sites, but may increase the suitability of other sites that are not currently used owing to predator access or for other reasons.

With climate change already underway, planning for the conservation of marine biodiversity is an imperative. Series of actions are being proposed. These can be grouped into five key issues, namely:

- the implementation of an inventory of the Arctic's biodiversity and of schemes for monitoring trends in the biodiversity resource, including appropriate indicators;
- the completion of a circumpolar network of marine and maritime protected areas;
- the development of circumpolar guidelines for managing arctic biodiversity in a sensitive manner, bearing in mind the needs of local communities and the fact that "controlled neglect" may be an appropriate means of management;
- the establishment of fora for developing integrated management schemes for coasts and seas; and
- the review of marine regulatory instruments, with recommendations for further actions where necessary.

Conservation is unlikely to be easy, but as many as possible of these five key issues should be developed on a circumpolar basis. This is particularly the case for the marine environment because many of the species tend not to be localized, but to be widely distributed throughout the Arctic Ocean as a whole. Indeed, some species have regular, seasonal patterns of migration. Satellite tracking has shown that walrus (*Odobenus rosmarus*) and narwhal (*Monodon monoceros*) can move great distances within the Arctic Ocean in relatively short periods of time. Similarly, polar bears, ringed seals, and beluga whales (*Delphinapterus leucas*) have been shown to exhibit extensive and rapid circumpolar movements.

The main requirement for the conservation of marine biodiversity is the need to take a holistic approach. The majority of national parks and reserves are predicated primarily upon the protection of coastal birds and mammals. This needs to be expanded to include the ecosystems upon which these birds and mammals depend, and upon which the commercially exploited fish populations also depend. It is not just the vertebrate animals that are important, but the whole range of biodiversity, and especially those small and often unknown organisms that are either trapping solar energy by photosynthesis or decomposing organic matter to enable the recycling of nutrients. It is the totality of the biodiversity of the marine habitats and ecosystems of the Arctic that support the sustainable production of the biological resources upon which the indigenous peoples, and others, depend.

Although there are many unknowns, it is likely that many of the vertebrate animals will move northward, with many of these species likely to become less abundant. However, for the phytoplankton, it is the extent of the mixing of the ocean layers that will determine the increases and decreases for the various taxonomic groups.

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