Impacts of Warming Temperatures on Alaska's Marine Ecosystems

Alaska Marine Conservation Council

Increasing Temperatures in Alaska:

Alaska is warming at twice the rate of most places around the globe. Our annual temperatures have increased 3–5 °F and our winter temperatures are up 7–10 °F. This trend is projected to continue. Such temperature changes will have profound effects on Alaska's marine ecosystems. Alaska's commercial fisheries (providing half of the US domestic catch) and traditional subsistence ways of life, will be changing in complex and uncertain ways as the climate changes.

Melting Sea Ice:

Seasonal formation and melting of sea ice in the Bering Sea is a defining feature of this highly productive ecosystem. Timing of the spring phytoplankton bloom, which supplies energy to the entire ecosystem, is regulated by the timing of ice retreat. When temperatures increase, less sea ice forms in the winter and it melts earlier in the spring, resulting in delayed spring phytoplankton bloom.

The change in timing of the phytoplankton bloom affects which predators consume the nutrients and the effect is carried all the way up the food chain. Colder temperatures and more sea ice normally favor benthic (bottom-dwelling) communities like mollusks and crustaceans and in turn the marine mammals and seabirds who prey on them. In contrast, warmer temperatures and reductions in sea ice result in more food available for fish in the pelagic zone (water column). Scientists are concerned that a loss of plankton production will in turn reduce the overall productivity of the sub-polar Bering Sea ecosystem.

Bering Sea ice is breaking up earlier in the spring. Photo: NOAA

Sea ice loss is also profoundly affecting marine mammals like seals, walrus, and polar bears. They use the sturdy pack ice to haul-out and rest after swimming and feeding. As the ice retreats, it can be farther away from favorable continental shelf foraging areas, causing the animals to swim farther and expend even more energy to get the food they need.

Northward Shifts in Distribution and Migration:

Temperature is one of the primary factors controlling fish distribution. In spring melting sea ice creates a "cold pool" that persists through the summer on the Bering Sea shelf, supporting a specialized benthic ecosystem. When there is reduced winter ice, the cold pool retracts northward, leading to changes in the species composition in these ecosystems.

Walrus rely on Bering Sea ice as a platform for resting and accessing prey on the sea floor. Photo: NASA

During a recent series of especially warm years, the seasonal extent and thickness ice was reduced and the temperature barrier created by the cold pool retreated. Fish survey data from 1982-2006 shows 45 fish species shifted the center of their distribution north.

Mismatches Between Prey Availability and Predator Needs:

Another important factor controlling fish distribution is prey availability. Changes in the ecosystem can separate predators from their prey both in place and time. A mismatch occurs if, for example, warmer water temperature causes a fish population to spawn before the spring sunlight-controlled plankton bloom. Young fish starve without plankton available to eat at the right time.

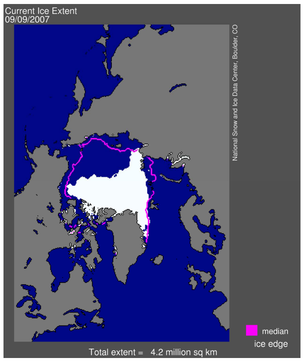
Changing Rates of Metabolism:

Fish are ectothermic (cold-blooded) so their body temperature and metabolism are controlled by the temperature of the surrounding water. Living in cold water slows their metabolism and warmer water increases their metabolism. Fish in warmer water will need to consume more prey to sustain their increased metabolism.

Starvation is a big concern especially for young fish during their first winter. As little fish with small energy reserves, they must forage enough in the summer to survive the winter when there is little food available. In a warmer ocean, their metabolic rate will increase and their energy reserves will be depleted faster. As a result, fish could be very vulnerable to warming temperatures: the warmer it is, the faster they use up their fat reserves before food becomes available again in spring. Increased metabolism will exacerbate the problems from other impacts of warming temperatures like a food resource mismatch or distribution changes.

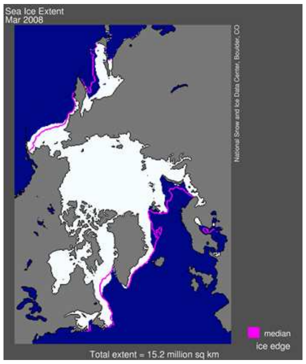
Not All Years Are the Same:

Even though summer sea ice in the high Arctic was the lowest on record from 2007-2009, winter sea ice in the Bering Sea extended very far to the south. How can the Bering Sea have lots of ice some years if Alaska is warming up? Global climate change is not linear—especially in the oceans, where conditions are driven by complex oceanographic and atmospheric forces and cycles on various time scales. Alaskans should expect the Bering Sea to be cold some years and especially warm during others. Scientists at the Pacific Marine Environmental Lab project a warming trend characterized by strong inter-annual variability. It is also ecologically important to track sea ice thickness and timing — not just location of the ice edge. For example, the Cupik word for November means "when the ice comes in." In November 2007 there was no ice on lakes or around the coast of Nunivak Island. However when the ice came in late, it extended far into the southern Bering Sea compared to most years on record.



Sept. 2007 Summer sea ice cover in the Arctic was the lowest on record. Source: National Snow & Ice Data

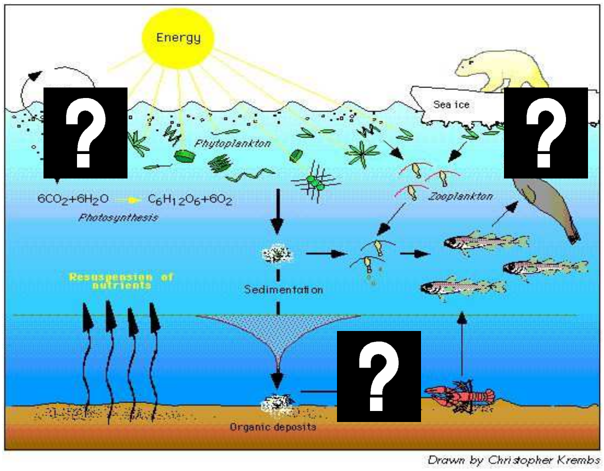
The trajectory of warming oceans may overwhelm decadal shifts between warm and cold cycles. This is a variable that fishery managers have not encountered and have not addressed in management strategies.



March 2008 Bering Sea winter ice extended beyond the historic median. Source: National Snow & Ice Data Center

Complex Community Re-organization:

The greatest concern in terms of climate change impacts on marine ecosystems is that even as scientists are beginning to understand individual aspects of the effects of climate change, they cannot predict the cumulative effect on the whole ecosystem. We will not simply see a wholesale northward shift in marine ecosystems as temperatures increase. Instead, as each species responds differently to changing environmental factors, they will interact and affect each other in different and complex ways. These inherent uncertainties in the impacts of climate change on marine ecosystems is of great concern to scientists, resource managers, fishermen, and coastal Alaskans.



Uncertainties exist in how the food chain will change as a result of temperature increases. Illustration adapted from a drawing by Christopher Krembs.

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Updated July 2010

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