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Tracing Carbon Through the Arctic Food Web

Puzzle Plot

Despite average winter temperatures being -30°F and being covered by sea ice for much of the year, the Arctic is home to a huge variety of living things (humans included) that have adapted to these harsh conditions. Did you know that there is an Arctic fish, the polar cod, that produces antifreeze proteins to keep its blood from freezing? However, environmental conditions are changing. The Arctic is warming twice as fast as the global average and as a result, sea ice is melting rapidly. Scientists are racing to learn more about the changing Arctic climate system with some ecologists investigating the question, “how might the decline in sea ice affect Arctic organisms large and small?” *Image above from Shawn Harper, NOAA.*



Pause and Play: Watch these videos to observe [Arctic warming](#) and [sea ice decline](#)

To answer this question, scientists are paying special attention to Arctic algae, plant-like organisms that produce food/energy through photosynthesis. Arctic algae are described as occupying the “base” of the Arctic food web because the energy they produce via photosynthesis flows to all other organisms in the Arctic (Figure 1).

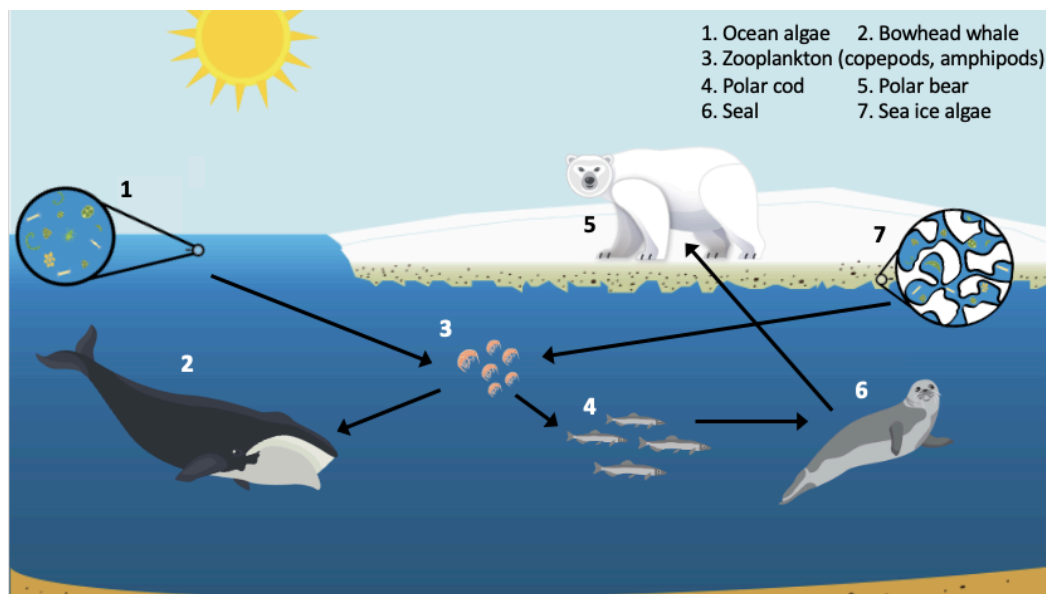


Figure 1. Arctic food web showing different feeding relationships amongst Arctic organisms.



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There are two types of Arctic algae, those that live in and under the sea ice (sea ice algae) and those that live in the open ocean (ocean algae, often referred to as phytoplankton) (Figure 2). Over the past few decades, scientists have used satellites to measure changing algae populations and have discovered that ocean algae populations have increased across the Arctic, while sea ice algae populations have decreased in parts of the Arctic. Changing Arctic algae populations are likely to affect the rest of the Arctic food web, but how?

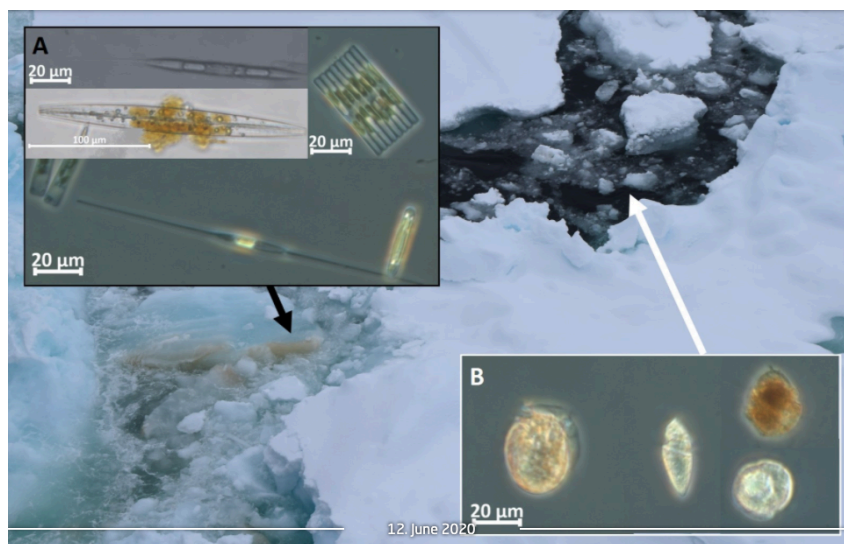


Figure 2. Images of sea ice algae (A) and ocean algae (B) from MOSAiC Team Ecosystem.

Scientists have discovered that ocean and sea ice algae make different types of carbon-based fats. Why does this matter? Well, these carbon-based fats are transferred to animals when algae are eaten, all the way up to polar bears and bowhead whales (Figure 3). If scientists can measure the amount and type (*ocean algae* vs. *sea ice algae*) of carbon-based fat in Arctic animals, they can determine whether the animal's diet is more dependent upon ocean algae or sea ice algae.

- **Stop and Talk:** Refer to figure 3 to discuss the following questions:
 - What do the small circles and triangles represent?
 - Based on the figure, do you think copepods eat more ocean algae or sea ice algae?
 - Based on the figure, do you think bowhead whales eat more copepods or amphipods?
 - Do you think bowhead whales are more dependent upon ocean algae or sea ice algae? How do you know?



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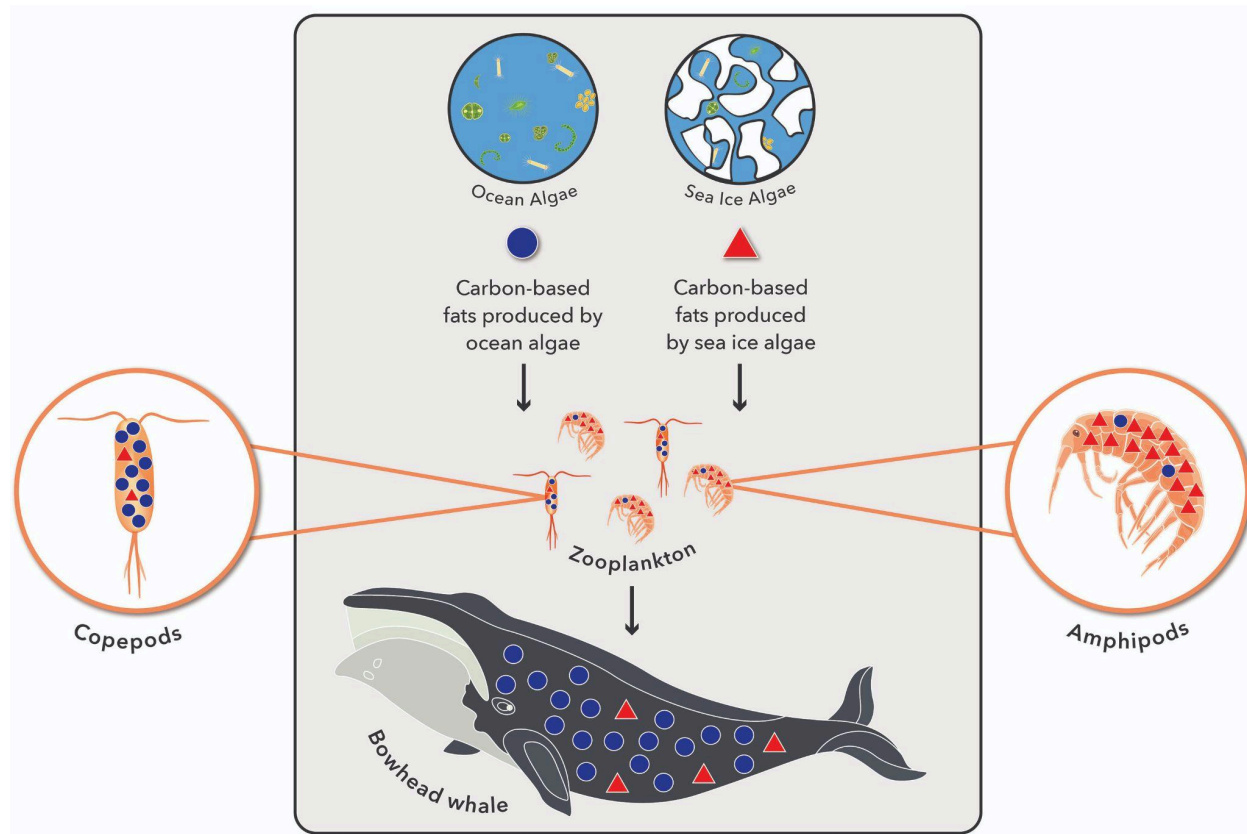
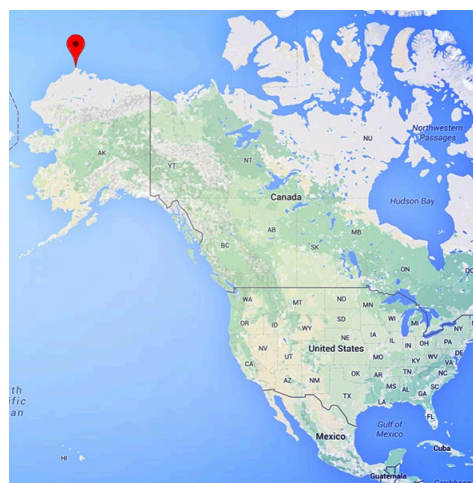


Figure 3. Sea ice algae and ocean algae produce different kinds of carbon-based fats, which are transferred to zooplankton (copepods, amphipods), and then up the food chain when they are eaten.

In 2008, scientists measured the amount and type of carbon-based fats in a variety of Arctic organisms in Utqiagvik, Alaska (formerly known as Barrow, Alaska). From these results, scientists were able to determine which organisms rely on carbon produced by sea ice algae (Table 1), which is important given the fact that sea ice algae populations may decline in the future! **Figure 4 (right).** Map showing the location of Utqiagvik, Alaska (red point).



Pause and Play: [Watch this video](#) to see how scientists are studying the Arctic food web.



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Identifying Important Science Ideas

1. Study the Arctic food web (Figure 1) from the Puzzle Plot text to answer the question below:

Construct a food chain that starts with sea ice algae

Sea ice algae → →

Describe how carbon-based fats produced by sea ice algae are transferred to other Arctic organisms.

2. **Investigative Question:** What question are scientists investigating as they study the Arctic ecosystem?

3. **Make a prediction:** Declining sea ice has caused a shift in Arctic algae populations such that sea ice algae populations are declining in parts of the Arctic, while ocean algae populations are increasing across much of the Arctic.

In a few sentences, make a prediction about how changing algae populations might affect other Arctic organisms?



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Supporting Ongoing Changes in Thinking

In 2008, scientists measured the amount and type of carbon-based fats in a variety of Arctic organisms. The results of their investigation are shown below in figure 5.

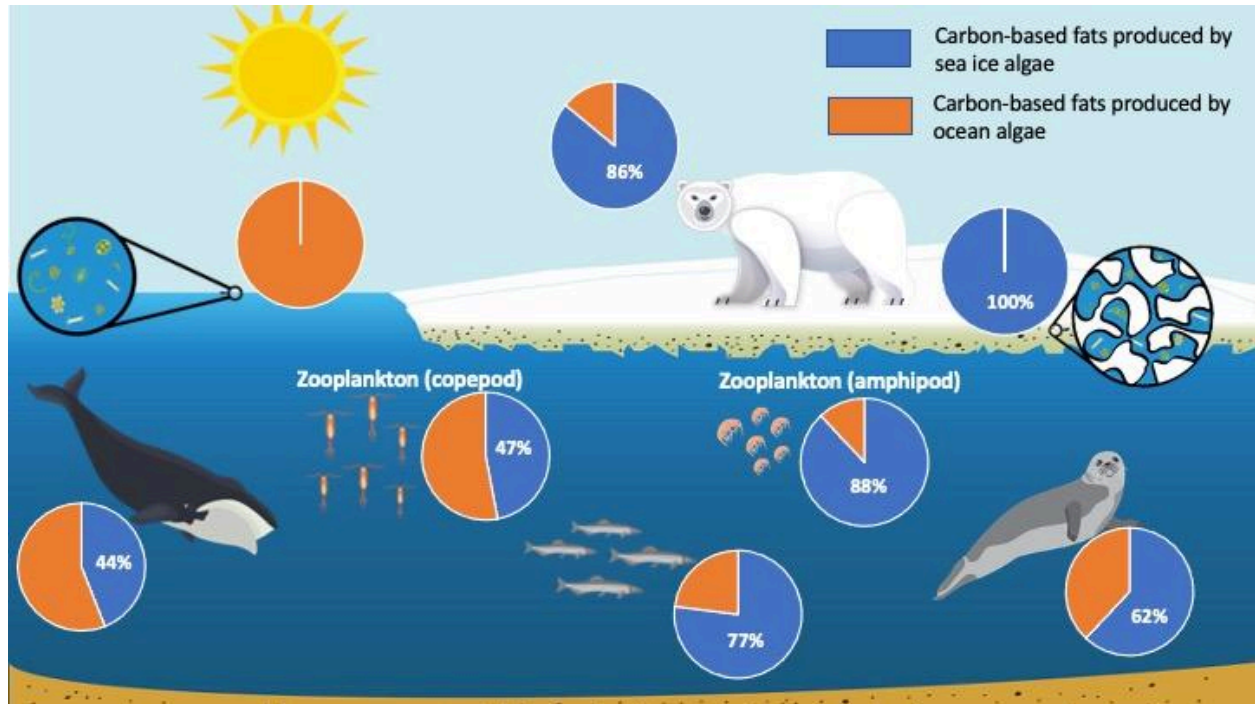


Figure 5: Relative amount and type (ocean vs. sea ice algae) of carbon-based fats present in various Arctic organisms.

Instructions:

Refer to figure 5 to answer the following questions

4. What do the different colors in the pie charts represent?
5. Which animals get more of their carbon-based fats from sea ice algae?



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6. Complete the food chain below by adding the Arctic animals that are most dependent upon sea ice algae.

Sea ice algae →

7. How might a decrease in sea ice algae affect the organisms you listed in question 6.

8. Which animals get more of their carbon-based fats from ocean algae?

9. Complete the food chain below by adding Arctic animals that are most dependent upon ocean algae.

Ocean algae →

10. How might an increase in ocean algae affect the organisms you listed in question 9?

11. **Revise your prediction about the investigative question** (see question 3): Did the data support your prediction? Explain.



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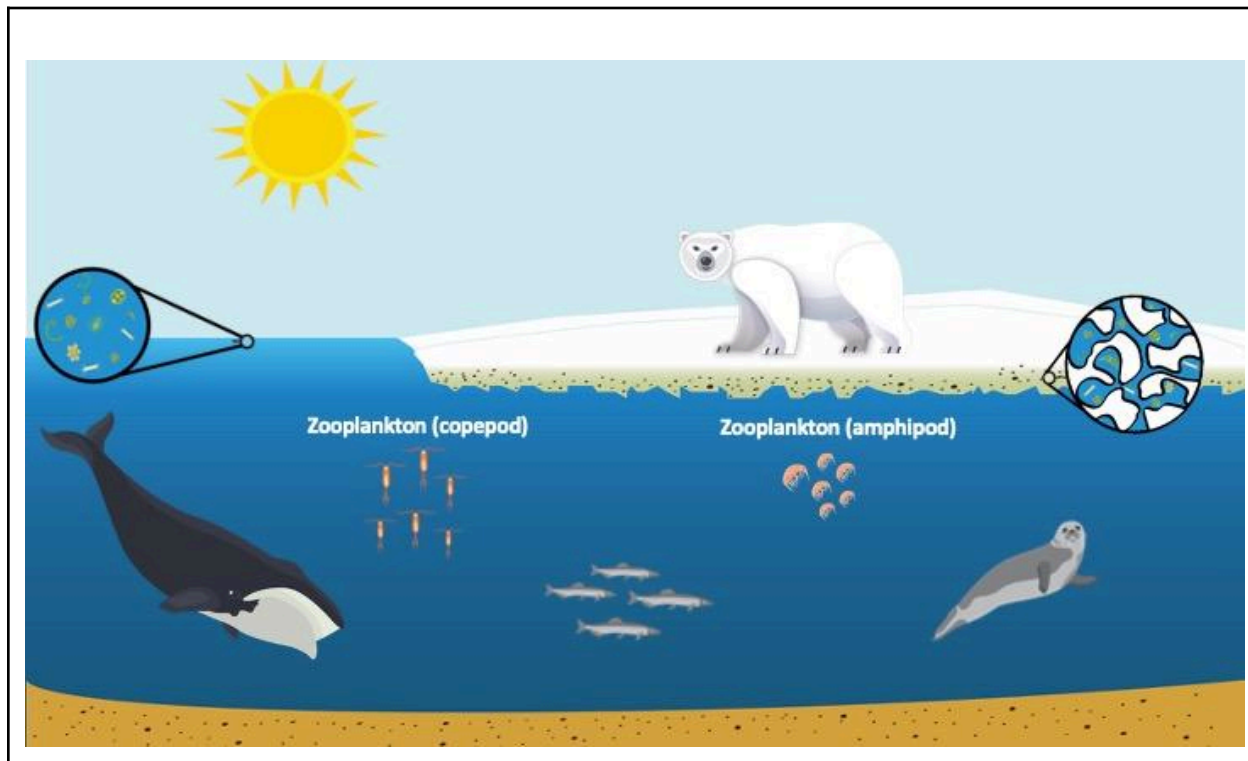
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Constructing Evidence-Based Explanations

12. Gotta-Have Checklist: A gotta-have checklist is a list of ideas and evidence that are needed to fully explain a question. Use the table below to create your own gotta-have checklist.

What ideas do we need to have to answer the question, “How might the decline in sea ice affect Arctic organisms large and small?”	What evidence do you have to support these ideas (e.g., number from the graph)?
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13. Construct a model (annotated sketch) to explain the investigative question, “How might the decline in sea ice affect Arctic organisms large and small?”





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13. **Digging deeper:** Arctic indigenous peoples have lived and thrived in the Arctic for thousands of years, sustaining themselves by hunting and foraging and thus making them an important part of the Arctic food web. How might the decline in sea ice affect the indigenous people that call the Arctic home?