ScienceNews
IN HIGH SCHOOLS | EDUCATOR GUIDE

Arctic passageways let SPECIES MINGLE

SOCIETY FOR SCIENCE & THE PUBLIC

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About the article

The *Science News* article "Arctic passageways let species mingle" explores how animals might move around and interact in new ways as melting ice opens new Arctic channels.

"Arctic passageways let species mingle" can be used across a wide range of curricula, with a focus on **biology** and **ecology**. The activities, questions and discussions in this educator guide support the following education standards:

Next Generation Science	Common Core
Ecosystems: Interactions, Energy and Dynamics: H-LS2-2, H-LS2-4, HS-LS2-6	ELA Standards: Reading Informational Text (RI): 1, 3, 7
	ELA Standards: Writing (W): 3, 6
	ELA Standards: Speaking and Listening (SL): 1, 2, 3, 4, 5
Reinforcement for Middle School: Ecosystems: Interactions, Energy and Dynamics: MS-LS2-1, MS-LS2-2, MS-LS2-4	ELA Standards: Reading for Literacy in History/Social Studies (RH): 2, 3, 7, 8, 9
Earth's Systems: MS-ESS2-2	ELA Standards: Reading for Literacy in Science and Technical Subjects (RST): 1, 2, 7, 9
Earth and Human Activity: MS-ESS3-5	ELA Standards: Writing Literacy in History/Social Studies and Science and Technical Subjects (WHST): 2, 6, 7, 8, 9

Prior to reading

Guide student reading by pointing out connections between this article and what students are learning in class. Here, find ideas for standard-aligned paths to follow while reading:

- Show students a time-series graph of average sea ice extent for the Arctic (Blackline Master 1), or share one of many videos showing time-lapse imagery of changes in sea ice, such as this OurWorld video. What is happening to sea ice in the Arctic? What is responsible for changes in the extent of sea ice? Encourage students to think about seasonal, yearly and decadal patterns. This is a good opportunity to review the concept of feedback loops. *(As temperatures warm, ice melts. The remaining water reflects less solar radiation than the ice did, leading to further warming and thus more melting.)* How might melting ice affect travel through the Arctic? Ask students to consider the cultural, political, economic and ecological consequences of the melting.
- Arctic sea ice serves as a natural barrier separating animal populations. Can you think of other similar barriers *(the Mississippi River, mountain ranges such as the Rockies, deserts, the oceans that separate islands)*? How does separation affect the evolution of organisms? Use this opportunity to introduce or review ideas related to reproductive isolation and speciation. What might happen to two separated populations when barriers no longer exist?

  Ask students to consider other ecological consequences of melting sea ice and a warming climate. Animals may already be relocating in response to climate change, as described in this article from *Science News*. And some evidence suggests that tundra-dwelling grizzly bears and Arctic polar bears might interact more often, as described in this article from the National Wildlife Federation.

After reading: Comprehend

You can adapt and print these questions (Blackline Master 2) to check for comprehension and analysis before or after discussion:

1. **What is the main topic of the article?** *(As Arctic sea ice melts, once separated animals can move into new waters and mix with new populations. These changes will likely come with unexpected consequences.)*
2. **What animals already appear to have crossed between the Atlantic and Pacific?** *(Marine mammals and seabirds, including gray whales, the common eider, the tufted puffin and the Manx shearwater.)*
3. **What is one possible way that feeding habits of gray whales might affect burrowing animals on the sea bottom?** *(Gray whales gouge the sea bottom as they feed, so animals burrowing there may get churned up and eaten.)*
4. **What does it mean that the Suez Canal has become an "invasion corridor"?** *(With no natural barrier separating the bodies of waters, invasive species have moved in and clogged fishing nets, blocked intake pipes and wiped out native species.)*
5. **Why didn't the building of the Panama Canal result in a massive invasion corridor between the Pacific and Atlantic oceans?** *(The canal is filled with freshwater and locks, creating a water chemistry barrier between the two oceans that most animals cannot cross.)*

After reading: Analyze

1. **Researchers and marine personnel have spotted a trickle of animals in locations where they don't normally exist, but no one is yet claiming that new populations have been established. Why? What kind of observations or data might help scientists understand the extent of the invasion?** *(Perhaps the misplaced animals were strays who had gotten knocked off-course, or perhaps they were merely visiting these new waters before returning to their original habitat. Helpful data might include observations that animals are able to feed or mate in the new environment, records of new births, genetic data that looks at relationships between animals in the new and old habitats, tracking data that indicate how long an animal has been in a particular location and so on.)*

2. **Are scientists certain about the ecological consequences of the melting of Arctic passageways? Why or why not?** *(Answers will vary, but students should recognize that scientists are not certain to what extent populations will mix and what the consequences of that mixing will be. Though scientists expect that animals will take advantage of new habitats if they can, the effects are hard to predict because of the complexity of ecological systems. The possibility of interbreeding with different populations or subspecies of their kind, or maybe even different species, for example, depends on a whole host of factors such as the timing of mating, reproductive biology and mating signals. The effect on food webs depends on how many animals move, what they end up feeding on, when and how much. Some consequences may be immediate; others may take decades or even centuries to emerge.)*

3. **According to the article, *Neodenticula seminae* diatoms turned up in the Labrador Sea in the late 1990s. Why do you think these diatoms could be a good indicator for a changing world?** *(The scientists believe circulation patterns might be changed, bringing these diatoms to the Labrador Sea. Because there has been little shipping across the Arctic so far and it would be unusual for a ship to exchange ballast water out in the Labrador Sea, researchers argue the diatoms probably did not travel in ballast water.)*

Discuss and assess

After students read the article independently, return as a group to the concepts outlined prior to reading. Invite students to share their answers and observations from the article and lead a class discussion that further underscores your current curriculum. The discussion can serve as an informal assessment. Ideas for further reading discussion or writing prompts include:

- Imagine you are a Pacific gray whale and you've found yourself in the Atlantic after passing through Arctic waters. You were just following food along the coastline and ended up in these new waters. How would your life be different in the Atlantic? Consider unfamiliar animals you would encounter in your new area. Would there be new foods, new competition and new potential mates? How would the new environment affect your chances for survival? If other Pacific whales joined you, how might the long-term survival of your population be affected? Encourage students to consider not only the challenges but also potential benefits, in the form of new food sources. What about the effect on genetic diversity? Ask students: Would you stay in the new waters or would you go back? Students might draw on their own experience. Have they ever moved to a new neighborhood or joined a new group? How did they cope with the changes?
- Ask students: Should people take action to keep animals in their original habitats? If so, what might those actions look like? Should we protect existing populations when other animals invade or let "nature take its course"? What are the pros and cons of each approach? Ask students to take a side and evaluate their position. Are they motivated more by practical concerns or philosophical positions? Who else would students expect to get involved in this debate, and what side would these people take? Students might consider ecotourists, fishermen, native populations, environmental groups and so on. Consider other situations: efforts to protect the giant panda or to rid the Florida Everglades of invasive species, for example. Would students take the same position in these situations? Why or why not?

Extend

Offer students other ways to explore the content of the article as it relates to your curriculum, such as:

ARCTIC OPENINGS

Ask students whether they've heard of the Northwest Passage. What image does that phrase create in their minds? *(The Northwest Passage is a sea route that links the Atlantic and Pacific oceans through the system of islands in the north of Canada, known as the Canadian Arctic Archipelago.)* Beginning in the 1500s, explorers sought to find this route. Why would people want to find a Northwest Passage? *(To shorten the distance ships must travel to transport people and goods from Europe to Western North America and Eastern Asia.)*

Not until the 1940s did the first ship make it through the Northwest Passage in a single season (though multi-year trips had succeeded before that). What obstacles might have prevented an earlier crossing? Students might research some of the many attempts, including Sir John Franklin's lost expedition in the 1840s. To learn about the Franklin expedition, visit PBS NOVA for an interactive account of the search for the missing ship and crew. For a reading on a successful crossing, consider directing students to one of many personal and modern accounts, such as a photo blog by Ralph Lee Hopkins.

With additional research, students can map the paths that vessels take through the Northwest Passage. Why do they take these routes? Students might consider the depth of the water, a route's proximity to land and the thickness of the ice. Students might also think about the best time of year to attempt a crossing, and the importance of ice breakers for cargo vessels. Use Blackline Master 3 for a map of Arctic landmasses.

FOOD WEB SHAKE-UP

Students may remember studying food chains and food webs in elementary and middle school. Organisms moving to new environments have the potential to affect existing ocean food webs. To review the concept, have students cut out the images from Blackline Master 4. Using their own knowledge about organisms' diets (or the information provided, depending on their level), students can work in pairs or small teams to create as many food chains as possible. Teams can check each other's work. What's the longest food chain a team can create? When the chains are created, students can take note of what animals are found in multiple chains. By drawing out these overlapping chains on a separate piece of paper, students will create an Arctic food web. The answer key can be found here: http://www.grida.no/graphicslib/detail/coastal-arctic-food-web-drift-ice_e343.

We often think about what will happen to an ocean food web when an organism is removed due to overfishing, for example. But what happens when an organism is added? Students can trace the potential effects using the food web they have created.

FOLLOW THAT WHALE

The article "Arctic passageways let species mingle" discusses the potential for populations of Atlantic and Pacific whale populations to mingle. In a recent *Biology Letters* paper (link here: http://www.north-slope.org/assets/images/uploads/Heide-Jorgensen%20et%20al%202011%20Bowheads%20NW%20Passage.pdf), researchers tracked bowhead whales. Give students time to study the charts found on Page 2 of the paper and answer the questions on Blackline Master 5. What types of information can be gained from these and similar tracking studies (*seasonal ranges, migration patterns, feeding and mating waters, habitat overlap, effectiveness of conservation efforts*)? Students can use simple search terms to find satellite tracking data for many marine organisms, such as sea turtles, bluefin tuna and great white sharks.

GUESS WHAT'S MOVED IN?

- **Purpose:** Students will design an experiment to determine whether an unusual animal sighting is an anomaly or represents a population that is spreading or relocating due to changes in environmental conditions.
- **Notes to the teacher:** This activity is designed to help students think critically about experimental design. It is up to you whether you want students to implement their designs to collect data. This could be an individual extension (think science fair).
- **Directions**:
  1. Discuss the unusual animal sightings introduced in the article (killer whales in Hudson Bay, Atlantic common eiders in California and so on).
  2. Select which animals to focus on (either one per student or one per group of students) and have students research some details about the animals' lifestyles, diets, population size, behaviors, habitat ranges and migration patterns.
  3. Tell students that their objective is to develop a study question and study design focused on their animal and the information in the article. They might want to design a study to find out whether their animal has established itself in a new region, or they might want to ask something more specific: What is the animal feeding on? Is the animal competing with native residents for food? How many animals have relocated? Is the animal breeding in its new habitat? Has the animal displaced existing fauna?
  4. Have students state their study question in simple terms. Encourage them to formulate a hypothesis. You might want students to share their questions and hypotheses with the class for feedback, and then give them the opportunity to revise their initial attempts.
  5. Students should brainstorm how they would go about answering their question. Some considerations:
     a. What type of evidence do I need to answer my question?
     b. Where will I collect that evidence?
     c. How? What methods will I use?
     d. Can I benefit from the help of citizen scientists? If students don't know about citizen science, you might consider introducing the idea with a specific example, such as the BioSCAN project at the Natural History Museum of Los Angeles County, in which samples of insects were collected from local backyards and analyzed. 30 new species of flies were identified in just a few months of sampling.
     e. What sampling techniques will help me avoid bias?
     f. Will my study have a control? Is there an indicator species I can use for these purposes?
     g. What is the best time of year for my experiment?
     h. How often do I need to repeat my data collection? Or, how many samples is enough?
     i. What materials or equipment do I need?
     j. Will I need to do any special analyses to process my data?
     k. What will I do if my results are not what I expected?
     l. How would I share my results with a wider audience?
  6. Once students have drafted their experimental design, have them share their work across teams. Explain what it means to be a critical friend within the scientific community and encourage students to analyze each team's design carefully and find ways to strengthen it.

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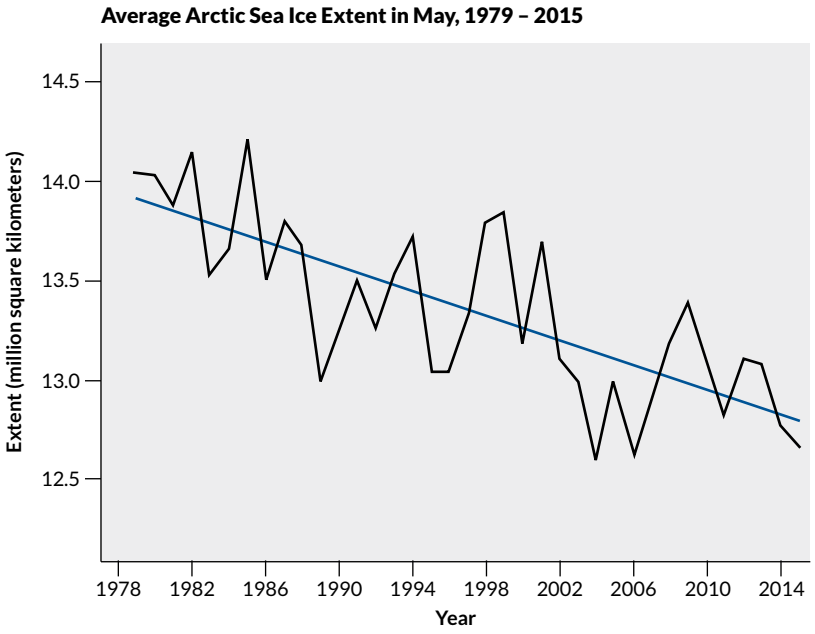
Time-series graph of Arctic sea ice

Examine the graph of Arctic sea ice extent and answer the questions that follow.



1. How has Arctic sea ice extent changed over the time frame shown?

2. What is the difference between the black line and the blue line?

3. What do you think is causing the trend seen here?

SOURCE: NATIONAL SNOW AND ICE DATA CENTER

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Comprehend

After reading the article, "Arctic passageways let species mingle," answer these questions:

1. **What is the main topic of the article?**

2. **What animals already appear to have crossed between the Atlantic and Pacific?**

3. **What is one possible way that feeding habits of gray whales might affect burrowing animals on the sea bottom?**

4. **What does it mean that the Suez Canal has become an "invasion corridor"?**

5. **Why didn't the building of the Panama Canal result in a massive invasion corridor between the Pacific and Atlantic oceans?**

Analyze

1. **Researchers and marine personnel have spotted a trickle of animals in locations where they don't normally exist, but no one is yet claiming that new populations have been established. Why? What kind of observations or data might help scientists understand the extent of the invasion?**

2. **Are scientists certain about the ecological consequences of the melting of Arctic passageways? Why or why not?**

3. **According to the article, *Neodenticula seminae* diatoms turned up in the Labrador Sea in the late 1990s. Why do you think these diatoms are a good indicator for a changing world?**

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Mapping Arctic routes

The map above shows only the landmasses surrounding the Arctic. This is what the Arctic would look like with no sea ice.

1. **Conduct some research to find out the routes ships have taken through the Northwest Passage. Sketch the routes on the map of landmasses above.**
2. **Why do vessels take this route? Do all vessels use the same route? Why might a cargo ship take a different pathway than a sailing vessel? Why might the time of year influence the path that a vessel chooses to take?**

3. **As sea ice melts, new Arctic passageways are opening up. Sketch a route that you think might be used more commonly in the future.**
4. **Why did you select this route?**

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Food web shake-up

1. **Cut out the pictures of the organisms below.**
2. **Do your own research or use the details attached to create as many food chains as you can. What's at the top of the food chain? What's at the bottom? What's the longest chain you can create?**
3. **Look again at your collection of food chains. Notice that some organisms appear in multiple food chains. Using these organisms as a guide, turn your food chains into a food web. On a separate sheet of paper, draw a food web based on your food chains.**
4. **Food webs help researchers think about the health of a community. Look at the food web you've created and consider what might happen if:**
   - Polar bears are removed from the food web.
   - Primary producers are removed from the food web.
   - Kittiwake are removed from the food web.
   - Another subspecies of Arctic fox enters the food web.
   - Squid flood the food web.
   - The population of eider ducks increases.


Fulmar


Arctic fox


Glaucous gull


Other pelagic invertebrates


Mussels, snails


Black guillemot


Little auk


Eider duck


Brünnich's guillemot

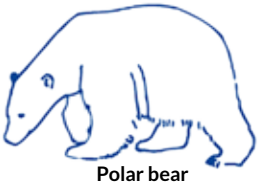

Kittiwake


Ringed seal


Bearded seal


Squid


Polychaeta


Polar bear


Benthic fish


Primary producers


Pelagic crustaceans


Benthic crustaceans


Polar cod


Amphipods, krill, prawns

SOURCE: UNEP/GRID-Arendal, 1997. Arctic Climate Impact Assessment (ACIA), 2004.

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Food web shake-up

If you aren't familiar with these animals, consider these clues:

- Primary producers make energy from the sun.
- Polar bears eat ringed seals and bearded seals.
- Arctic foxes eat ringed seals and eider ducks.
- Pelagic crustaceans eat primary producers.
- Eider ducks eat mussels, benthic crustaceans and pelagic invertebrates.
- Fulmars eat polychaeta and squid.
- Glaucous gulls eat polar cod, little auks, black guillemot, Brünnich's guillemot and kittiwake.
- Other birds eat a combination of amphipods, krill, prawns, pelagic crustaceans and polar cod.
- Polar cod eat pelagic crustaceans, amphipods, krill and prawns.
- Benthic fish eat benthic crustaceans.
- Ringed seals eat polar cod.

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Follow that whale

The maps provided show the radio telemetry tracks from four bowhead whales from two different stocks, or groups that travel together (yellow and red). The white areas show Arctic areas with more than 50 percent concentration of sea ice. Researchers once believed that the stocks remained separated because thick ice kept them apart.

1. **What do you notice about these tracks?**

2. **How fast do the whales travel?**

3. **Do all the whales travel the same paths?**

4. **What might explain why some tracks appear to cross over land? What about over ice?**

5. **Based on what researchers believed, why is the inset map (between b and c) particularly interesting?**

6. **What questions do these maps raise that could be researched further?**

SOURCE: M.P Heide-Jorgenson et al/*Biology Letters* 2011