CANADA’S ARCTIC MARINE ATLAS

This Atlas is funded in part by the Gordon and Betty Moore Foundation.
BOTTOM OF THE FOOD WEB

Introduction
The species that make up the base of the marine food web and those that create important seafloor habitat structure all interact to form a web. The Arctic, like other ecosystems, is comprised of species that rely on the water column for food and habitat. The food web in the Arctic is not only important for understanding the impacts of consuming fish and marine mammals, but also for understanding the impacts of consuming plants and other organisms. This chapter focuses on the organisms that make up the base of the marine food web, including phytoplankton, zooplankton, and the invertebrates that feed on them.

Cultural significance
Seasonal blooms of phytoplankton serve to concentrate many other species, including fish, invertebrates, and marine mammals. Phytoplankton are also important for understanding the impacts of consuming fish and other marine organisms. The timing of the annual phytoplankton blooms is critical for the growth and survival of many species, including fish and marine mammals. Phytoplankton are also important for understanding the impacts of consuming plants and other organisms.

Ecological significance
Phytoplankton get their energy from the sun, and from nutrients and form the basis that feeds all other marine animals. Seasonal blooms trigger a cascade of feeding, reproduction, and growth in other species, and changes in these blooms to time and space have ramifications throughout the food web. Amphipods beneath the sea ice, while they are small, are a significant food source for marine fish and bird species as well as baleen whales, which filter the water to capture the nutrient-rich zooplankton.

Gaps in knowledge
As sea ice cover changes and more light is available for longer periods of time, the impact of increased phytoplankton and a second fall bloom on Arctic food webs is not well understood. The effects of ocean acidification, especially in areas of upwelling, are unknown across Arctic ecosystems. Phytoplankton are vulnerable to changing temperatures and nutrient input from land, and ocean acidification poses a significant threat. Zooplankton are vulnerable to climate change, and ground populations can shift with changing sea ice distribution as well as the timing of the annual phytoplankton blooms. There is also some concern that toxins can be taken up by zooplankton, which can shift with changing sea ice distribution as well as the timing of the annual phytoplankton blooms. Zooplankton are vulnerable to climate change, and populations can shift with changing sea ice distribution as well as the timing of the annual phytoplankton blooms.

Conservation concerns
Environmental changes are already evident in the Canadian Arctic, most notably a decline in the volume and extent of sea ice cover and an increase in river discharge to the Arctic Ocean. These changes lead to both an increase in the annual spring phytoplankton bloom and a new fall bloom, which is a shift from the characteristic Arctic production cycle to that of the Atlantic. In addition, the new species of phytoplankton that have been found in the Arctic include species previously known only in the Pacific Ocean, suggesting that the community structure is also changing as a result of climate change and changing ocean circulation. With increasing ocean acidification, the calcium-based skeletons of some diatoms may not form properly. Primary productivity in the Arctic has increased 30% over the last 10 years, indicating significant changes in the base of the food web.

Distribution
Arctic phytoplankton are found throughout the surface of the water column as well as beneath the sea ice. They are most abundant between April and August, during the bloom period and summer, when sunlight is available.

Ecological significance
Phytoplankton are the basis of the Arctic marine food web. Spring blooms starting in April and continuing to August trigger zooplankton growth and activate key feeding areas for zooplankton, fishes, seabirds, and marine mammals. Changes in phytoplankton community structure and growth have ramifications throughout the Arctic food web. As phytoplankton die, they fall to the sea floor, becoming a nutrient source for sea floor ecosystems and transferring carbon from the ocean into sediments.

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Gaps in current knowledge
As sea ice cover changes and more light is available for longer periods of time, the impact of increased phytoplankton and a second fall bloom on Arctic food webs is not well understood. The effects of ocean acidification, especially in areas of upwelling, are unknown across Arctic ecosystems.

For further reading, see p. 106.
Monthly Chlorophyll-a Climatologies

The series of maps below shows the monthly average chlorophyll-a concentration in the Canadian Arctic based on satellite imagery. Chlorophyll-a is the green pigment in phytoplankton, so areas with high chlorophyll-a concentrations are places where phytoplankton are growing. Phytoplankton can be seen blooming in select locations in April, which expand across the Canadian Arctic through the spring and summer months. The blooms provide food for zooplankton and the rest of the food web, including fishes, seabirds, and marine mammals, which gather at these feeding sites.
Amphipods

Natural history
Amphipods form a diverse group of crustacean zooplankton that inhabit all types of Arctic marine habitats. Hundreds of amphipod species have been recorded in the Canadian Arctic seas alone, and many of them are endemic (found only in the Arctic). They are composed of two main families, the Gammaridae and the Hyperiidae. Gammaridae are primarily found beneath the sea ice and sea-bottom habitats of the Canadian Arctic. Onisimus species have distinctive shiny, red eyes. O. littoralis is adaptable and feeds opportunistically beneath the sea ice, on the sea floor, and in surface waters. It eats sea ice algae, zooplankton, and even dead organisms and detritus when food is scarce. In contrast, O. glacialis is strictly found under sea ice, where it feeds on ice-associated food resources such as sea ice algae and other sympagic or ice-associated crustaceans.

The surface-dwelling Hyperiidae species can be carnivorous or omnivorous, and sometimes scavengers. One of the most abundant species in the Canadian Arctic is Themisto libellula. T. libellula is primarily carnivorous and preys on zooplankton in surface waters, including large amounts of calanoid copepods.

Distribution
Arctic amphipods can be found across Arctic seas. Their distribution is dictated by the types of habitats and food resources available. Onisimus littoralis and Onisimus glacialis are among the most abundant Gammaridae in sea ice and sea-bottom habitats of the Canadian Arctic. Onisimus species have distinctive shiny, red eyes. O. littoralis is adaptable and feeds opportunistically beneath the sea ice, on the sea floor, and in surface waters. It eats sea ice algae, zooplankton, and even dead organisms and detritus when food is scarce. In contrast, O. glacialis is strictly found under sea ice, where it feeds on ice-associated food resources such as sea ice algae and other sympagic or ice-associated crustaceans.

Gaps in current knowledge
In general, information on the ecology and life cycles of most amphipod species in the Arctic is very scarce. Data on the diversity and distribution of Arctic amphipods is also lacking. A better understanding of their ecology would be useful due to their pivotal role in Arctic marine food webs, particularly regarding the possible responses of ice-associated species to disappearing sea ice.

Pteropods

Natural history
Pteropods are a zooplankton group of free-swimming molluscs. Their name means “wing footed” because their foot is modified to form a pair of swimming wings. Three species are found in the Arctic. The two most abundant in the Canadian Arctic are Limacina helicina, a shelled species also named the “sea butterfly,” and the naked species Clione limacina, or “sea angel.” The sea butterfly, L. helicina, can measure up to 8 mm in its adult form, while the sea angel, C. limacina can measure up to 4 cm. L. helicina is an omnivorous filter feeder that captures prey using large, mucous webs in which phytoplankton and smaller zooplankton (such as calanoid copepods) get entangled. This unique feeding technique allows L. helicina to feed on prey larger than itself, including other L. helicina. C. limacina feeds on phytoplankton at the larval stage, but the adult form is carnivorous and feeds almost exclusively on L. helicina. C. limacina has developed specific adaptations to feed on the shelled pteropod L. helicina, including a synchronized predator–prey life cycle and the production of specialized lipid reserves, which allow it to survive long periods when its prey is unavailable.

Ecological significance
Arctic amphipods are major food source for fishes, seabirds, and marine mammals in the Canadian Arctic. They live in a variety of habitats and are thus preyed upon by diverse larger animals such as Arctic Char, Gray Whales, Bowhead Whales, and ice-associated species such as Arctic Cod and seals.

Conservation concerns
There is currently no conservation concern for amphipods. The availability of sea ice habitats is diminishing due to the shrinking ice cover, which may threaten sympagic amphipods that rely on sea ice algae and other sympagic organisms for food.

Gaps in current knowledge
Climate change is of great concern for Arctic ptero- pods: ocean acidification driven by the rise in CO2 emissions will make it more difficult for pteropods, L. helicina in particular, to produce their shells. Moreover, among Arctic zooplankton, pteropods were shown to have the highest levels of mercury, a harmful contaminant that biomagnifies in aquatic food webs. Thus, they transfer considerable amounts of mercury to Arctic fishes, seabirds, and whales, and in turn to Inuit that eat these larger animals.

Conservation concerns
Contaminants are a big concern for Inuit health; improved knowledge is needed about the interplay between pteropods’ ecology and accumulation of contaminants, as well as their role in transferring toxic elements to top predators. Furthermore, laboratory experiments on the effects of acidification on L. helicina should be extended over long periods of time to assess potential acclimation to future conditions.
Calanoid Copepods

**Natural history**

Calanoid copepods are the most abundant type of zooplankton, and they are major prey for fishes, birds, and whales. The zooplankton biomass of all Arctic seas is dominated by the calanoid copepods Calanus glacialis and Calanus hyperboreus, but several other calanoid species are present including Calanus plumchrus, Calanus marshalli, Pseudocalanus spp., Moina laevis, Trictonia borealis, and Microcalanus spp.

C. glacialis and C. hyperboreus are endemic to Arctic waters. They have developed specific adaptations to this extreme environment such as a resting stage, called diapause, which allows them to overwinter in the cold Arctic waters. C. glacialis and C. hyperboreus range between 3 to 8 mm in length, depending on the life stage, with C. hyperboreus being slightly larger. Calanoid copepods increase in size by molting. After hatching, they have several stages of development, including the nauplius stage, followed by six copepodite stages, with the last one being the adult stage.

**Distribution**

C. glacialis and C. hyperboreus can account for as much as 70% of the zooplankton biomass in some areas of the Canadian Arctic. Both species are distributed across the Arctic seas, with C. glacialis being most abundant on shelf areas and C. hyperboreus associated with central basins and deeper shelves. The two species migrate down to deep waters during the winter. C. glacialis between 200 and 500 m and C. hyperboreus between 500 and 2,000 m. Their vertical distribution can also vary daily in response to changing light patterns, a process called nycthemeral migrations.

**Ecological significance**

C. glacialis and C. hyperboreus are the most important herbivores in Arctic waters, grazing on large amounts of phytoplankton and ice algae, especially during the brief but intense spring bloom. They transport carbon to deeper waters through their respiration—carbon that is not recycled by the phytoplankton blooms. Inversions of boreal zoo-plankton species as a result of climate change are also a concern. Despite their stable status, the key role of calanoid copepods in Arctic marine food webs calls for careful monitoring of their response to climate change.

**Conservation concerns**

There is no conservation concern for Arctic calanoid copepods at this time. However, climate change could eventually affect these species through, for example, their peak abundances not coinciding with the phytoplankton blooms. Inversions of boreal zooplankton species as a result of climate change are also a concern. Despite their stable status, the key role of calanoid copepods in Arctic marine food webs calls for careful monitoring of their response to climate change.

**Gaps in current knowledge**

Data on the diet of Arctic calanoid copepods and their interactions with other zooplankton species is limited. Some aspects of their vertical migrations remain poorly understood, such as the effect of nycthemeral migrations on the ocean carbon pump, and a year-round portrait of their seasonal migrations is lacking. Further research about the role of calanoid copepods in the ocean carbon pump is scarce and should be extended to more Arctic areas.

**Corals**

**Natural history**

Corals are invertebrates that can anchor in soft sediments and on hard surfaces. While corals are most often viewed as tropical species, their existence and ecosystem function in deep-water and cold-water environments has been an important area of research for the past three decades.

Hard corals have a solid skeletal structure; soft corals have minute internal skeletal structures called sclerites that provide support and are also used to identify the species. Cold-water hard corals include several species groups, including black corals or anthopatharians, gorgonians of which there are large and small species, and scissortails, all of which are small. The most abundant soft corals include Antipathes grandiflorus, Gorgonaria subuliformis, and Daphnia florida, with several species of nephthians also found.

Corals form colonies made up of polyps that feed by filtering plankton from the water. Corals have a variety of reproductive strategies, from broadcast spawning to sexual reproduction, where new polyps bud from the parent coral and begin a new polypiferous structure. Corals are thought to be slow growing, with larger species and thickets of bamboo coral hundreds to thousands of years old. Soft corals have been observed to reach 3–4 mm within three to four months. Deep-water coral colonies range in size from small and solitary to large, branching tree-like structures—with records of the gorgonian Paregoria orbicularis as high as 3 m.

In Baffin Bay, unique forests of bamboo coral, Keratinosia spp., were filmed in 2013. These forests were estimated to reach up to 1 m in height, and are anchored in soft sediments in the sea floor through a complex root structure. These corals formed an unusual habitat structure in this otherwise muddy environment.

Finally, sea pens, or Penatulacea, are important sea floor species, with some growing more than 2 m high. Sea pen fields can be dense, providing both shelter and food for other marine species.

**Distribution**

Hard corals are found along the shelf edge from eastern Labrador and continue into Baffin Bay, with records in areas that have been surveyed and distribution likely into the high Arctic. There is an apparent shift in coral diversity and abundance between Davis Strait and Baffin Bay, but this may be also due to sampling intensity. Hard corals reach peak abundance between 300 and 1,200 m. Soft corals and sea pens are found on the continental shelf and shelf edge.

**Ecological significance**

Corals provide structural habitat for many species, including commercial fish species. The relative importance of corals as habitat depends on their overall size and body structure, as well as their geographical environment. Corals anchored in soft sediment can help to ensure sediment stability.

**Conservation concerns**

Corals are impacted by fishing activity, with the first pass of a trawl, or bottom-fishing gear, the most damaging. Continued fishing pressure can hamper recovery of corals through disturbance of the sediment and newly settled recruits. Corals are also vulnerable to climate change, particularly those with calcareous skeletons, which are affected by ocean acidification.

**Conservation status**

Corals are not currently designated as threatened or endangered. However, this status does not take into account recent changes in coral diversity and abundance in the Canadian Arctic. Continued monitoring and research are needed to better understand the status of corals in the region.

**Cold Water Corals and Sponges (cont’d on pages 46–47)**
Sponges

Natural history
Sponges are an ancient type of animal, with a fossil record longer than 800 million years. They feed by filtering water to trap and digest bacteria and other particulate materials. Most sponges are supported by skeletal components called spicules. Other sponges contain a fibrous material that provides skeletal support. Sponges grow in myriad forms: some encrusted on rock faces, some in branching forms, and some in globular forms of various sizes. They are often found in areas with soft and hard corals and other invertebrates, all of which together can form complex sea floor habitats. These habitats can be oases for a wide variety of other marine species, including commercially fished species.

Recent efforts have been made to collect sponges through research trawl surveys. In the eastern Canadian Arctic, about 100 different species have been recorded. Samples identified through research surveys show dominance by the Glass Sponge, Asconema foliata and the Demosponge, Mycale lingua. Data collected through observer records and fishing activity has revealed large biomass of Geodid sponges, which are also found further south along the Labrador coast, the Grand Banks, and in North Atlantic waters surrounding Iceland and the Faroe Islands. Other commonly found sponges in the Arctic include those in the genus Polymastia. Several species of carnivorous sponges from the genus Chondrocladia have also been found in Canadian Arctic waters.

Distribution
Sponges are distributed throughout Arctic waters, in both hard-bottom areas and soft sediments. In recent years, samples have been collected from research trawl surveys and in situ videos, providing an increased understanding of species richness and distribution.

Ecological significance
Sponges diversify the types of habitats found on the sea floor, and they harbour other marine invertebrate species. Sponge spicules provide structure, particularly in soft-sediment environments. High concentrations of sponges have been identified as “sensitive benthic areas” and “vulnerable marine ecosystems” and are protected from fishing in some areas. Egg deposition by cuttlefish has been discovered in Mycale on the Labrador shelf, suggesting that some sponges provide important habitat for life stages of other marine invertebrates.

Conservation concerns
Sponges can be damaged by bottom trawling, and recovery rates for Arctic species are unknown. Fishing trawls have caught up to 8,000 kg of sponges at a time in the Davis Strait / Saglek Bank area, primarily those in the Geodid family. Encrusting species and those that are low growing or round are less susceptible to harm by fishing gear.

Gaps in current knowledge
Sponges in the Canadian Arctic are only just starting to be recorded and identified. While their ecological significance can be inferred from knowledge gathered in other areas, relatively little is known about their reproduction and growth rates, nor about their significance for other species in the ecosystem.
**FURTHER READING**

**BOTTOM OF THE FOOD WEB**


