

Changing Climate

Environmental Cycles

Middle School Guide

REACH Up

Raising Educational Achievement
through Cultural Heritage Up

Environmental Cycles

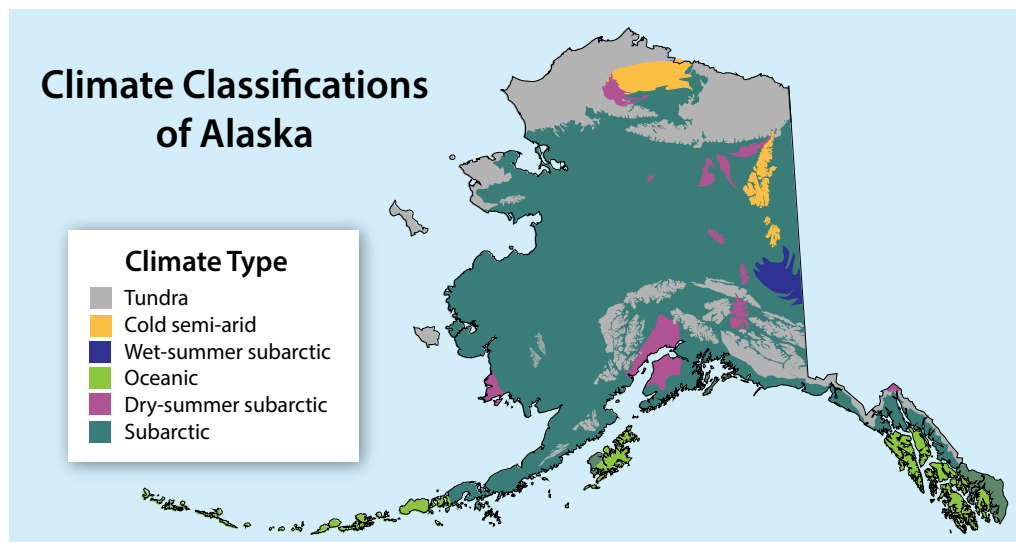
What is Climate?

Climate is the long-term average of weather conditions that occur in a particular region. The Bering Strait region of Alaska includes subarctic and tundra climates. Subarctic climates are characterized as having their coldest months average below 0°C (32°F) and at least one month that averages above 10°C (50°F). Much of Alaska has a subarctic climate in which there is no significant difference in the amount of precipitation between seasons. Some areas get most of their precipitation in winter (dry summer subarctic), while other areas receive most of their precipitation in summer (wet summer subarctic.) The tundra climate is characterized by temperatures that average below 10°C (50°F) in the warmest months. The tundra climate is a subcategory of polar and alpine climates; the other subcategory of polar climate is an ice cap climate, where all twelve months of the year average below 0°C (32°F). Which climate classification describes your community?

Residents across the Bering Strait region report changes to the local climate. Scientists, both local and distant, are working to understand this climate change. The changes have been so extensive and persistent that a New Arctic is emerging.

The New Arctic is warmer, with less sea

ice and shorter winters. In the New Arctic, permafrost is thawing and glaciers are shrinking. Measuring and understanding climate change requires collecting data about the weather and environmental conditions in the area over a long period of time. Both qualitative data (the use of words to describe what is observed) and quantitative data (the use of numbers to describe what is observed) are used in climate science. Qualitative data might include descriptions of visual environmental observations, oral histories of extreme weather events, and photographs of sea ice conditions. Quantitative data about weather, such as temperature, wind speed, and snow depth can be gathered using instruments. What qualitative and quantitative environmental observations do you make? When and why do you observe weather?

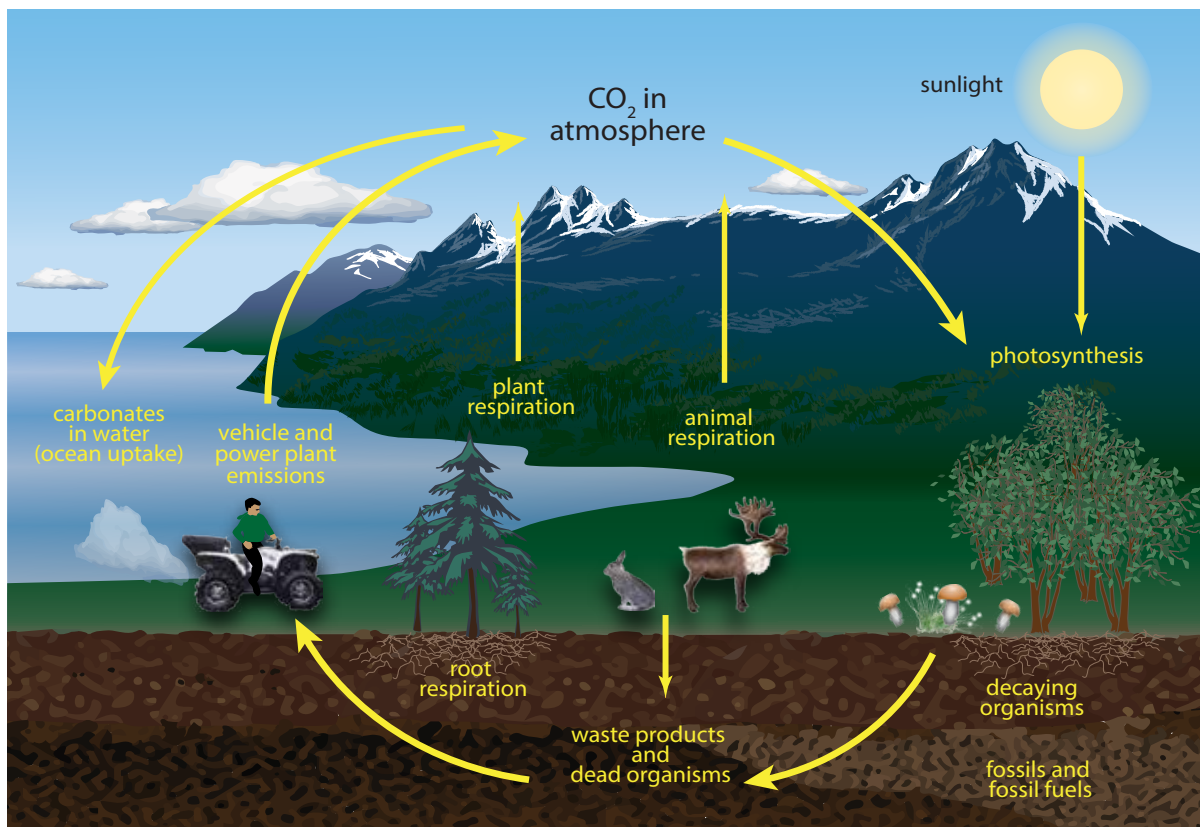


Map based on Wikimedia map "Köppen Climate Types of Alaska." Source: WorldClim.org.



The Carbon Cycle

The compound water (H_2O) exists in different phases and within different regions on Earth. The movement of water between regions is called the water cycle. Another important environmental cycle is the **carbon cycle**. The carbon cycle is the circulation or exchange of carbon between the environment and living things. Carbon is an element. An element is a type of matter that cannot be chemically broken down into a simpler component. Oxygen, hydrogen, and nitrogen are examples of other elements.



Carbon compounds are present in living things such as plants and animals as well as nonliving things such as rocks and soil. Carbon compounds can exist as gasses such as carbon dioxide and as solids such as coal. Carbon is essential for life as living things are based on carbon and carbon compounds.



Carbon Cycle

Carbon atoms move through various regions on Earth, called **reservoirs**. The major reservoirs on Earth (and the approximate amount of carbon they contain) include:

Carbon Reservoir	Amount of Carbon (Gigatons)
Deep Ocean	38,400
Fossil Fuels	4,130
Terrestrial Biosphere	2,000
Surface Ocean	1,020
Atmosphere	720
Sediments	150

Carbon is released to the atmosphere from **carbon sources** that produce carbon dioxide (CO_2), including natural system and human activities. It is stored in **carbon sinks** that hold onto CO_2 , such as plants, animals, soils, rocks, and water.

Plants take CO_2 out of the atmosphere through **photosynthesis**, the process by which they use sunlight to make the food they need from CO_2 and water, and release oxygen as a byproduct. The carbon dioxide is converted into carbon compounds that make up the body of the plants such as shoots, leaves, roots, and fruits.

Animals eat the plants, taking in carbon. They inhale oxygen and exhale carbon dioxide (**respiration**). The carbon dioxide exhaled by animals rises to the atmosphere and is also available for plants to use in photosynthesis.

Plants also release CO_2 back to the atmosphere by respiration, but the amount of CO_2 that plants give off in respiration is far less than the amount that plants take up during photosynthesis.

Plants that are not eaten by animals die and decompose, and the carbon is stored in the soil or released into the atmosphere. The **decomposition** process also creates other gasses such as methane (CH_4).

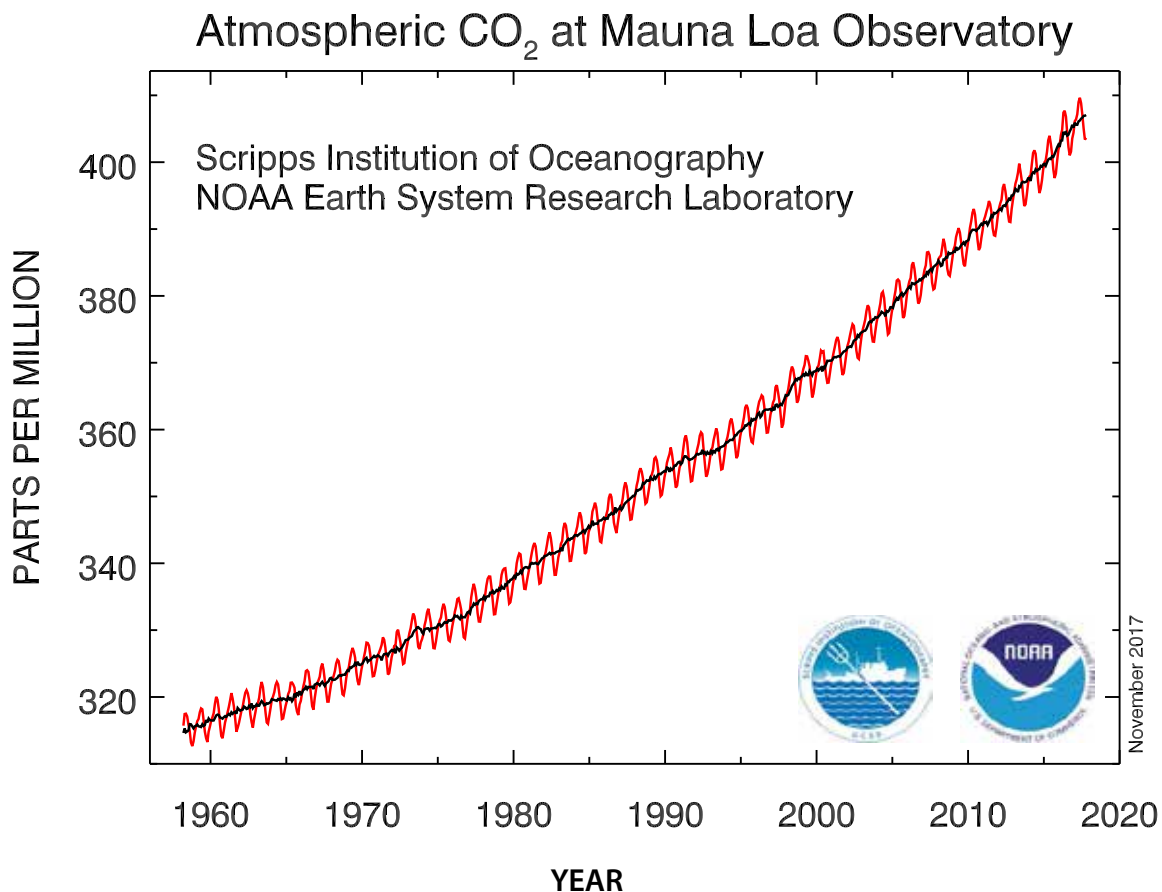
The ocean is the biggest carbon sink on Earth; it absorbs more CO_2 from the atmosphere than the land does. Just like plants on land, tiny organisms called phytoplankton go through photosynthesis and therefore need carbon to make their own food. Phytoplankton are eaten by zooplankton, which are eaten by larger marine life on the food web, such as fish and whales.



Carbon Cycle

Too much carbon dissolved in ocean waters can accelerate ocean acidification, which affects small organisms such as pteropods (or sea butterflies). Species on higher trophic levels such as fish, birds, and whales feed on pteropods and can also be affected by ocean acidification.

Nature works well to balance the carbon available through the carbon cycle. Human activities, however, can tip the balance. By burning fossil fuels like coal, gas, and oil, stored carbon is released into the air, which contributes to warming the Earth beyond optimal levels. Additionally, cutting down trees for development reduces the amount of plants available to remove carbon from the atmosphere.



This graph shows the steady increase in atmospheric carbon dioxide measured at Mauna Loa Observatory in Hawaii between 1958 and 2017. The red curve represents the carbon dioxide data and the black curve represents the seasonally corrected data. Source: NOAA Earth System Research Laboratory, Global Monitoring Division, November 2017.



Ask an Expert

1. Watch the video *Environmental Cycles* available at www.k12reach.org/videos.php.
2. Interview elders or cultural knowledge bearers in your community. Some questions you may want to ask:
 - What was sea ice like in different seasons in the past compared to today?
 - How is climate change affecting sea ice in your area?
 - Have you witnessed any changes in the severity of storms over the years? Could you describe the changes?
 - Have you or someone you know had to make any changes to your hunting or other lifestyle due to changes in sea ice? If so, how?
3. If the person you interview speaks an Alaska Native language, ask them what language and dialect(s) they are familiar with. Ask them to please translate the following words:

- atmosphere
- land animal
- marine animal
- ocean
- plant
- respiration
- sea ice
- soil
- waves



Sean Komonaseak, from the community of Wales, discusses environmental changes he has observed. Photo: Kelsey Skonberg, REACH Up.

Compare your words with the translations on the Environmental Cycles Vocabulary page in this guide. Are any of the terms the same or similar?



Environmental Cycles Vocabulary

Would you like to know Alaska Native language terms related to environmental cycles?

Work with your classmates to practice environmental cycle vocabulary words in English and the indigenous language of your community. Your teacher will give you vocabulary cards with the English word and an illustration on one side. Write the corresponding indigenous term on the blank line on the back of each card. Use the words that you learned from a local elder or cultural knowledge bearer, or choose the translation below that is closest to your community.

Miriam Toolie - Siberian Yupik
St. Lawrence Island Yupik dialect
Savoonga, AK

- atmosphere - **aghtuneq**
- land animal - **qutem teghikusa**
- marine animal - **meghem teghikusa**
- ocean - **imaq**
- plant - **piitesiighaq**
- respiration - **aneghta**
- sea ice - **qelughtaaq**
- soil - **suna**
- waves - **nengulghat**

Becky Atchak - Yup'ik
Northwest dialect
Stebbins, AK

- atmosphere - **cella**
- land animal - **nunamiutaq ungunssiq**
- marine animal - **imarpim ungyngsiq**
- ocean - **imarpik**
- plant - **nauciq**
- respiration - **anerneq**
- sea ice - **cikuq**
- soil - **nevuq**
- waves - **qaiq**

Jolene Nanouk - Iñupiaq
Qawiaraq dialect
Unalakleet, AK

- atmosphere - **sila**
- land animal - **pitaqsrat**
- marine animal - **nassugbiaq**
- ocean - **tagiuq**
- plant - **nausiat**
- respiration - **aniqsaaq**
- sea ice - **tagium sikua**
- soil - **nuna**
- waves - **qailiq**



Activity

You are a Carbon Atom!

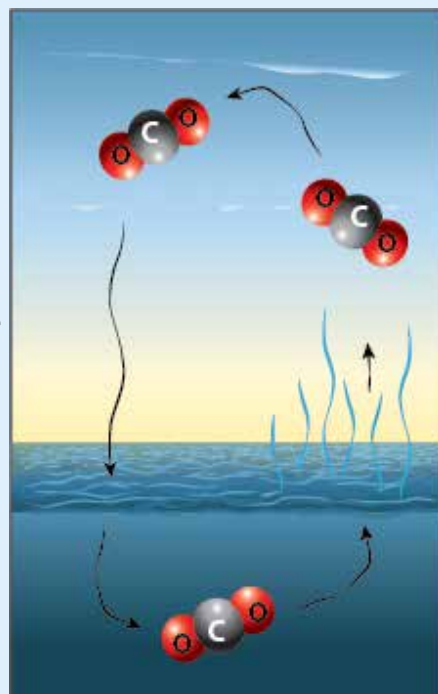
You are a Carbon atom. In this activity, you will learn about the carbon cycle by visiting the places where carbon is stored. The places include Atmosphere, Surface Ocean, Marine Life, Deep Ocean, Land Plants, Land Animals, and Soil.

Materials

- Student Worksheet: *You Are a Carbon Atom!*
- Information Sheet: *Carbon Reservoir Station Cards*

Procedure

1. Pretend you are a Carbon atom. You will be visiting different stations that represent carbon reservoirs. These carbon reservoirs are described on the following pages; the same descriptions will be posted at the stations set up by your teacher. You can start at any place. Using the worksheet, go through all the places and learn facts about you (carbon) in each area.
2. Between each station there are questions. Write your answer to each of the questions in your worksheet.



Discuss

1. Share your results with your classmates.
2. If there is a different opinion about the answers, discuss why you thought your answer was correct.
3. Discuss how carbon circulates.



Carbon Reservoirs

Atmosphere



While you are here in the atmosphere, you will be bonded to two atoms of oxygen to form carbon dioxide (CO_2). CO_2 is only a very small part (0.04%) of the Earth's atmosphere, but it plays a large role in the energy balance of the Earth.

CO_2 in the atmosphere acts like a blanket over the Earth by trapping longwave radiation, which otherwise would radiate heat away from the Earth. CO_2 is the largest contributor to this effect (currently 63%).

Because of burning fossil fuels, such as coal, oil, and natural gas, the amount of CO_2 has increased substantially since the Industrial Revolution. As the amount of CO_2 increases, so will the warming effect.

Surface Ocean



You got here either by diffusing from the atmosphere, by decomposing marine life, or from circulating water from the deep ocean. The ocean absorbs more carbon dioxide (CO_2) from the atmosphere than the land does. (The ocean absorbs 85%, compared to the 15% absorbed by land.) Cold water absorbs more carbon than warm water.

Marine Life



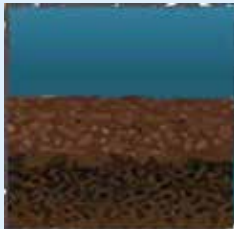
You have been taken up by tiny organisms such as phytoplankton and microalgae, to make the food they need through a process called photosynthesis. In photosynthesis, organisms use sunlight to make their food from carbon dioxide (CO_2) and water. The phytoplankton and microalgae are eaten by zooplankton and invertebrates, which are eaten by larger marine life, such as fish and whales. Carbon is essential for marine life survival, but an excess amount of carbon dissolved in ocean

waters is harmful to marine organisms such as algae, pteropods ("sea butterflies"), shellfish, and corals.



Activity

Deep Ocean



You got here from circulation with the surface ocean and dead and decaying marine life. When carbon gets to the deep ocean, it usually stays there for hundreds of years before moving on. The deep ocean holds more than 65% of the Earth's carbon.

Land Plants



You have been taken out of the atmosphere by a plant for photosynthesis. Photosynthesis is the process by which a plant uses sunlight to make the food it needs from carbon dioxide (CO_2) and water. You are now one of the building blocks (carbon compounds) that make up a plant.

As a byproduct of photosynthesis, plants produce oxygen, which is used by living organisms. Plants also release CO_2 back to the atmosphere by respiration, but the amount of CO_2 that plants give off in respiration is far less than the amount that plants take up during photosynthesis.

Land Animals



You have been taken into the body of an animal from a plant it ate. Carbon is the basic building block to most cells in the body of animals, including humans. Carbon makes up 18% of the human body.

Animals inhale the oxygen made by plants and exhale carbon dioxide (CO_2) as a waste product (respiration) to the atmosphere.

When a carnivore eats another animal, the carbon from the prey animal is transferred to the meat-eater. When an animal dies and its body decomposes, some of the carbon stored within its body gets transferred to the soil.

Soil



The plant or animal you were in has died and you are now a part of the decomposing layer of plants and animals, called detritus. Soil is also made of inorganic materials such as sand, silt, and clay. Soils store about 3% of Earth's carbon. As bacteria and fungi breakdown the detritus, carbon is released back into the atmosphere.



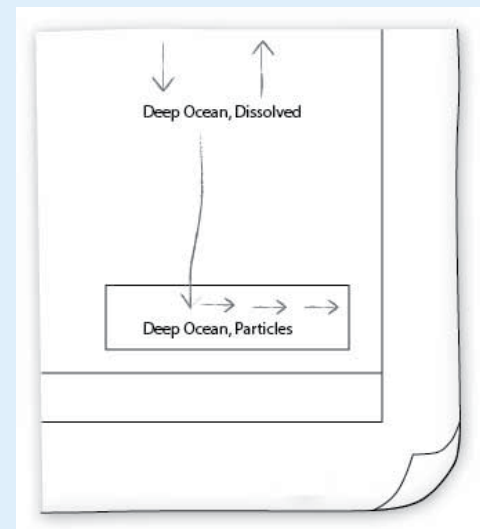
The Carbon Cycle Game

Materials

- Student Worksheet: *Carbon Cycle Game*
- Dice Number Chart
- Dice

Procedure

1. You are a carbon atom moving through the carbon cycle.
2. Next to “1” on the worksheet, write the name of the reservoir where you start (e.g., Atmosphere, Surface Ocean).
3. Roll the die.
4. Consult the Dice Number Chart. The number you roll indicates what reservoir you will visit next; write the name of that reservoir (e.g., Ocean Plants, Land Plants) in the next row of the chart. **Note:** If a die tells you to stay in place for a turn, you should write the name of that reservoir in the next row of the chart before re-rolling.
5. Read about the process that is moving you from one reservoir to another. Then go to your next station as instructed by the die.
6. Repeat 3 – 5 above until you fill out the chart (15 rounds).
7. On the second part of the worksheet, indicate the journey you (the carbon atom) took, using arrows. **Note:** If you stayed in the same reservoir, add a horizontal arrow for each time you stayed in the same reservoir.
8. Compare the cycle your carbon atom experienced with a classmate’s version of the carbon cycle.



Discuss

Discuss the journey you took with the class.

1. Overall, which reservoirs were visited most?
2. Which reservoirs have long residence times and which have short residence times?
3. What are the processes that move carbon from one reservoir to another?
4. Is the carbon cycle a circle?



Diminishing Sea Ice

As you have learned in the previous activities, carbon is essential for life and it is needed in the atmosphere to keep the Earth warm. The amount of carbon is balanced naturally through the carbon cycle, but human activities can tip the balance, contributing to the warming of the global climate.

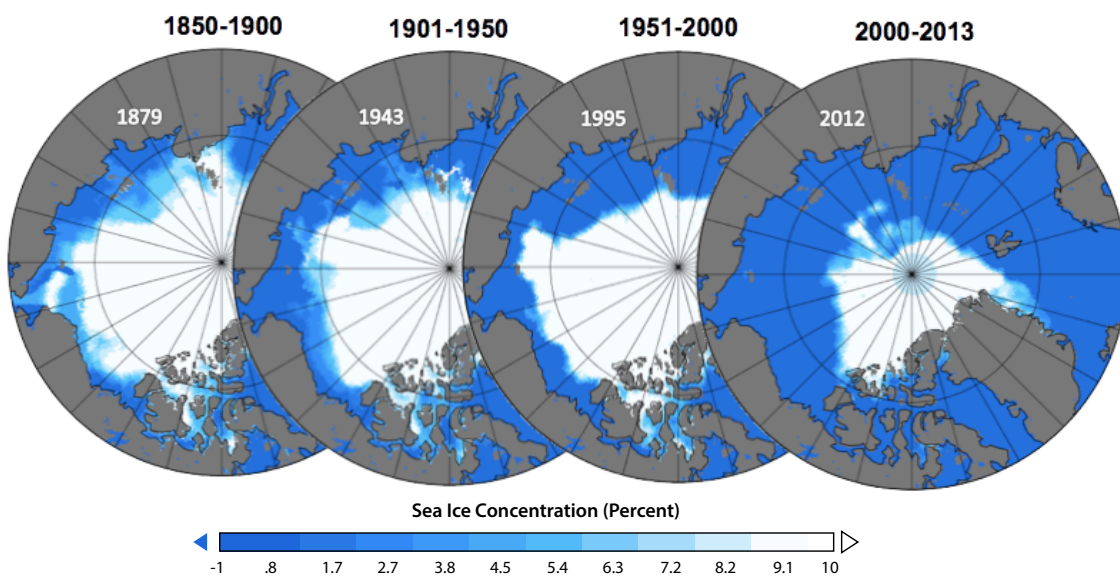
Climate change is manifested in our environment, such as increasing permafrost thaw, vegetation changes, and changes in timing and length of the seasons.

Climate change is also affecting the ocean. When ice is present, less moisture evaporates from the ocean to the atmosphere, and therefore fewer clouds develop. Less sea ice may result in stronger storms due to increased moisture in the atmosphere.



In this 2014 photo, the ice of Kotzebue Sound was breaking up earlier than normal, as is now becoming more commonplace.
Photo: Putt Clark, REACH Up.

Lowest September minimum Arctic sea ice extents



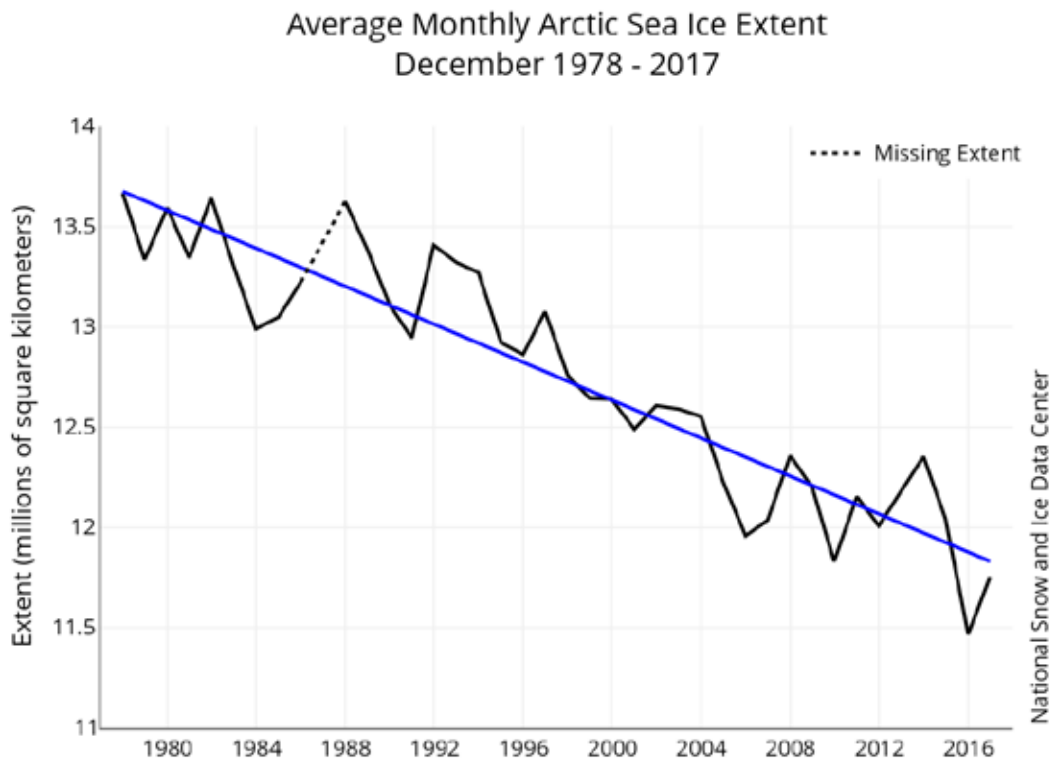
Credit: F. Fetterer, National Snow and Ice Data Center, NOAA.



Sea ice also keeps large ocean waves from forming. Diminishing sea ice, therefore, contributes to significant coastal erosion. National Snow and Ice Data Center reports that in Shishmaref, for example, large waves due to diminishing sea ice have caused serious erosion and storms are now threatening to destroy the village's large fuel storage tanks near the shore. Changes in sea ice, such as thinning and unusual cracks, also impact travel safety, making subsistence hunting more difficult. If the recent trend of less sea ice continues, coastal communities may face even more dire situations.



A fisherman pulls a sled behind his snowmachine on his way out to the ice fishing grounds of Kotzebue Sound.
Photo: Putt Clark, REACH Up.



Monthly December ice extent for 1978 to 2017 shows a decline of 3.7% per decade. Source: National Snow and Ice Data Center, University of Colorado Boulder.



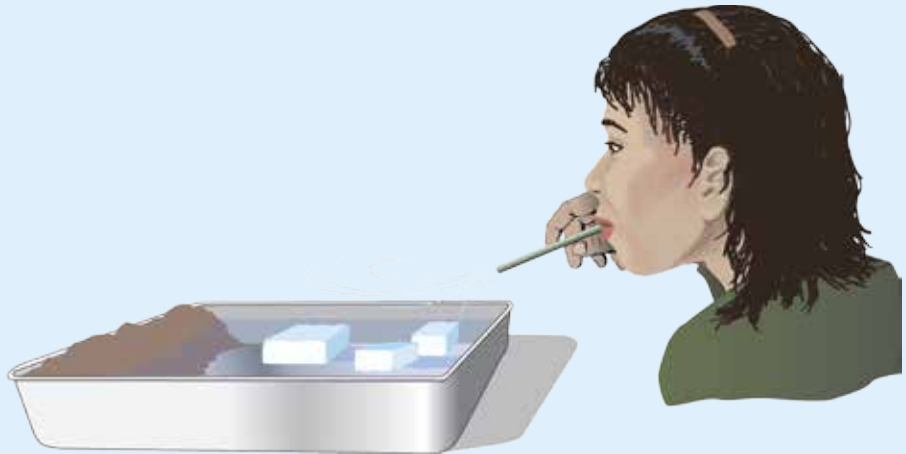
Activity

Does Ice Prevent High Waves?

In the following activity, you will experiment with different types of sea ice and different levels of sea ice cover, and how sea ice loss affects shorelines.

Materials

- Rectangular pan
- Sand
- Water
- Yarn
- Tape
- Straw
- Styrofoam pieces
- Bubble wrap
- Ruler
- Anemometer



Predict

1. What are possible effects of the presence of sea ice on the shore compared to no ice?
2. Which type of ice, *multiyear sea ice* or *first-year sea ice*, do you think protects the shorelines better and why?

Procedure

Part 1: Multiyear Ice

1. You will create a “storm” by blowing into a straw. Try to create a “wind” speed of 10-15mph. Face away from your classmates and test your blowing using an anemometer. Practice several times to check that you can consistently produce a wind speed of 10-15mph.
2. Carefully add sand to the narrow side of the pan. Push the sand with your hand to create a “shelf” of sand that is level with with the top of the pan (or close to the top of the pan). This represents the shore.
3. Carefully fill the rest of the pan halfway to the top with water. The depth of the water should be half the height of the sand. The water represents ocean. Make sure you do not tilt the pan to avoid the sand soaking up water.
4. Place yarn over the shoreline. Secure it on both sides of the pan with tape. The yarn should be placed tightly over the edges of the pan and not sitting in the water.



5. Place Styrofoam pieces to cover 75% of the surface of the water. The Styrofoam pieces represent multiyear sea ice.
6. Hold the straw near the “ocean” side of the pan and blow across the surface of the water several times, using the same rate as you tested with the anemometer (in Step #1). Remember to blow **across** the water, not downward into the water. **Note:** Make sure no one is on the “shore” side of the pan and that your work area is cleared of objects that should not get wet.
7. Observe how the ice and waves move, and what happens on the other side of the sea ice, the shoreline, and beyond. If erosion is observed, place another yarn over the newly formed shoreline and measure the difference between the initial and the newly formed shorelines, using a ruler. Record your observations.
8. Remove $\frac{2}{3}$ of the Styrofoam pieces. Now the “ocean” is covered with 25% sea ice. Repeat Steps 6 and 7. Record your observations.
9. Remove the remaining Styrofoam pieces from the pan. Now the ocean is ice-free (0% ice cover). Repeat Steps 6 and 7. Record your observations.
10. Remove the yarn strings, and proceed to Part 2, the first-year ice experiment.

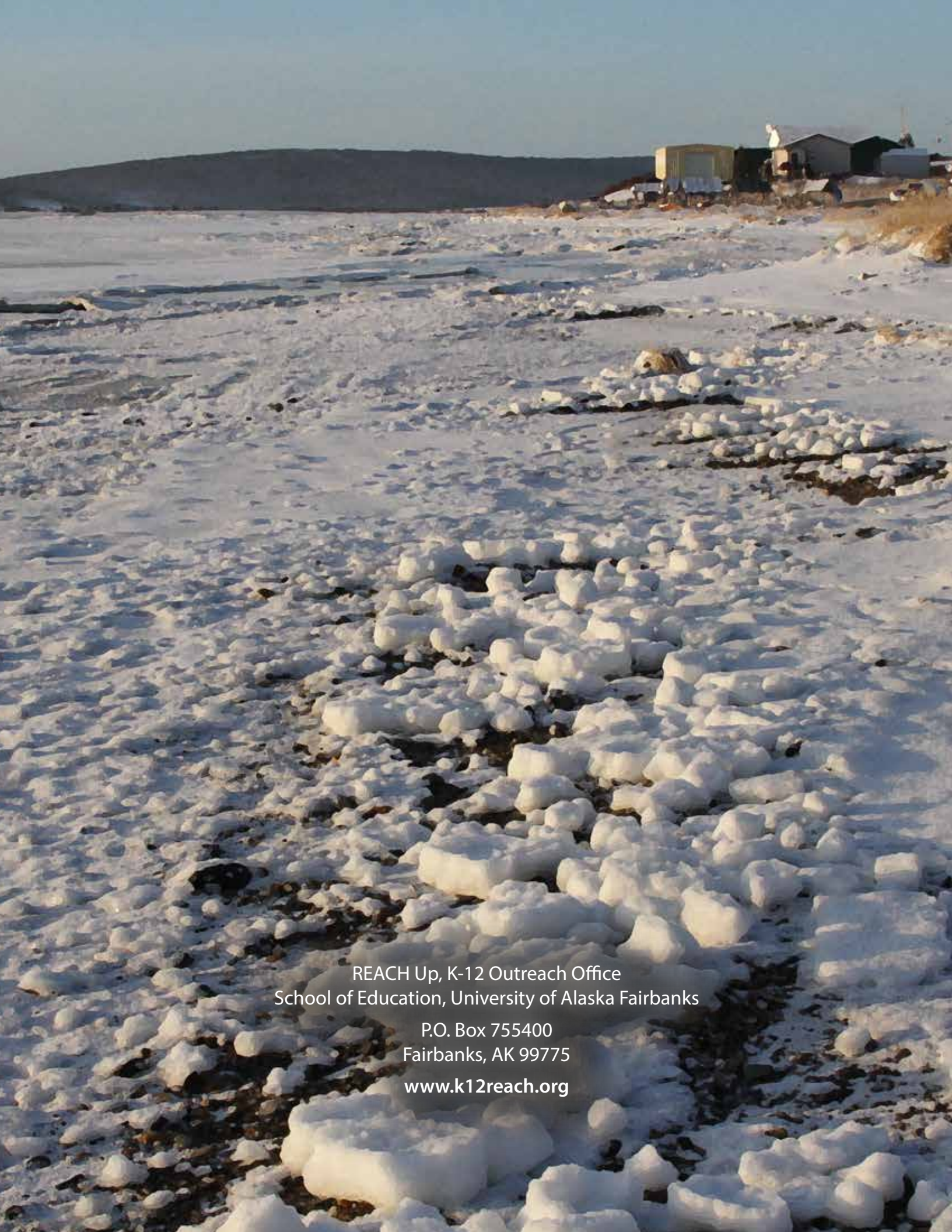
Part 2: First-year Ice

11. Place yarn over the current shoreline and secure it with tape.
12. Place bubble wrap pieces to cover 75% of the water surface. The bubble wrap represents first-year ice. Repeat Steps 6 and 7 above. Record your observations.
13. Remove $\frac{2}{3}$ of the bubble wrap pieces. Now the “ocean” is covered with 25% first-year sea ice. Repeat Steps 6 and 7. Record your observations.
14. Remove all the bubble wrap pieces from the pan. Now the ocean is ice-free (0% ice cover). Repeat Steps 6 and 7. Record your observations.
15. When all data has been collected, clean up the station.

Discuss

1. Compare the results of the multiyear and first-year ice with 75%, 25%, and 0% ice cover.
2. Share your results with the class. Discuss with the class:
 - a. How does sea ice affect the severity of a storm on the shore and the areas beyond the shore?
 - b. What is the impact of sea ice loss as the Earth continues to warm?
 - c. Why do you think sea ice loss is important to coastal communities?
 - d. What steps can we take as individuals and as a community to lessen the warming trend of the globe?





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