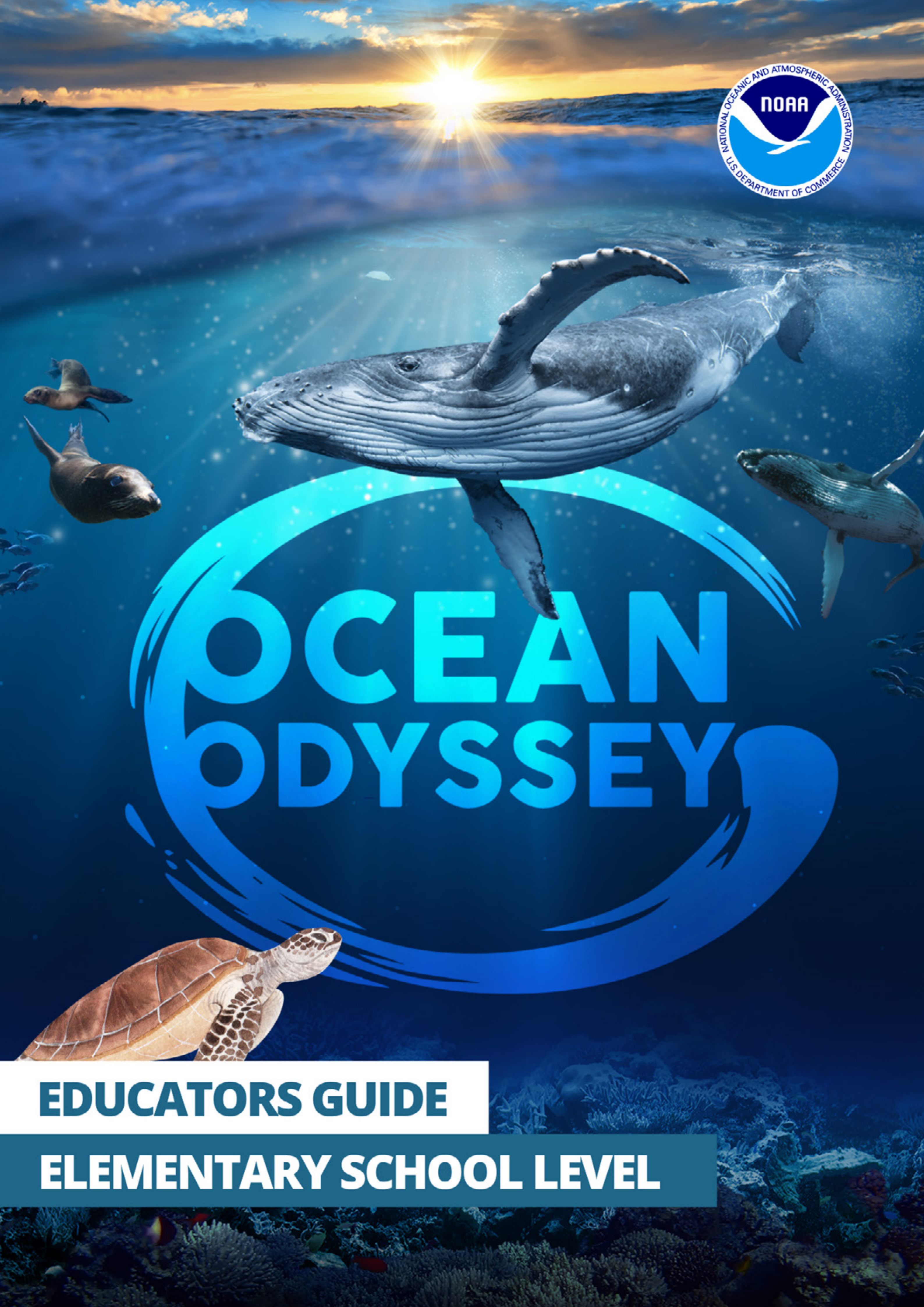

# OCEAN ODYSSEY

## EDUCATORS GUIDE

## ELEMENTARY SCHOOL LEVEL

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# WELCOME TO THE OCEAN ODYSSEY GUIDE FOR EDUCATORS

This guide includes 8 elementary school level lessons, inspired by topics from Ocean Odyssey, a film for IMAX and other Giant Screen theaters. Watching the film is not required to carry out any of these lessons, but can serve to enhance students' learning experience of the topics presented in these activities.

Host-narrated by oceanographer Sylvia Earle, Ocean Odyssey is an immersive film following a mother and calf humpback whale on their migration from the tropics to Antarctica. On this journey, we learn how ocean currents nurture life in diverse environments, including tiny phytoplankton in ocean upwellings, clownfish and anemone in the Great Barrier Reef, seabirds on a subtropical island and endangered nurse sharks in an underwater cave. Connecting it all is the understanding that the ocean and life on land are intricately interconnected.

The challenges facing the ocean and its inhabitants cross geographic and ethnic boundaries. Understanding the ocean and its ecosystems is essential to comprehending and protecting this planet on which we live. This is among NOAA's most important missions, to better understand and protect our ocean and coasts, their ecosystems, and the communities that rely on them.

We must all be stewards for a cleaner, healthier, and more sustainable ocean. The first step in that role is education. We must prepare and inspire today's young people, who will be our leaders tomorrow.

We hope the activities in this guide, and films like Ocean Odyssey which inspired them will help lead you and your students to learn more about our ocean planet, its myriad of wonders beneath the waves, and work to maintain healthy ecosystems that are resilient in the face of change.

## USERS NOTE

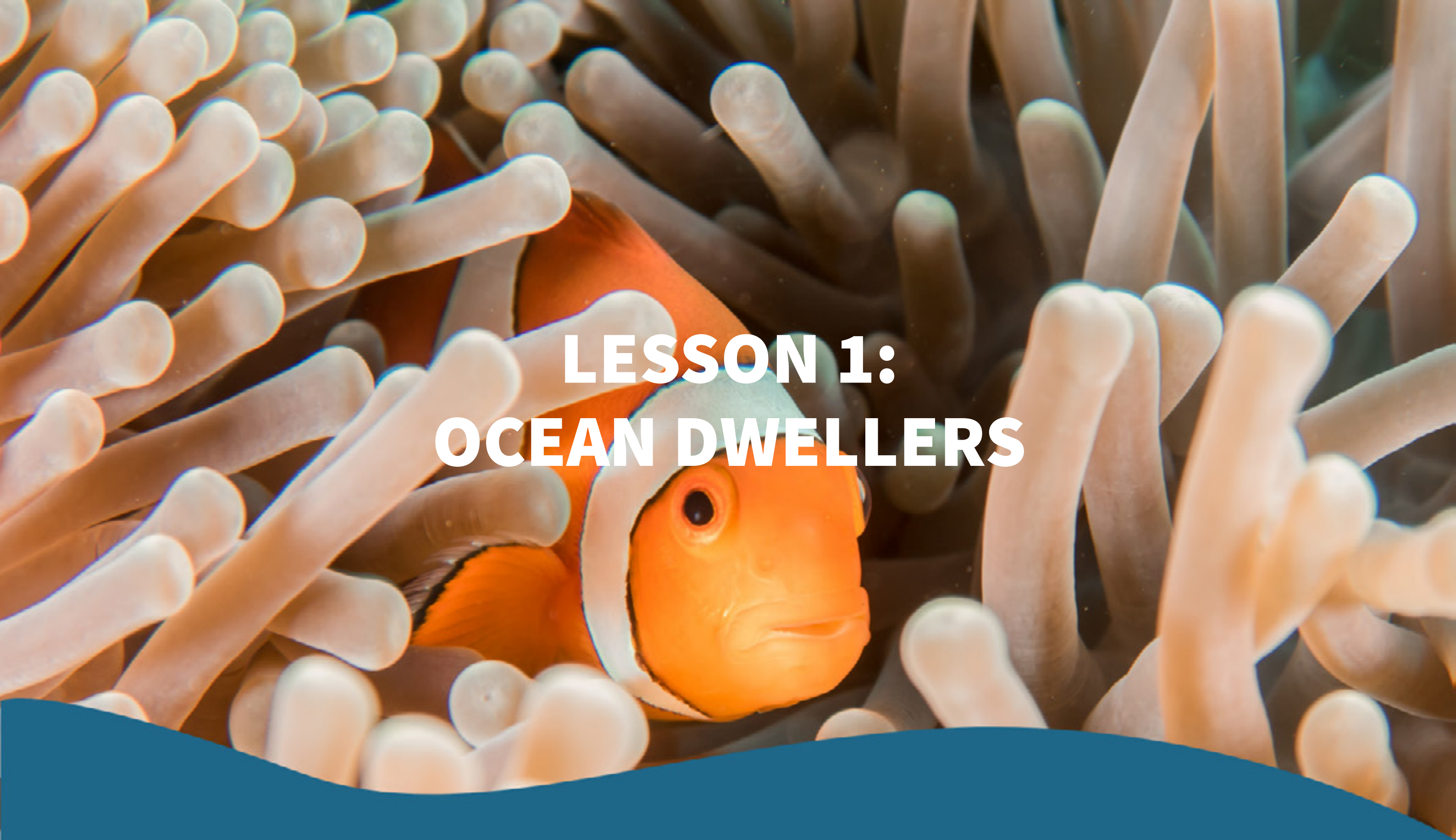
All of the lessons in this guide have been aligned to major national education standards, including the Next Generation Science Standards (NGSS), Ocean Literacy Principles, Common Core State Standards (Mathematics and English Language Arts), and National Geography Standards. Titles or summaries of standards are at the beginning of each lesson. To access the full standards referenced, please see links in the appendix.

These lessons progress for use from younger to older grade bands, but they all contain aspects and resources which may be adapted for all grade bands.

This guide can be downloaded online at https://oceanservice.noaa.gov/education/ocean-odyssey/

You can learn more about Ocean Literacy and how to integrate it into your curriculum at: https://oceanservice.noaa.gov/education/literacy.html

You can discover more ocean topics and educational resources for all ages at: https://oceanservice.noaa.gov/education/



# LESSON 1: OCEAN DWELLERS

## INTRODUCTION

The importance of ocean currents for marine life is clear. Ocean currents serve as nurseries for some animals while others spend their whole lives in them. There are a variety of plants and animals that live in and around the currents, and this biodiversity shows how important the ocean and its currents are for so many living things.

## LESSON SUMMARY

In this lesson, small groups of students use card sets to learn about some of the plants and animals that live in the ocean. They explore where the living thing lives, what it looks like and where it gets its energy. They share information with classmates as they place picture cards on a chart to show the depth at which the living thing lives in the ocean.

## OBJECTIVES

- Students will explore the living things that live in the ocean, including what they look like, where they live, and their predator-prey relationships.
- Students will learn that different living things primarily live at particular depths in the ocean.

## ESTIMATED TIME

45 minutes. If you would like to complete this lesson over 2 days, complete steps 1-3 on day 1 and the remainder of the lesson on day 2.

## STANDARDS ADDRESSED

**Science (NGSS)**: 2-LS4-1. Make observations of plants and animals to compare the diversity of life in different habitats.

## OCEAN LITERACY PRINCIPLES

5a Ocean life ranges in size from the smallest living things, microbes, to the largest animal on Earth, blue whales.

5d Most of the major groups that exist on Earth are found exclusively in the ocean and the diversity of major groups of organisms is much greater in the ocean than on land.

5e The ocean provides a vast living space with diverse and unique ecosystems.

## FOCUS QUESTION

How are living things that live in the ocean similar to and different from each other?

## MATERIALS

- Ocean Dwellers card sets, see "Preparation"
- Ocean Depth Chart master, see "Preparation" for options on how to create the chart and the materials needed
- Tape
- Plain paper, one sheet per student
- Pencils, pens, markers, and/or crayons

## PREPARATION

- Print and cut apart the Ocean Dwellers card sets. Each set should have 4 cards about the same living thing–a card about what it looks like, a card about where it gets its energy, a card about where it lives, and a card with a picture of it. Three of the cards have information and one is a picture of the plant or animal. Each group of 3 students should get 1 set of 4 cards about a living thing. Students will use these sets of cards and will place the picture of the living thing on a chart to show how deep in the ocean it lives.

- If you are not able to project the Ocean Depth Chart master attached to this lesson, or if you prefer to make a larger chart, you can create your own by using three colors of construction or butcher paper. Create a large rectangle of "ocean" with the bottom third of the rectangle made from black paper to represent the midnight zone of the ocean, the middle third made from dark blue paper to represent the twilight zone, and the top third made from paper that is a lighter blue color to represent the sunlight zone. Students will need to place 10 cards with pictures of living things on the chart to show the depth at which they live, so ensure that the overall rectangle is large enough for them to easily tape approximately 3-5 cards per depth level. Add water depth labels along the left side, as shown on the Ocean Depth Chart master.

## FACILITATION

**Step 1**. Ask students if they know any plants or animals that live in the ocean. Have them brainstorm their ideas. They may come up with some ideas, such as sharks, whales, or jellyfish, depending on their experience with the ocean. The students may not have many ideas at this point. Even if that is the case, do not try to prompt them as they will have a chance to learn about different living things through this activity. Tell students that they are going to have a chance to learn about some different plants and animals that live in the ocean and to share what they learn with their classmates.

**Step 2**. Have students work in groups of 3. Give each group a set of Ocean Dweller cards about one living thing (see "Preparation" for more information). Tell them that one student will describe the plant or animal, one will describe what it eats and what eats it, and one will share where it lives. They will need to be able to place the card with the picture of the living thing on the class Ocean Depth Chart (see Preparation).

**Step 3.** Give students time to read their cards to their group and make sure they know what the information means. Your students may have different levels of understanding about the animals listed on the energy cards (1 of the 4 types of cards in the Ocean Dwellers card set), depending on their prior knowledge and experience. Circulate around the room discussing their ideas about the cards and determining if they need additional information about any of the animals. The Monterey Bay Aquarium has an Animals A to Z webpage (https://www.montereybayaquarium.org/animals/animals-a-to-z) that you can share with students to show them pictures and descriptions of animals with which they are not familiar.

**Step 4**. Have each group share what is on their cards and tape the plant or animal picture in the right level of the Ocean Depth Chart to show where the living thing lives. As students are putting their animals on the chart, share that there are three main zones in the ocean where animals live. You may wish to add labels with the name of the three zones that are represented on the chart.

- The **sunlight zone** is from the surface of the water to about 650 feet deep. This is the zone where sunlight can still reach. It also has warmer temperatures because of heat from the sun.
- The **twilight zone** reaches from about 650 feet deep to about 3,300 feet deep. In this depth zone, any sunlight is very faint. Plants would no longer be able to make food in this zone because there is not enough light.

- The **midnight zone** reaches from about 3,300 feet to a little over 13,000 feet deep. The only visible light at this depth is made by animals themselves because light cannot reach this depth.
- Beyond the midnight zone (and not represented on the chart in this lesson), there is the abyssal zone, or the abyss, where the water is near freezing and few animals can survive the pressure, and the hadal zone, which reaches into the deep trenches in the ocean.

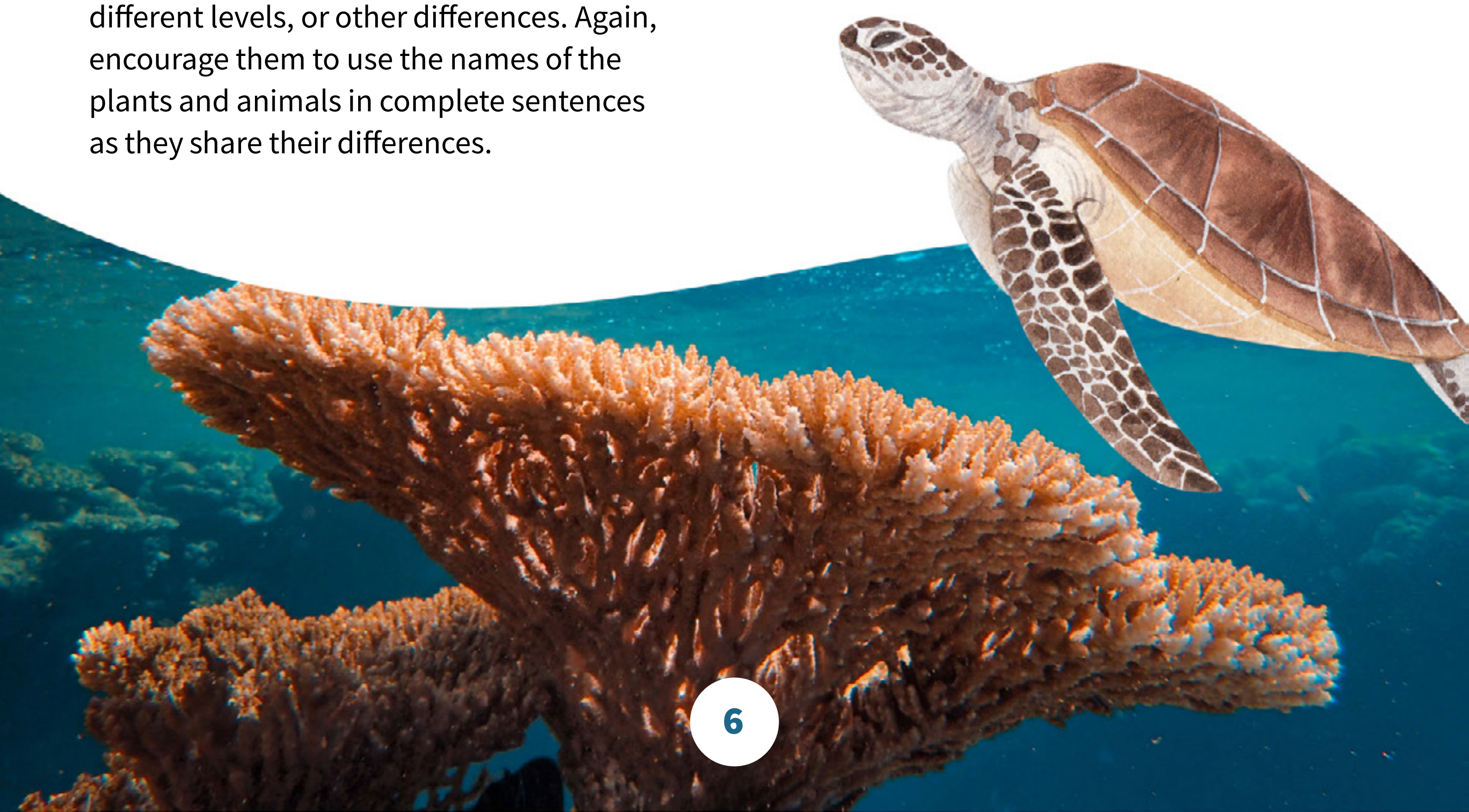
**Step 5**. Once all the animals are on the Ocean Depth Chart, ask students to look for similarities between some of the living things. They might choose 2-3 plants and animals that live in the same level of the ocean, animals that are similar colors, or other similar features. Encourage them to use the names of the plants and animals as much as possible and to share their similarities in a complete sentence.

**Step 6**. Next, have students find differences between some of the living things. They might find plants and animals that have different body shapes, that live in different levels, or other differences. Again, encourage them to use the names of the plants and animals in complete sentences as they share their differences.

**Step 7**. Ask students to draw 2 of the living things on a piece of paper and label them. At the bottom have students write a sentence that starts with one of the following stems.

- These living things are alike because _____.
- These living things are different because _____.

**Step 8. Lesson Summary:** Ask students to think of their favorite plant or animal. Then have them think of three ways that plant or animal is similar to or different from a plant or animal that they learned about in this lesson. You can ask the students to focus specifically on the plant or animal that the small group they were in learned about, or to simply pick one of the plants or animals they heard about during the lesson.



## EXTENSION

Have students choose a plant or animal that lives in the ocean and do research to describe it, list what it eats and what eats it, and how deep in the ocean it lives. Discuss the diversity, or the many kinds of plants and animals that live in the ocean. Some NOAA resources that teachers may use to guide their student's research include the following.

- Marine Life Resource Collections (https://www.noaa.gov/education/resource-collections/marine-life)
- Regional Activity Books (https://oceanservice.noaa.gov/education/regional-activity-books.html)
- National Marine Sanctuaries Resources (https://sanctuaries.noaa.gov/education/students/)
- Estuary Education Resources (https://coast.noaa.gov/estuaries/curriculum/index/students/)

# OCEAN DEPTH CHART

250 feet

500 feet

750 feet

1000 feet

1250 feet

1500 feet

1750 feet

2000 feet

2250 feet

2500 feet

2750 feet

3000 feet

3250 feet

3500 feet

3750 feet

4000 feet

4250 feet

4500 feet

4750 feet

5000 feet

## Kelp: What does it look like?

Kelp are large, brown algae, which are a type of seaweed. They make their own food, like land plants, and can form forests underground. The forests help to protect many animals. The animals can hide from rough storms or other animals.

## Kelp: How does it get energy? What gets energy from it?

Kelp and other algae are like underwater plants because they get their energy from the Sun. It grows in shallow water so sunlight can reach it.

Some of the animals that eat kelp are sea urchins, sea otters, and spiny lobsters.

## Kelp: Where does it live?

Kelp lives in shallow, cold, open water. They usually grow in the ocean between 49 and 131 feet deep.

## Giant Pacific Octopus: What does it look like?

Giant Pacific Octopuses have very large heads and eight legs. They are usually a reddish-brown color. They can change colors and textures to blend in with what is around them.

## Giant Pacific Octopus: How does it get energy? What gets energy from it?

Giant Pacific Octopuses hunt at night. They mostly eat shrimp, clams, lobsters and fish.

Some animals that eat Giant Pacific Octopuses are seals, sea otters, sharks and large fish.

## Giant Pacific Octopus: Where does it live?

Giant Pacific Octopuses get their name because they live in the Pacific Ocean. They live in shallow water to almost a mile deep. Most often, they live in water about 16 feet deep.

## Anglerfish: What does it look like?

Anglerfish have large heads and sharp teeth that are see-through. These fish are dark gray or dark brown. They range in size from 1 foot to 3 ½ feet.

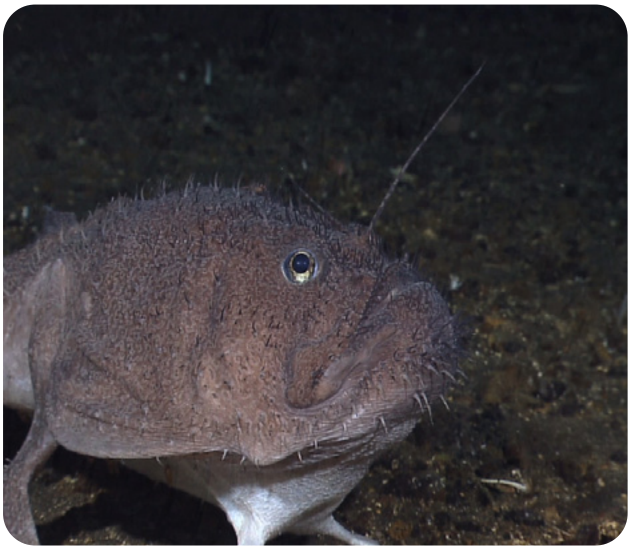
## Anglerfish: How does it get energy? What gets energy from it?

Anglerfish eat shrimp, small squid, turtles, and small fish. They are not picky and will eat almost anything that will fit in their mouths.

In general, anglerfish do not have predators that eat them. Humans can catch and eat them.

## Anglerfish: Where does it live?

Anglerfish live in the Atlantic and Antarctic Oceans. Some live in shallow water. Most of them live up to a mile (5,280 feet) deep in the ocean where no sunlight can reach.



## Tube Worm: What does it look like?

There are different kinds of tube worms. The tube worms that live in the Gulf of Mexico can grow to be 10 feet long. They grow slowly and can live over 250 years. They live in clusters of hundreds of tube worms. The tube worms are white with red at the end. They do not have mouths, eyes, or stomachs.

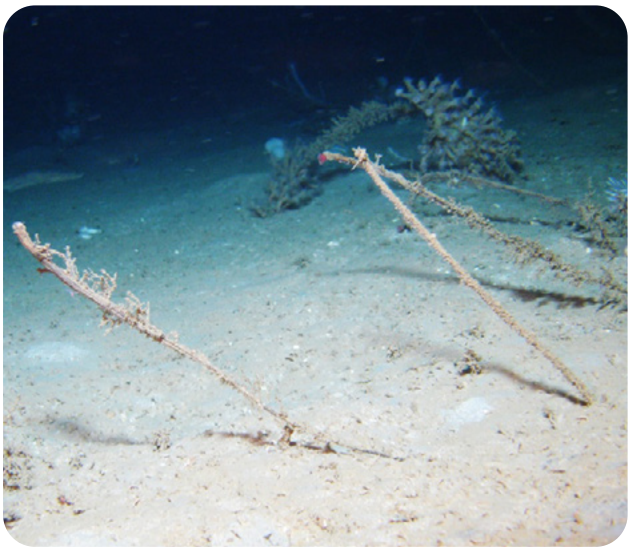
## Tube Worm: How does it get energy? What gets energy from it?

Tube worms get energy from bacteria that live within their bodies. The tube worms live in places where their bacteria get what they need to make energy. The tube worms and bacteria live together so both get what they need.

Many kinds of fish eat tube worms to get energy.

## Tube Worm: Where does it live?

There are many different types of tube worms. One type of tube worm lives in the Gulf of Mexico. It stays at about 2,000 feet deep.



## Jellies: What does it look like?

Jellyfish are dome-shaped bodies with tentacles. They do not have spines, so jellies are a better name for them than jellyfish. The smallest jellies are about half an inch wide. The largest can be 6 feet wide. The tentacles on these large jellies can be more than 49 feet long!

## Jellies: How does it get energy? What gets energy from it?

Jellies eat almost anything they run into. Most eat plankton, which are tiny living things that drift along in the water. Larger jellies can also eat small fish and shrimp.

Sea turtles, fish, and even other jellies get their energy from eating them.

## Jellies: Where does it live?

Jellies are found in all of the world's oceans. They are found in shallow and deep water, between 985 feet and 4,500 feet deep.

## Horseshoe Crab: What does it look like?

Horseshoe crabs have a hard, rounded shell that is brownish-green. They have 10 legs and 10 eyes. Females can be 18-19 inches long while males are a little smaller. They are tan to dark brown in color.

## Horseshoe Crab: How does it get energy? What gets energy from it?

Horseshoe crabs eat small clams, worms, and algae. They do not have teeth, so they crush their food with their legs before they put it in their mouths.

Sharks, sea turtles, and seagulls eat horseshoe crabs. Horseshoe crab eggs are also an important food for these animals.

## Horseshoe Crab: Where does it live?

Horseshoe crabs live in the Atlantic Ocean, Pacific Ocean, and Indian Ocean. Adults prefer shallower water, up to 90 feet deep.

## Clownfish: What does it look like?

Clownfish are yellow, orange, or a reddish color. Many of them have white stripes. They are usually 3-6 inches long.

## Clownfish: How does it get energy? What gets energy from it?

Clownfish mostly eat plankton and algae. They can eat other small foods in the ocean.

Clownfish are food for large fish, eels and sharks.

## Clownfish: Where does it live?

Clownfish live in the Indian Ocean, Pacific Ocean, and along the Great Barrier Reef. They are usually found in shallow water, from about three feet to about 40 feet deep.

## Sea Lion: What does it look like?

Sea lions are large animals. California Sea Lion males are up to 8 feet long and can weigh up to 660 pounds! They have short, thick hair and a big chest and belly. They can walk on all 4 flippers.

## Sea Lion: How does it get energy? What gets energy from it?

Sea lions eat fish, squid,and octopus.

Sea lions are large animals. Their predators are orcas and sharks.

## Sea Lion: Where does it live?

Sea lions live along the coasts of North and South America, Australia and Asia. They live in shallow water but can dive as deep as 600 feet to get fish and squid.

## Orca Whale: What does it look like?

Orcas are very large. Males are 20 to 26 feet long and can weigh up to 12,000 pounds. They have black on the upper side of their bodies. They are white on the underside of their bodies.

## Orca Whale: How does it get energy? What gets energy from it?

Orcas get energy from eating fish, birds, sea turtles and other animals.

Orcas are large and do not have any predators.

## Orca Whale: Where does it live?

Orcas live all over the world. They can live in different temperatures of water. Scientists think that they mostly live between 850 to 1,500 feet deep in the water.

## Blacktip Reef Shark: What does it look like?

Blacktip Reef Sharks have dark backs and white bellies. They also have black tips on their fins. They have short, round snouts and teeth that look like a saw.

## Blacktip Reef Shark: How does it get energy? What gets energy from it?

Blacktip Reef Sharks mainly eat fish.

Other sharks and large grouper fish can eat the Blacktip Reef Sharks for energy.

## Blacktip Reef Shark: Where does it live?

Blacktip Reef Sharks live in the Pacific Ocean along Thailand, Japan, the Philippines and Australia. They can also live in the Indian Ocean. These sharks live in water from about 65 to 250 feet deep.

# LESSON 2: EARTH’S WATER MOVES

## INTRODUCTION

The ocean is one body of water that is interconnected across the world. Ocean currents serve as nurseries for some animals while others spend their whole lives in them. There are many kinds of plants and animals that live in and around ocean currents. This biodiversity shows how important the ocean and its currents are for so many different types of living things.

## LESSON SUMMARY

In this lesson, students have a chance to see how much of Earth is covered by water using a map and mathematics skills. They use an investigation to see one way that water moves around the world then consider why these currents are important for living things.

## OBJECTIVES

- Students will be able to describe how much of the Earth is covered by water.
- Students will explore ocean currents and gyres.
- Students will learn the locations of the major ocean gyres across the world, and what moves with these currents.

## ESTIMATED TIME

60 minutes. If you would like to complete this lesson over 2 days, consider pausing the lesson between steps 5 and 6.

## STANDARDS ADDRESSED

**Science (NGSS)**: 2-ESS2-2. Develop a model to represent the shapes and kinds of land and bodies of water in an area.

## OCEAN LITERACY PRINCIPLES

1a The ocean as a defining physical feature of our planet

1c "Global ocean conveyor belt"

3a The interaction of oceanic and atmospheric processes controls weather and climate.

3c Heat exchange between the ocean and atmosphere can result in dramatic global and regional weather phenomena.

3f The ocean has had, and will continue to have, a significant influence on climate change.

3g Changes in the ocean-atmosphere system can result in changes to the climate that in turn, cause further changes to the ocean and atmosphere.

**Mathematics (CCSS):** 2.MD.D.10 Draw a picture graph and a bar graph (with single-unit scale) to represent a data set with up to 4 categories. Solve simple put-together, take-apart, and compare problems using information presented in a bar graph.

**Geography**: Standard 1.4 The interpretation of geographic representations.

Standard 3.2 The distribution of people, places, and environments form spatial patterns across Earth's surface.

## FOCUS QUESTION

- Print and cut apart the Ocean Dwellers card setside, as shown on the Ocean Depth Chart master.

## MATERIALS

- Map that includes the area where students live and the nearest ocean, to project or display. Students should be able to clearly see where they live and the nearest ocean basin on the map, so a map with colors and state/country boundary lines may be helpful depending on your location. Maps on the Internet often allow for different views or layers, which will allow you to project a version that will support your students.
- World Map handout, one per student and one to project using a document camera or LCD projector

- Markers, crayons, or colored pencils, in sets of one blue and one green or brown. One set per 1-2 students.
- Small paper straws, one per student. Please do not use plastic straws as they are a major source of litter, marine debris, and have a very detrimental impact on all types of animals living on land and in the ocean. Paper straws can be placed in paper recycling following use.
- Baking dish or pie pan, one per group of 4 students
- Enough water to fill each baking dish or pie pan to a depth of approximately 1 inch
- Coarse ground pepper
- Gyres of the world handout, see "Preparation"

## PREPARATION

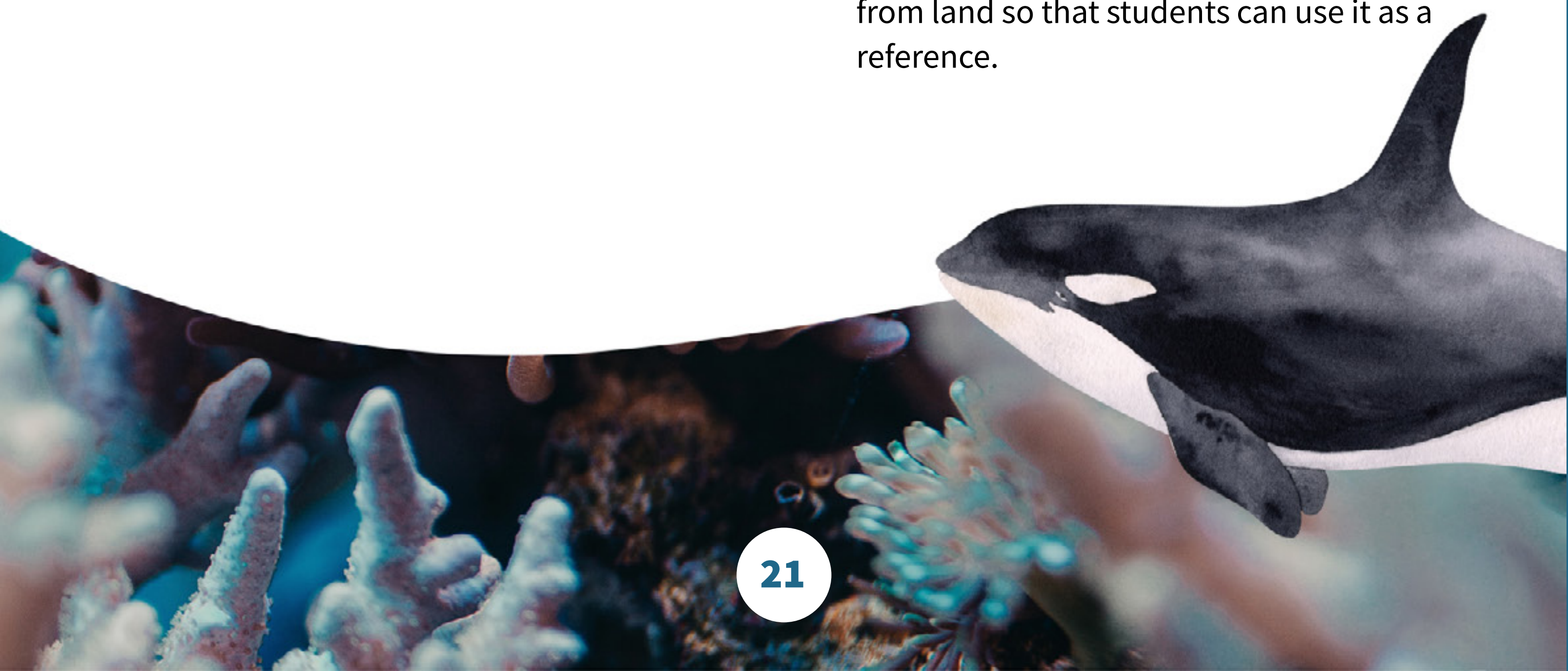
- Make enough copies of the Gyres handout for each group of 2-3 students to have one description. There are 4 descriptions per handout, so for a class of 30 (with 10 groups of 3 students) make 3 copies of the handout. Cut apart the descriptions.

## FACILITATION

**Step 1**. Project or display a map that includes where your students live in relation to the nearest ocean. Help students locate where they live and the nearest ocean on the map. For your own information, and to share with students as it comes up, the ocean is one body of water that is interconnected across the world. Ocean basins are bounded by the continents and have distinct characteristics. The ocean basins include the North and South Pacific, North and South Atlantic, Indian, and Arctic Ocean basins. Scientists also recognize the Southern Ocean, which circles Antarctica.

**Step 2**. Help students understand that the ocean is a very large body of water that is all interconnected. You might have them compare the closest ocean basin to a pond, lake, or river that is close to where they live and is visible on the map.

**Step 3**. Tell students that you can get an idea of how big the ocean is based on the map. Distribute the World Map handout. Ask students to color in squares that are all or mostly water with blue and squares that are all or mostly land with green or brown. You may wish to also display a world map that shows water in a different color from land so that students can use it as a reference.



**Step 4**. When students have colored in all the squares, ask them to count the number of blue squares and record that number in the appropriate place on the handout. Have them do the same for the number of brown squares.

**Step 5**. Ask students to draw a bar graph to show the amount of land and the amount of water on Earth. To do this, they should graph the number of squares they counted for each surface. Then have students compare how much of the Earth is covered in water versus land. They should be able to say that there is more water than land on Earth. About 70 percent of the Earth's surface is covered by water, so the bar for that surface should be more than twice as high as the bar for land.

**Step 6**. Share with students that there is more to the ocean than the map shows. The wind affects the way the water in the ocean moves. Have the students complete the activity in the NOAA resource, How It is Currently Done (https://www.weather.gov/jetstream/ll_current). Ask them, what is happening when the "wind" is blowing the water?

## How it is done:

The constant pushing of air molecules into each other is the reason we feel wind. As one molecule bumps into another, it transfers energy into the next molecule. The wind constantly pushing on the ocean's surface also transfers energy to the water.

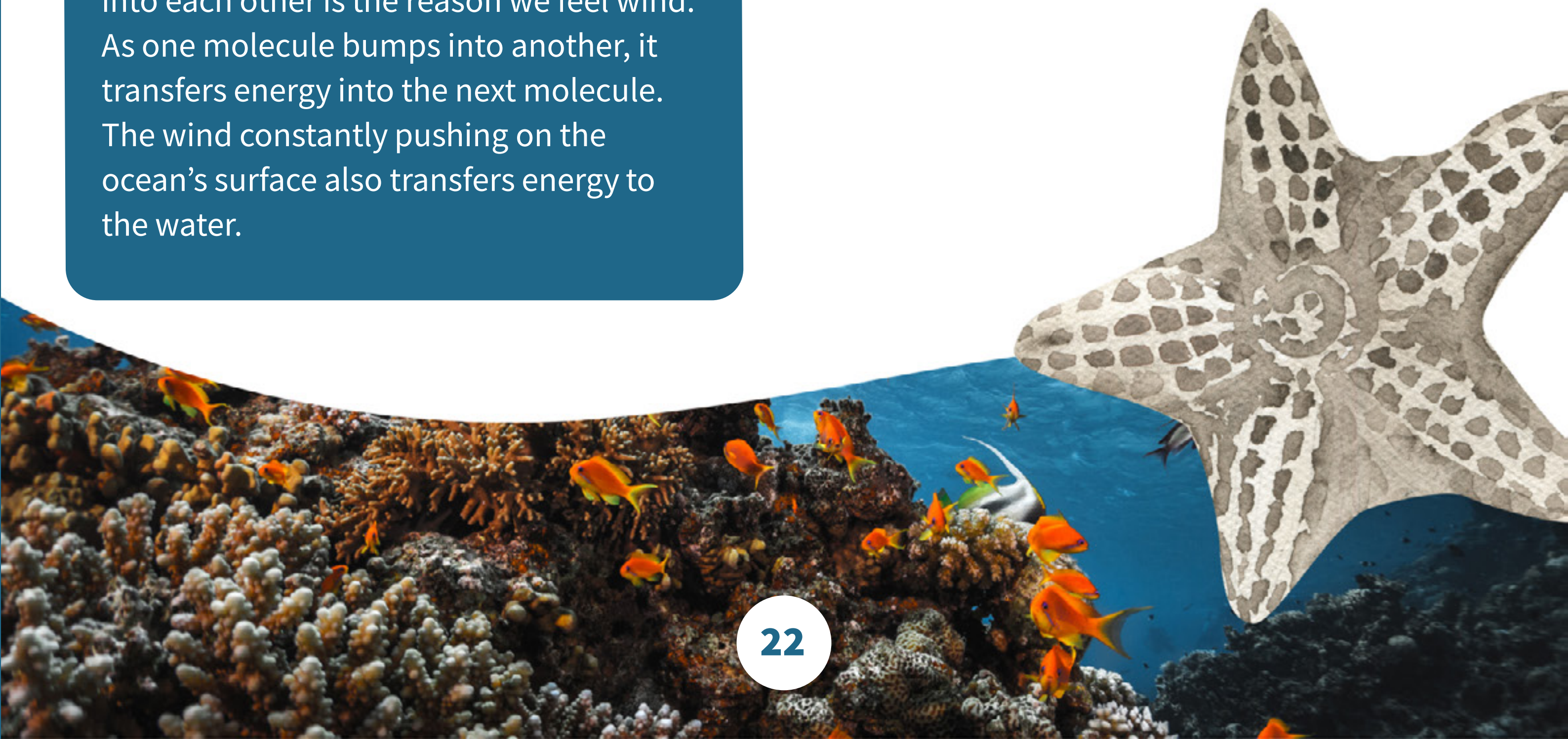
This energy transfer is responsible for the motion of the world's ocean currents. Students will make their own ocean currents using straws and black pepper.

**Total time:** 10 minutes

**Supplies:** One small paper straw per student, one baking pan (or pie pan) for each group of 4 students, coarse ground black pepper

## Procedure:

1. Fill the baking pan with water to about 1 inch deep.
2. Position one student on each corner of the pan.
3. Sprinkle some black pepper in one corner of the baking pan.
4. At each corner position, have the students aim their straw along the side of the pan to their left.
5. Have each student gently blow through the straw across the top of the water and observe the motion of the pepper.



**Step 7**. Tell students the following information.

As you've seen, one of the ways that water moves is because wind blows it. In the oceans, there are five areas where winds and the rotation of Earth cause major, permanent currents. The water in these currents travel in a circular motion over thousands of miles. These currents are known as gyres.

For additional discussion: The wind systems over the Atlantic and Pacific Oceans in the northern hemisphere move in a clockwise motion. The wind transfers some of its energy to the sea surface generating currents in the same clockwise direction. In the Southern Hemisphere, the wind moves in a counter-clockwise motion. As a result, the ocean's currents also move in a counter-clockwise direction.

**Step 8**. Divide students into groups of 2-3 and give each group a description from the Gyres handout. Have them read the information and determine how they would draw the gyre on the map. You will likely have multiple groups with the same information. When groups share, they can discuss if all groups agree on where to draw the gyre.

**Step 9**. Project the world map handout and hold a class discussion about the location of the gyres. Point out where North America is and ask if, in the previous step, any groups read about a gyre that was near that continent. Have one of the groups come forward to point out where their gyre should be. If you are projecting the map onto a board, have them draw the gyre where it belongs. If you are projecting on a screen or have a physical map, give them one of your prepared pictures of a gyre and have them tape it where it goes. If more than one group had the same description, allow one group to share where they think the gyre should go and allow the other group to agree or share their ideas.

**Step 10**. Share with students that the currents in the ocean help to move heat and warm water, food, and salt around the world. These materials help plants and animals, including humans, live by bringing nutrients to different parts of the world and spreading heat out across the globe.

## EXTENSION

If your students are interested in the gyres, a NOAA resource called JetStream Max: Major Ocean Currents (https://www.weather.gov/jetstream/currents_max) is an interactive map that can help students visualize the different currents. If you would like to have your students explore this, share the link with them, along with the information in the following table that includes the currents associated with each gyre, and in different parts of the ocean. Students can check the specific currents to see where the water in the gyre is warm and where it is cold, so they can look for patterns in both the temperature and direction of the water.

| Gyre | North Atlantic | South Atlantic |
| --- | --- | --- |
| Currents | • Gulf Stream<br>• North Atlantic<br>• Canary<br>• North Equatorial | • South Equatorial<br>• Brazil<br>• West Wind Drift<br>• Benguela |

| North Pacific | South Pacific | Indian |
| --- | --- | --- |
| • North Equatorial<br>• Kuroshio<br>• North Pacific<br>• California | • West Wind Drift<br>• Peru<br>• South Equatorial<br>• East Australia | • West Wind Drift<br>• West Australia<br>• South Equatorial<br>• Agulhas |

# WORLD MAP


Pacific Ocean
Australia &Oceania
Asia
Indian Ocean
Arctic Ocean
Europe
Africa
Atlantic Ocean
Southern Ocean
South America
North America
Pacific Ocean

## North Atlantic Gyre

- This gyre makes a large circle.
- It is north of the equator.
- It is east of North America.
- It is west of Europe and Africa.

## North Pacific Gyre

- This gyre makes a large circle.
- It is south of the equator.
- It is east of South America.
- It is west of Africa.
- .

## South Atlantic Gyre

- This gyre makes a large circle.
- It is north of the equator.
- It is east of Asia.
- It is west of North America.

## South Pacific Gyre

- This gyre makes a large circle.
- It is south of the equator.
- It is east of Australia.
- It is west of South America.

# LESSON 3: THE LIVES OF HUMPBACK WHALES

## INTRODUCTION

Every year, humpback whales make a grand migration. During this journey, the whales travel thousands of miles, communicate with one another and look out for predators. The whales spend summers feeding in the areas around Alaska, Washington and Oregon, then migrate to warmer waters in the winter to breed. Baby whales make these journeys alongside their mothers, meeting many of the milestones of their life. In this lesson, students have an opportunity to explore more about the milestones in a whale's life and compare it to their own development.

## LESSON SUMMARY

In this lesson, students work in small groups to compare the life milestones that are similar and different between humans and humpback whales. They consider that humpback whales travel in pods, and use evidence to explain why this strategy helps the whales survive.

## OBJECTIVES

- Students will explore the milestones in humpback whales' lives and compare them to human milestones.
- Students will describe evidence for why humpback whales might travel in pods.

## ESTIMATED TIME

60 minutes. If you would like to complete this lesson over 2 class periods, consider pausing the lesson between steps 6 and 7.

## STANDARDS ADDRESSED

**Science (NGSS):** 3-LS1-1. Develop models to describe that organisms have unique and diverse life cycles but all have in common birth, growth, reproduction, and death.

3-LS2-1. Construct an argument that some animals form groups that help members survive.

## OCEAN LITERACY PRINCIPLES

5d Ocean biology provides many unique examples of life cycles, adaptations, and important relationships among organisms that do not occur on land.

7b Our survival hinges on understanding the ocean.

7d (with extension) New technologies, sensors, and tools are expanding our ability to explore the ocean.

## FOCUS QUESTION

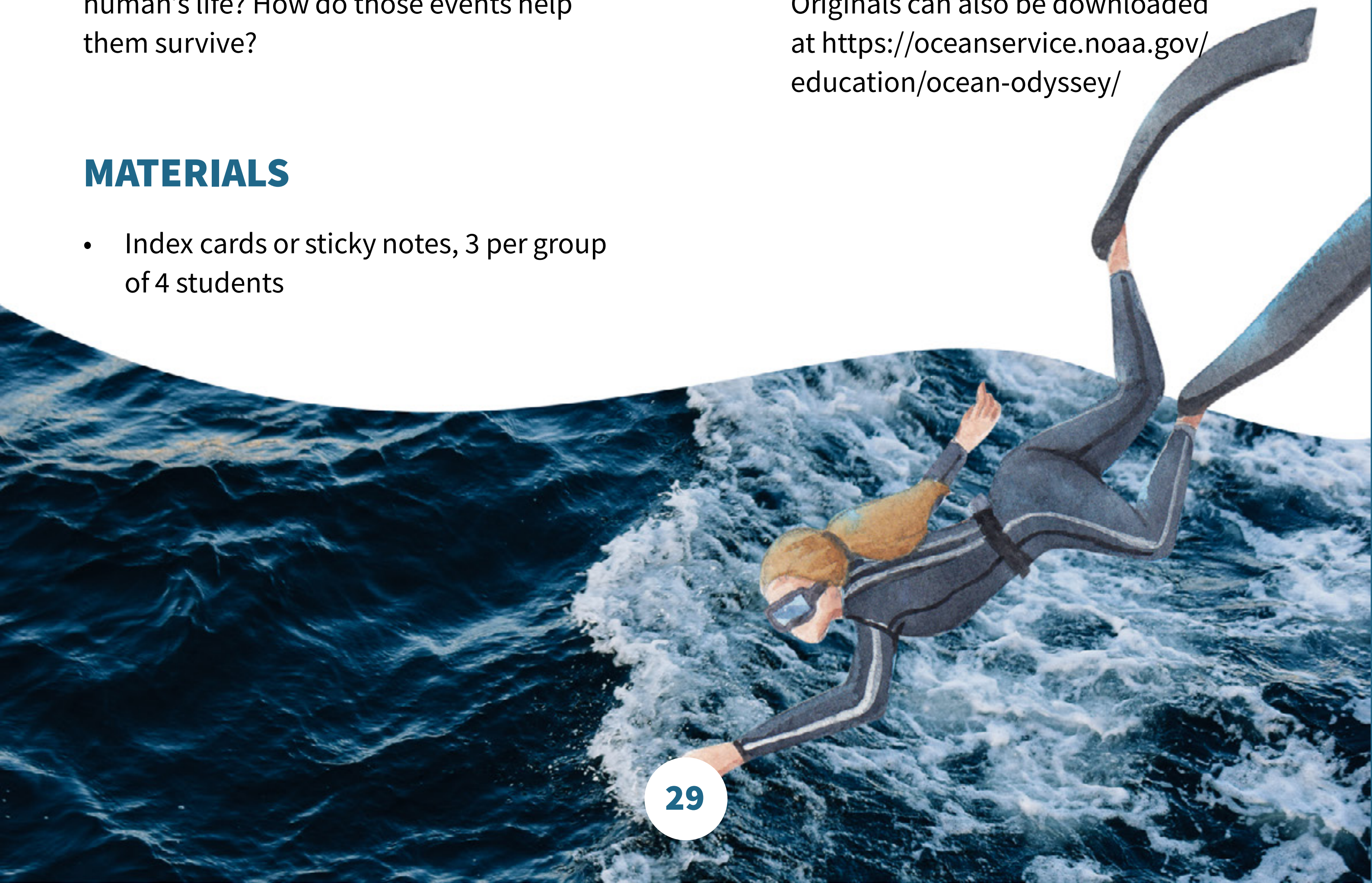
What are the significant events in a humpback whale's life compared to a human's life? How do those events help them survive?

## MATERIALS

- Index cards or sticky notes, 3 per group of 4 students
- Whale Milestone card sets, one per group, see "Preparation"
- Human Milestone card sets, one per group, see "Preparation"
- Humpback Whale Pods handout, one per student

## PREPARATION

- Make copies of the Whale Milestone card set and the Human Milestone card set so that each group of students has 2 complete sets to use. Consider whether you would like to laminate the card sets so that they may be reused for additional classes of students.
- Cut apart the Whale Milestone card set and the Human Milestone card sets and organize them so that you can provide groups of students with 2 complete sets of cards. Consider making laminated copies of the cards for multiple uses. Originals can also be downloaded at https://oceanservice.noaa.gov/education/ocean-odyssey/



## FACILITATION

**Step 1**. Tell students that they are going to have an opportunity to learn about humpback whales and their lives. Share the information from the introduction to this lesson, making the point that baby whales make these long journeys just as adults do. Let students know that in this lesson they will have the opportunity to learn more about the milestones, or significant life events, in a humpback whale's life.

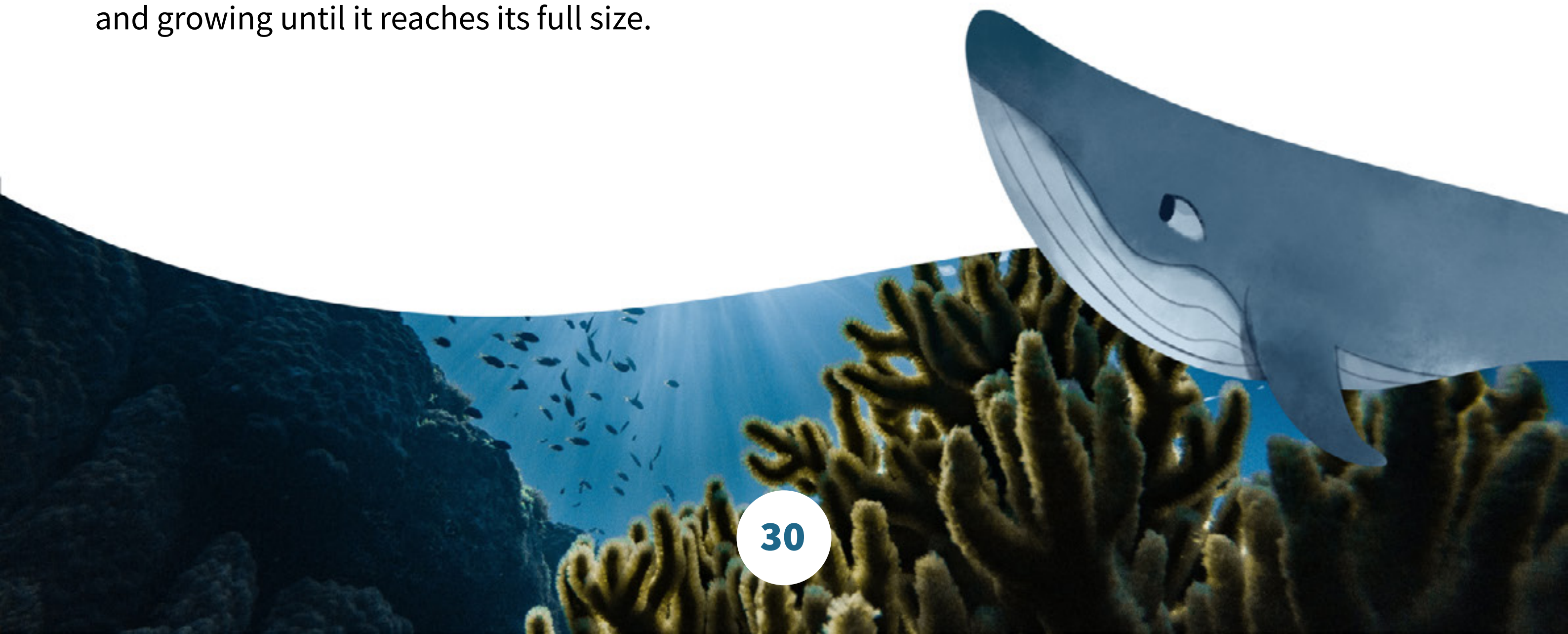
**Step 2**. Ask each group of 4 students to use index cards or sticky notes to make labels for 3 categories. The labels should be "baby," "growing," and "adult."

**Step 3**. Give each group a set of Whale Milestone cards and a set of Human Milestone cards. Tell them that one pair in the group should work with the whale cards and one pair should work with the human cards. Share that the cards show different milestones or life events in human lives and in whale lives, such as a human learning to walk. Have them try to put each card into the correct category to describe when it would happen in a whale or a human life. Students may struggle to know what ages to put into each category. Try to help them reason through the ideas, guiding them to the idea that an animal is a baby while it is drinking its mother's milk, and growing until it reaches its full size. For the whales, milestones up to a year should be in the baby category and between one and 10 years in the growing category. For humans, up to a year should be "baby" and up to about 18 should be in the growing category.

**Step 4**. Once both pairs in a group have completed their sorting, have them compare the two timelines. Ask them to mark the milestones that appear in both the human and the whale timeline using a check mark or other symbol. Consider having students pair up with another group to check if they sorted the cards in the same way and checked the same milestones. If there are differences, ask them to discuss their ideas and decide if any cards should be moved to a different category.

**Step 5**. Hold a class discussion to talk about the different milestones. Ask students to share what they found interesting or surprising about the humpback whales.

**Step 6**. Ask students which milestones were common between humpback whales and humans. They should realize that both have milestones for birth, growth, reproduction, and death.



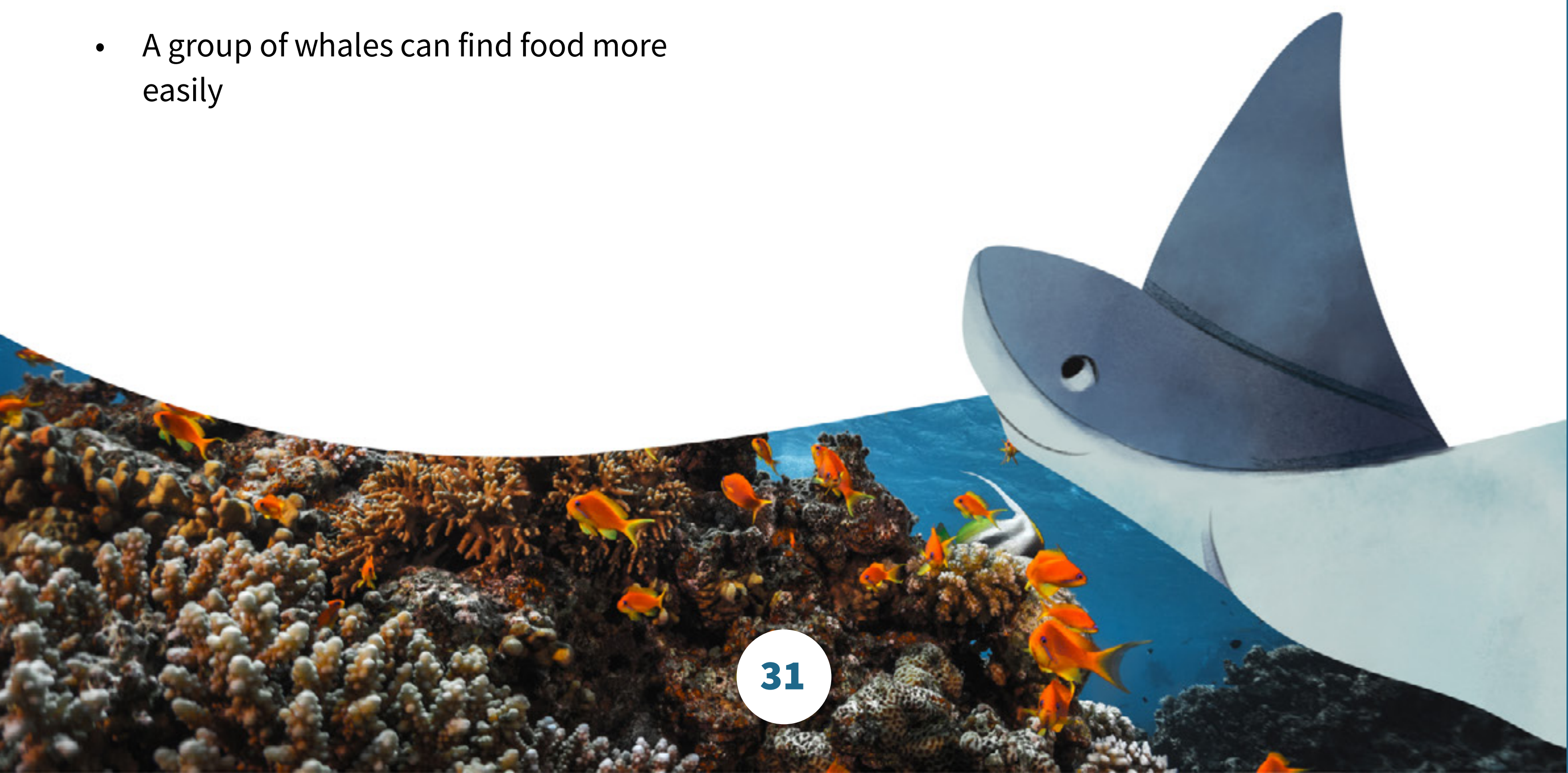
**Step 7**. Tell students that they are going to continue thinking about humpback whales. Ask the groups to pull out the cards that have a star in the corner and set the other cards aside. Share that the milestones on these cards are a few things that help the humpback whales to survive. In their groups, ask them to discuss how they think the features listed on the cards with stars help the whales live and survive.

**Step 8**. Once students have had a chance to discuss their ideas, hold a class discussion to help them learn more about the whales and how the starred milestones help them survive. Discuss the migration card last as it is likely to be more challenging for students. For that reason, the remainder of the activity helps them learn more about this survival tactic.

**Step 9**. Ask students to brainstorm as many ideas as they can about why whales might travel in groups or pods. Write their ideas on the board or a chart where students can see them easily. If students have trouble thinking of reasons, share with them some of the ideas that scientists have had. These include

- Whales travel with their families
- A group of whales can find food more easily
- A group of whales can keep predators away more easily because there are more of them
- A group of whales is better able to find their way when traveling 6000 miles or more. Certain whales may serve as leaders.
- A group of whales allows one to look out for predators or other dangers while others sleep
- A male whale can protect a female whale
- Whales communicate with one another in both loud songs and quiet whispers

**Step 10**. Distribute the Humpback Whale Pods handout. Share that the small groups whales travel in are called pods. Ask students to choose one of the ideas from the list you created during the brainstorm that they think might be the reason whales travel in pods. Have them write their idea in the area at the top of the handout.



**Step 11.** Share that the bottom of the handout has several facts about humpback whales. For each one, they should write

- a smiling face if it supports or would serve as evidence for the idea they wrote at the top,
- a frowning face if it would be evidence against the idea at the top, or
- leave the space blank if it is not evidence for or against the idea.

**Step 12.** Once students have had time to work individually, have them talk with a partner or small group about how they completed the handout. Tell students to make sure they understand what their partners chose for their ideas and to ask questions or share any new ideas they have.

**Step 13.** Hold a class discussion about each idea. Tell students that you can rule out ideas that have evidence against the statement. Through the discussion, try to narrow down the ideas to one or two that only have ideas that support them. Share that while we cannot be completely sure, scientists' current understanding is that whales likely travel in pods so others, particularly males, can help protect against predators and to allow for more communication during the long migration.

## EXTENSION

The Passive Acoustic Cetacean Map (https://apps-nefsc.fisheries.noaa.gov/pacm) shows where several kinds of whales, including Humpback whales, have been recently. Listening devices detect when the whales make sounds and show the number of times the whales were heard.

The site offers a tour to use the map, a user guide, and the map itself. Spend some time during class showing students the map and then check back regularly to see how the patterns of where whales are spending their time change.

NOAA's Ocean Sound and Impact of Noise Resource Collection (https://sanctuaries.noaa.gov/education/teachers/ocean-sound/) includes background information, lesson plans, videos, webinars, and more to help people learn about sound in the ocean, how animals that live in the ocean use and are impacted by noise, and how NOAA is working to monitor and understand underwater sound.

**Lesson 3 NOAA References**


- Passive Acoustic Cetacean Map. 2021. Woods Hole (MA): NOAA Northeast Fisheries Science Center v1.0.6.(https://apps-nefsc.fisheries.noaa.gov/pacm)
- National Marine Sanctuaries Ocean Sound and Impact of Noise Resource Collection (https://sanctuaries.noaa.gov/education/teachers/ocean-sound/)

Humpback whales drink milk from their mothers until they are about a year old.

Humpback whales can swim as soon as they are born.

Humpback whales grow until they are about 10 years old.

Humpback whales can have babies once they are about 6 years old.

Humpback whales eat up to 3,000 pounds of food per day.

Humpback whales can be 40-50 feet long, or about the size of 2 school buses.

Humpback whales can weigh up to 80,000 pounds.

Humpback whales “whisper” to their mothers while the pair migrates.

Humpback whales migrate in groups of 2-15 each year.

Humpback whales learn to hunt and eat solid food during their first year of life.

Humpback whales leave their mothers when they are about a year old.

In the wild, humpback whales live to be about 50 years old.

| | | |
|---|---|---|
| Humans learn to walk when they are about a year old | Most humans grow to be between 5-7 feet tall. | Humans drink their mother's milk or formula until they are about a year old. |
| Humans begin losing their "baby teeth" when they are around 5-7 years old. | Humans learn to talk when they are around a year old. | Humans leave their mothers when they are around 18 years old. There is a large range when this can happen. |
| Humans grow until they are about 18 years old. | Human bodies can begin to have babies in their teenage years. In the United States, the average age for becoming a parent is around age 26. | Humans eat 3-4 pounds of food per day. |
| In general, humans live to be 70-75 years old. | Adult humans can weigh from around 90 pounds to more than 300 pounds. | Humans begin school around age 5. |

**I think humpback whales travel in pods because:**

**Follow your teacher's instructions on how to fill out the last column.**

| # | FACTS ABOUT WHALES | ☺ ☹ Or / |
|---|---|---|
| 1 | Humpback whales travel in groups for only short amounts of time. | |
| 2 | Most pods have one male and one female or a mother, baby and male. | |
| 3 | All Humpback whales have magnetic material in their brains that help them know where to go when they swim. | |
| 4 | A pod may have a mother and baby, but if there are 2 adults in a pod they are not related. | |
| 5 | Sometimes scientists have seen Orcas, which are a predator for Humpback whales, following the singing and other noises that whales make. | |
| 6 | Humpback whales may rest by floating but do not sleep the way we think of it. They do not rest for more than about 30 minutes at a time because their body temperature drops too much if they stay inactive for longer. | |
| 7 | Humpback whales do not generally eat while they are migrating. | |

# LESSON 4: OCEAN CURRENTS

## INTRODUCTION

There is a clear connection between ocean currents and climate. Ocean currents help to move heat, support rainforests on land, and make life possible for animals across the globe. Without ocean currents large parts of Earth would be unlivable. Humans are already seeing the impact of climate change on life in the sea.

## LESSON SUMMARY

This lesson helps students explore the role of the ocean in climate. They do this through an investigation to show how hot and cold temperatures help to move water around the world. Students examine temperature and precipitation data from two cities and use their understanding of water movement to explain why these cities have differences between their temperatures and rainfall.

## OBJECTIVES

- Students will use a demonstration as a model to explain how water moves in the ocean.
- Students will analyze data about rainfall and temperatures in two cities in the world.
- Students will describe how water movement and proximity to the ocean affect the climate in a location.

## ESTIMATED TIME

60 minutes. If you would like to divide this lesson among multiple days, good break points are between steps 4 and 5 or between steps 7 and 8.

## STANDARDS ADDRESSED

**Science (NGSS):** 3-LS4-3. Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.

3-LS4-4. Make a claim about the merit of a solution to a problem caused when the environment changes and the types of plants and animals that live there may change.

3-ESS2-1. Represent data in tables and graphical displays to describe typical weather conditions expected during a particular season.

3-ESS2-2. Obtain and combine information to describe climates in different regions of the world.

## OCEAN LITERACY PRINCIPLES

1a The ocean is the defining physical feature on our planet Earth.

1c Throughout the ocean there is one interconnected circulation system.

## FOCUS QUESTION

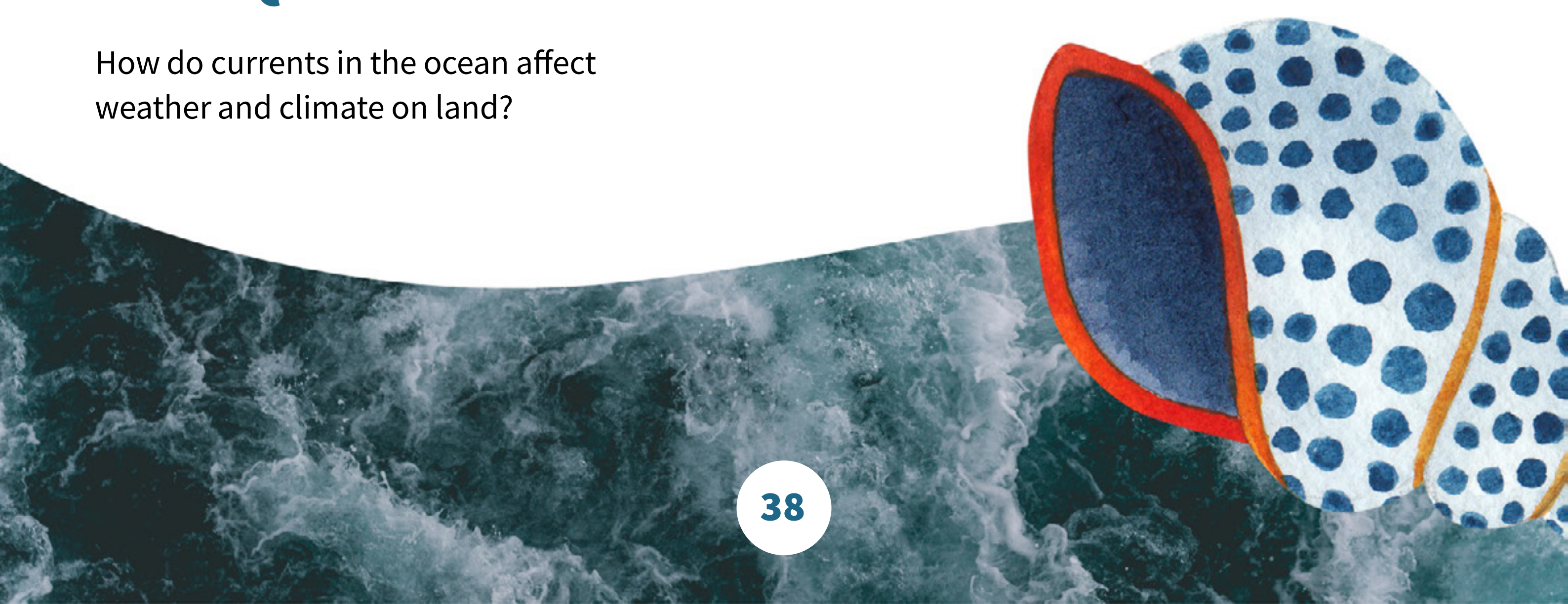
How do currents in the ocean affect weather and climate on land?

## MATERIALS

- Ice water
- Hot water, heated in an electric kettle, on a hot plate, or from a coffee machine
- Clear or transparent container (glass or heat resistant). A deeper container will help students observe the results more easily; however, a dish such as an 8" x 8" baking dish will work if that is what is available.
- Two distinct colors of food coloring, such as red and blue
- World Map master, one for display
- Milwaukee and Hobart Climate Data, one per student
- Oceans and Climate, one per student

## PREPARATION

- Read Lesson 2 in this guide. Consider if completing that lesson with your students might help support their learning in this lesson.



- Practice the demonstration, as described in step 3 below, to ensure that your set up works well. Adding hot water to the dish then slowly adding ice cold water to one side is one effective set up, though other variations such as adding ice to one side and letting it sit for several minutes may also work well.

- Decide how many times you want to repeat the demonstration to ensure that all students can easily make observations. Ensure you have enough materials prepared to repeat the experience a few times.

## FACILITATION

**Step 1**. Share with students that the ocean is very large. We cannot simply stand on a beach and see how the water moves. Today they are going to have a chance to explore how one kind of current in the ocean moves water.

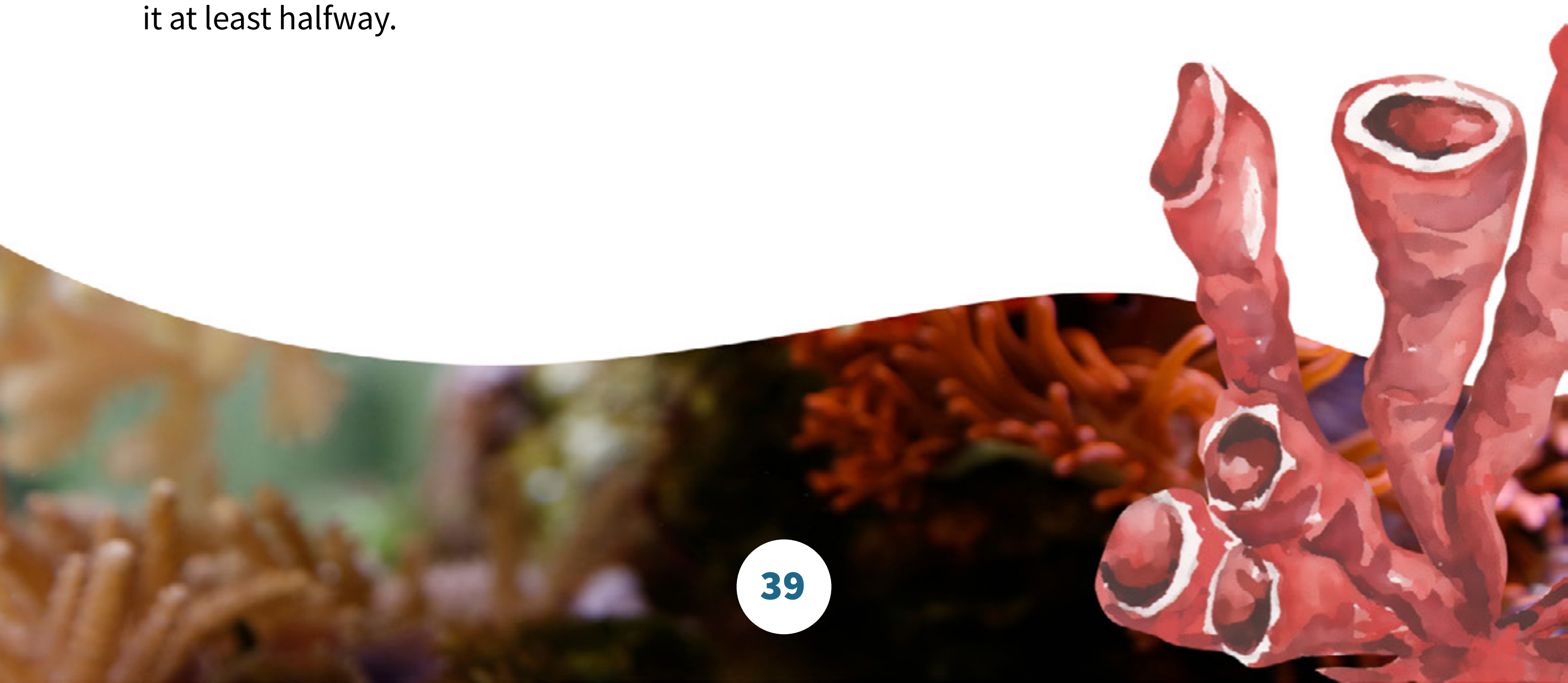
**Step 2**. Set up the demonstration in a way that students can see what happens in the dish from the side. To set it up, complete the following steps.

- Place the transparent container on a flat surface. Add hot water to the dish to fill it at least halfway.

- Add ice or ice water to one side of the dish. Do this very carefully to minimize mixing the hot and cold water. If you are adding ice water, try adding it very slowly along one side of the dish so that it does not disturb the water on the other side of the dish.

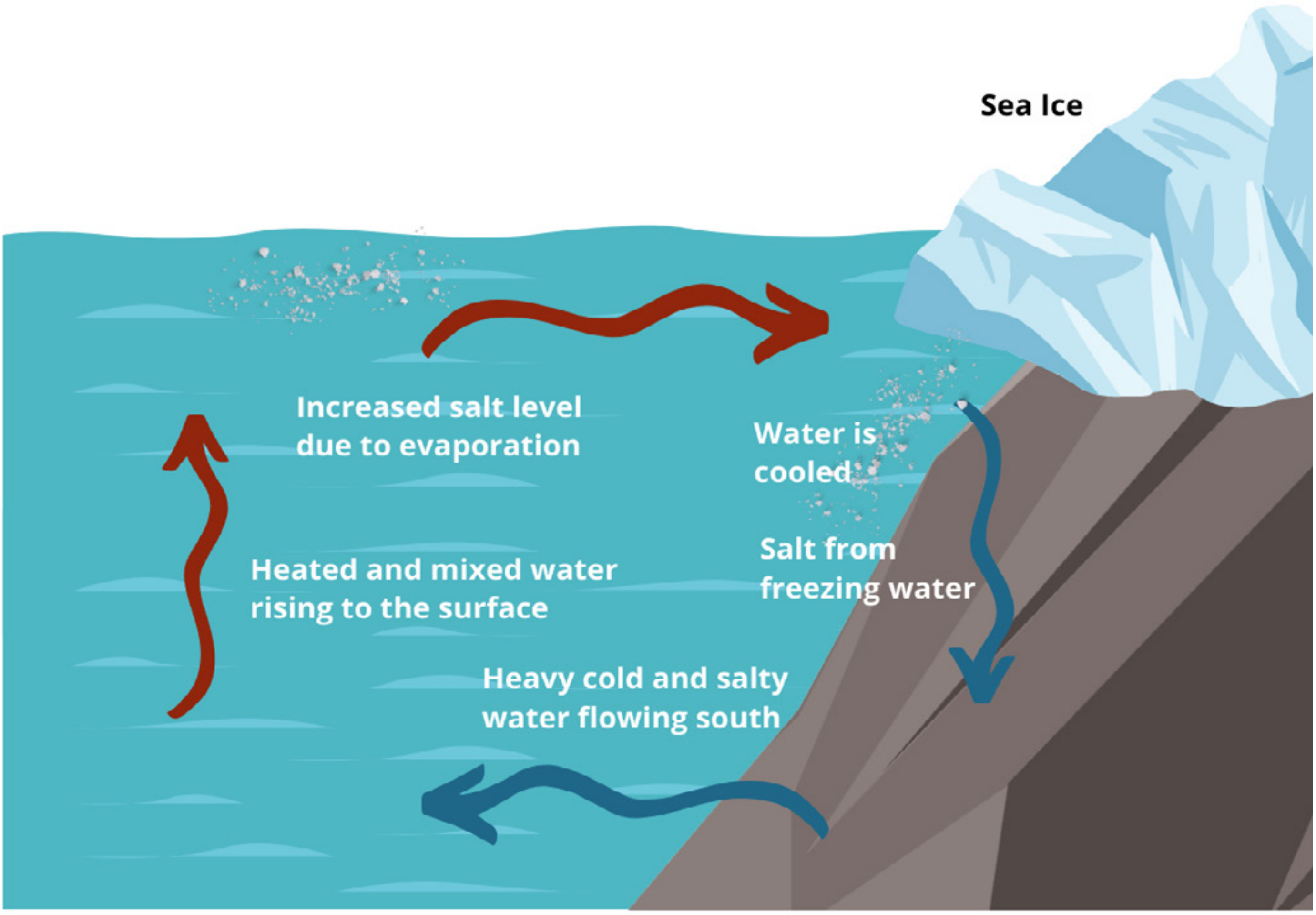
- With students watching carefully, add 3 drops of red food coloring (or another color) to the hot side of the dish, about an inch from the side. Add 3 drops of blue food coloring (or another color) to the cold side of the dish, about an inch from the side. Ask students to observe what happens over the next 3 minutes. You may wish to point out key observations, listed below, if students do not seem to be noticing them.

**Observations**: Students should be able to see that the food coloring on the cold side sinks to the bottom and then begins traveling toward the hot side of the dish, along the bottom. The food coloring on the hot side will disperse more quickly but should generally move toward the cold side of the dish.



**Step 3**. Ask students about why they think the colors moved the way they did. They do not have to develop a complete understanding but should know that the heat and water from the warm side moves to the cold side. As it cools off, it sinks and pushes water that is already on the cool side out of the way, toward the warm side. That water warms up, rises to the top part of the water in the dish, and the process creates a current. Draw a representation on the board as you discuss these ideas

**Step 4**. Explain that there are other kinds of currents in the world, including some that move by wind, tides, and the way the Earth rotates. Share with students that large currents depend on both heat and salt, but for now they are going to focus on heat. To relate this to ocean currents, show students the World Map master and ask where temperatures are warm and where they are cold. Students are likely to know that it is hot near the Equator and cold at the north and south poles. Ask them to connect what they saw in the demonstration to the water on Earth.

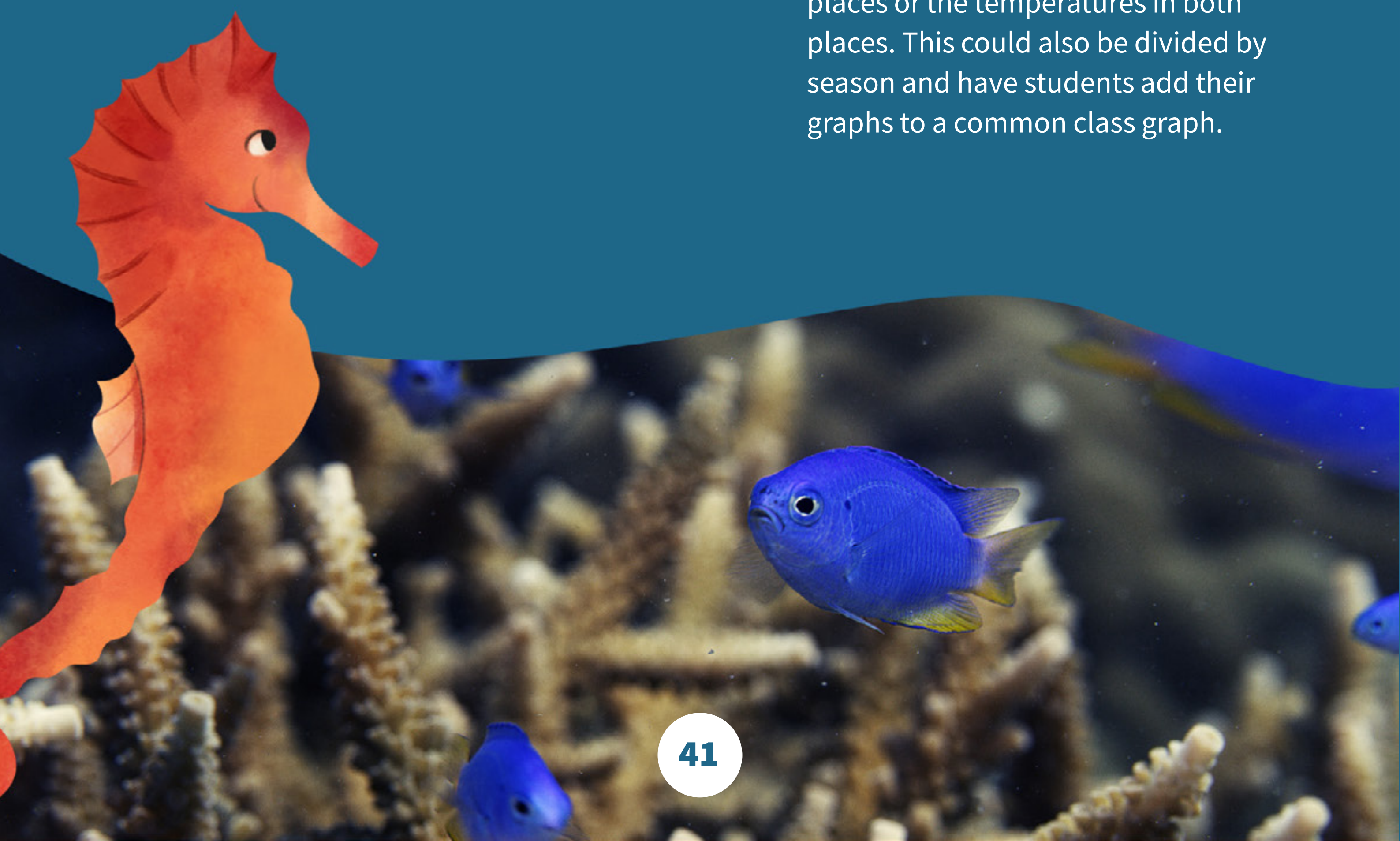


**Step 5.** Point out the two cities that are shown on the World Map master—Milwaukee, WI and Hobart, Australia. Share with students that Hobart, the capital of Tasmania, is at 43 degrees latitude south. Tell them that in the United States, the city of Milwaukee, Wisconsin is at 43 degrees latitude north, so they are the same distance from the equator. Ask students the following questions and accept all ideas at this point.

- How would you describe where each city is and what is around it?
- Do you think that the temperatures in Hobart and Milwaukee are the same or different? Why?
- Do you think the amount of rainfall in Hobart and Milwaukee is the same or different? Why?

**Step 6.** Share with students that they are going to have a chance to learn more about temperatures and rainfall in the two cities. Distribute the handout, Milwaukee and Hobart Climate Data, to students. Ask them to graph the data using a strategy appropriate for your students. The following are suggestions for how you might have students analyze the data.

- As a class, create a bar graph to show the average temperatures in each location and another to show the average rainfall in each location. If your students are not comfortable graphing on their own, this is the best option.
- Have pairs of students graph 1 of the 4 sets of data (rainfall in Milwaukee, rainfall in Hobart, precipitation in Milwaukee, precipitation in Hobart), then compare the two rainfall graphs and the two temperature graphs.
- Have small groups of students create two bar graphs on one set of axes to compare either the rainfall in both places or the temperatures in both places. This could also be divided by season and have students add their graphs to a common class graph.



**Step 7**. Lead a class discussion to compare the rainfall and temperatures in both cities. Students should see that in Hobart, both temperatures and precipitation are more even through the year, creating a mild climate. Milwaukee has a more distinct variation in temperature and amount of rainfall across the year. Ask students if they have any ideas of why that might be but accept all answers at this point.

**Step 8**. Tell students that they are going to have a chance to create a comic to learn more about why the two places might be different. Distribute the Ocean and Climate handout and different-colored pens or pencils. Show students that there are five boxes that will make up the comic and each has a description, with the fifth box being a summary of the other boxes together. Tell them that their task is to draw pictures for each box to show what the words are describing. They can discuss their ideas in their small groups to make sure everyone understands but emphasize that each student should draw pictures on the comic individually. Tell students that the goal is to be able to explain how the ocean affects climate, particularly when they think of Milwaukee and Hobart.

**Step 9**. Lead a class discussion to talk about their comics. Make sure they link box 4 of the comic to the demonstration. Have them discuss how the story in the comic relates to temperature and rainfall in Milwaukee and Hobart. As part of the discussion, share the Ocean Currents animation from Science on a Sphere (https://sos.noaa.gov/catalog/datasets/ocean-circulation-labeled-currents/). You may wish to point out:

- that the animation distinguishes between warm surface waters (red arrows) and deep, cold waters (blue arrows),
- gyres, which are the currents that are affected by heat and salt like the demonstration,
- other types of currents, such as the equatorial currents,
- that currents move water long distances around the world, and
- that Hobart is on an island south of Australia with a warm current running near it while Milwaukee is far inland and is less affected by ocean currents.

After the discussion, encourage them to explain why Milwaukee has more variable weather than Hobart, using their comic as a reference. They should relate it to both warm currents and to evaporation of water leading to storms.

**Step 10**. Remind students of the demonstration. Ask, what would happen if the two sides of the dish had water that was a similar temperature? How would that affect the story in their comics? If they struggle to reason through what would happen, consider repeating the investigation with one temperature of water while still using two colors of food coloring at opposite ends. Students should see that the food coloring disperses the same way on both ends and does not travel toward the other side of the dish.

**Step 11**. Ask students to use the discussion from the previous step with their comics to explain how Hobart would be different if the water at the poles became too warm for sea ice to form.

| Milwaukee, Wisconsin, USA 43° North | Average High Temperature (°F) | Rainfall (inches) | Hobart, Tasmania, Australia 43 ° South | Average High Temperature (°F) | Rainfall (inches) |
|---|---|---|---|---|---|
| **January** | 31 | 1.79 | **January** | 69 | 2 |
| **February** | 34 | 1.69 | **February** | 68 | 1.9 |
| **March** | 44 | 2.20 | **March** | 65 | 1.9 |
| **April** | 55 | 3.86 | **April** | 60 | 2 |
| **May** | 67 | 3.54 | **May** | 55 | 1.9 |
| **June** | 77 | 4.38 | **June** | 51 | 1.9 |
| **July** | 82 | 3.40 | **July** | 50 | 2.2 |
| **August** | 80 | 3.65 | **August** | 52 | 2.5 |
| **September** | 74 | 3.16 | **September** | 55 | 2.4 |
| **October** | 61 | 2.78 | **October** | 59 | 2.4 |
| **November** | 48 | 2.24 | **November** | 62 | 2.6 |
| **December** | 36 | 1.88 | **December** | 66 | 2.6 |

## EXTENSION

Divide students and have half the class learn about the plants and animals that live in Tasmania while the other half learns about plants and animals that live in the Milwaukee area. Have them choose one plant or and learn more about its life, including what might happen to the plant or animal if the climate in its home area changed. Have students share what they learned with the class so that they hear about plants and animals in both areas, then hold a class discussion about what would happen to living things if the climate changes where they live.

**Lesson 4 NOAA Reference**

- Science on a Sphere Ocean Circulation (https://sos.noaa.gov/catalog/datasets/ocean-circulation-labeled-currents/)

# WORLD MAP

**1**

The ocean absorbs energy from the sun, especially near the equator. This makes the ocean warmer, and it stores the heat.

**2**

The extra heat and humidity cause rainstorms. These storms move long distances because of winds. The rain often falls on land.

**3**

When the water heats up some of it will evaporate into the air. This warms up the air. It also makes it more humid, or moist.

**4**

Heat also moves with ocean currents. Some currents are part of cycles that start with sea ice in the poles. Other currents move because of wind, tides, or the way Earth rotates.

**5**

Summary: Heat and water move around Earth both in the ocean and in the air.

# LESSON 5: A WHALE OF A MIGRATION

## INTRODUCTION

Twice a year, humpback whales take an amazing 3000-mile journey. This seasonal migration takes them from cold waters where they spend summers feeding to warmer waters in the winter months to breed and raise young calves. How do the whales know where to go and how do they make sure they arrive?

## LESSON SUMMARY

In this lesson, students learn how scientists identify and track humpback whales. They explore data and a map about the long migration whales make seasonally. They use this information with readings to explain how whales know where to go on their journeys.

## OBJECTIVES

- Students will explore how scientists identify and track humpback whales.
- Students will learn about the ways whales keep track of where they are and where they are going during migration.

## ESTIMATED TIME

45 minutes. If you would like to teach this lesson over 2 class periods, consider pausing the learning between steps 5 and 6.

## STANDARDS ADRESSED

**Science (NGSS):** 4-LS1-1. Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

4-LS1-2. Use a model to describe that animals receive different types of information through their senses, process the information in their brain, and respond to the information in different ways.

SL.4.1.A Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information known about the topic to explore ideas under discussion.

## OCEAN LITERACY PRINCIPLES

5 The ocean supports a great diversity of life and ecosystems.

**Geography**: Standard 8 The characteristics and spatial distribution of ecosystems and biomes on Earth's surface.

**Mathematics (CCSS):** 4.MD.A.2 Use the 4 operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

**English Language Arts (CCSS):** RI.4.2 Determine the main idea of a text and explain how it is supported by key details; summarize the text.

## FOCUS QUESTION

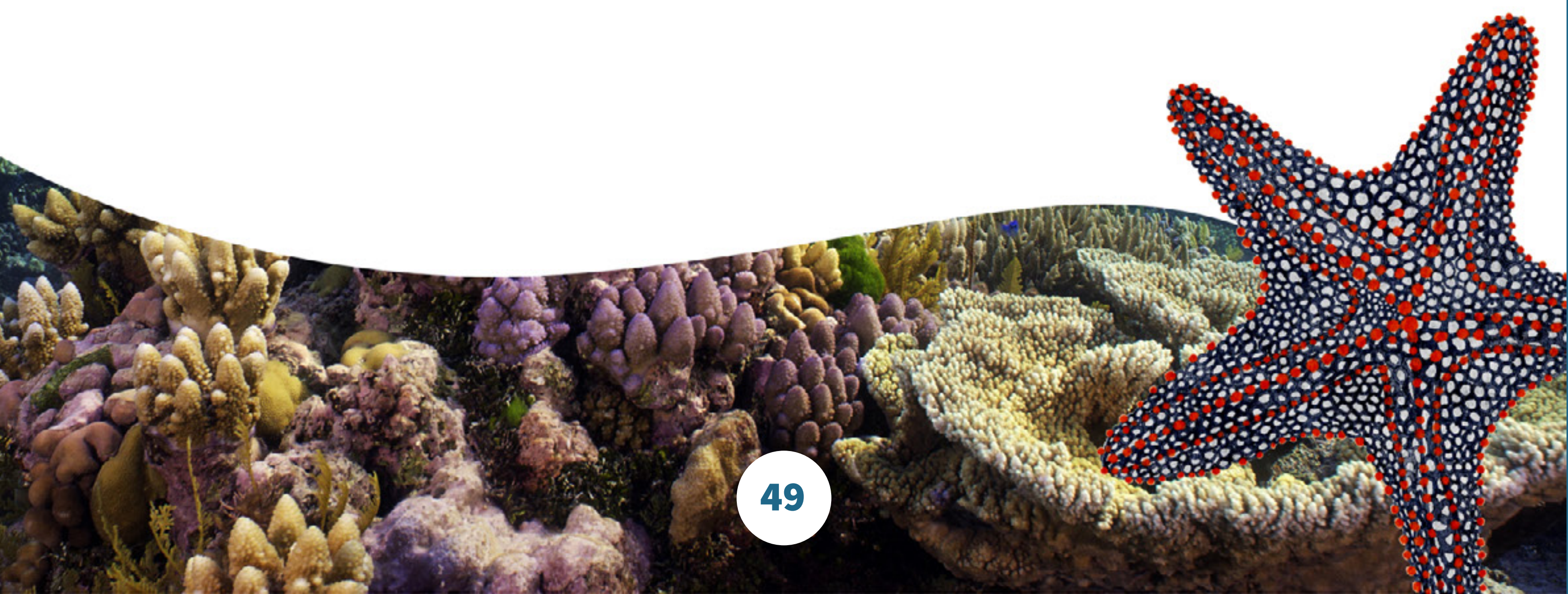
How do whales know where to go when they migrate?

## MATERIALS

- Identifying Whales, display copy
- Whale Tracking Data, one per student
- How Do Whales Know Where to Go, one copy per group of 3 students, cut apart
- Compass or compass application on a smartphone

## PREPARATION

- Make copies of all the handouts. For the handout How Do Whales Know Where to Go, cut the readings apart. Divide the readings so that each group of 3 students will get 1 copy of each of the 3 readings.



## FACILITATION

**Step 1**. Display the pictures of the humpback whale and the mother whale and her calf. Allow students a little time to observe the whales. Share that they can grow to be more than 50 feet long, which is about the length of 3-4 cars placed bumper to bumper.

**Step 2**. Next, share the whale tails on the Identifying Whales master. Tell students that the pictures represent eight different humpback whales. Give them a minute to observe the pictures quietly. Ask students if they think they could tell the whales apart based on the pictures and describe which features contributed to whether they could identify individual whales or not. Students should say that the different whales have different patterns of white on their tails. They may also describe that the shape of some of the tails seems different.

**Step 3**. Tell students that scientists can tell whales apart using their flukes, or the two lobes that make up their tails. Many whales have a pattern of white on their flukes that is unique to each whale. Scientists also look at the shape of the flukes; the trailing edge of the flukes, which is the end further from the body; and the notch, or V-shape where the two flukes come together in the center of the tail. By finding some unique features on each whale, scientists can identify individual whales in photographs. Ask students to choose one of the tails on the master and try to find 2-3 characteristics that are unique to that whale.

**Step 4**. Share that being able to identify each whale allows scientists to track the whale's movements through the water. Distribute copies of the handout, Whale Tracking Data. Ask students to examine the data in the table and the map to learn more about the migration routes that whales take. Depending on your students, you may wish to have them read the introduction to the data as a class, then have them examine the data in the table, followed by the map.

**Step 5**. Lead a class discussion about the information on whale migration based on the whale tracking data. Ask students questions such as:

- Where did the whales begin and end their migration? These whales migrated from Alaska to Hawaii. Share with students that not all humpback whales follow this route but that they are an example to think about how whales migrate. Share that humpback whales generally spend the warm summer months feeding in cooler waters and in the winter they migrate to warmer waters to breed and raise young whale calves. For the whales observed in 2014 and 2015, the migration pattern is usually to travel south to Hawaii in November and December. These whales generally travel back to Alaska in April and May.

- How far did the whales travel overall? How far can they travel in a day? The whales traveled between 4,300 and 4,800 kilometers or between 2,600 and 3,000 miles. Three of the whales traveled around 130 to 140 kilometers or 80 to 90 miles a day. The other whale traveled around 90 kilometers or 60 miles a day. To reinforce math skills, you can have students do these calculations by determining the distance traveled per day for one or more of the whales.

- Did the whales seem to follow a particular route or did they seem to wander around? Students should see that whales did not necessarily take the exact same route, but that they did not swim off course, in circles, or back and forth. Their paths from Alaska to Hawaii were fairly straight routes. Guide students to an understanding that the whales must have a way to navigate and know where they are along the route.

**Step 6**. In groups of 3, have students discuss how humans might know what route to take to get from New York City to Los Angeles, a distance about the same length as the route the whales migrate. Students are likely to say that they would use a GPS application or a map. Discuss their ideas, probing them with questions such as, how many times do you think you would need to go back and forth before you did not need a map? Would your answer change if you knew you only went back and forth once a year compared to more or less often?

**Step 7**. Follow up on the previous step by having small groups discuss:

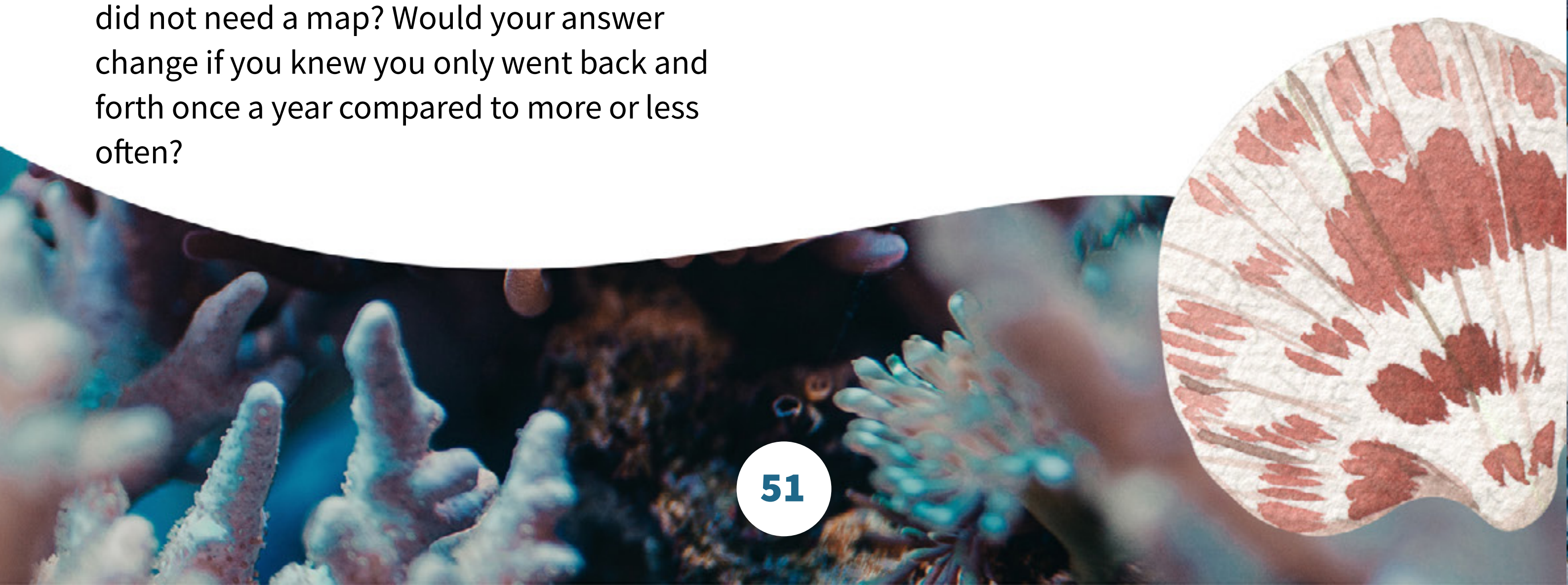
- whether whales can use the same methods humans do to know where they are going,

- how they think migrating back and forth only one time per year affects the whales' abilities to navigate, and

- how they think whales know where to go.

**Step 8**. Have students share their ideas to answer the question: how do humpback whales know where to go when they migrate? You may wish to give them some quiet time to individually write their ideas down before sharing with the class. Make a list of their ideas to display in the classroom.

**Step 9**. Tell students that they are going to have an opportunity to learn more about how whales know the route when they migrate. You will use a jigsaw strategy to support students in their learning. Give each group a set of readings from the handout How Do Whales Know Where to Go? Have each small group divide the readings so that each student reads one of the sections. This will be their home group for the jigsaw.



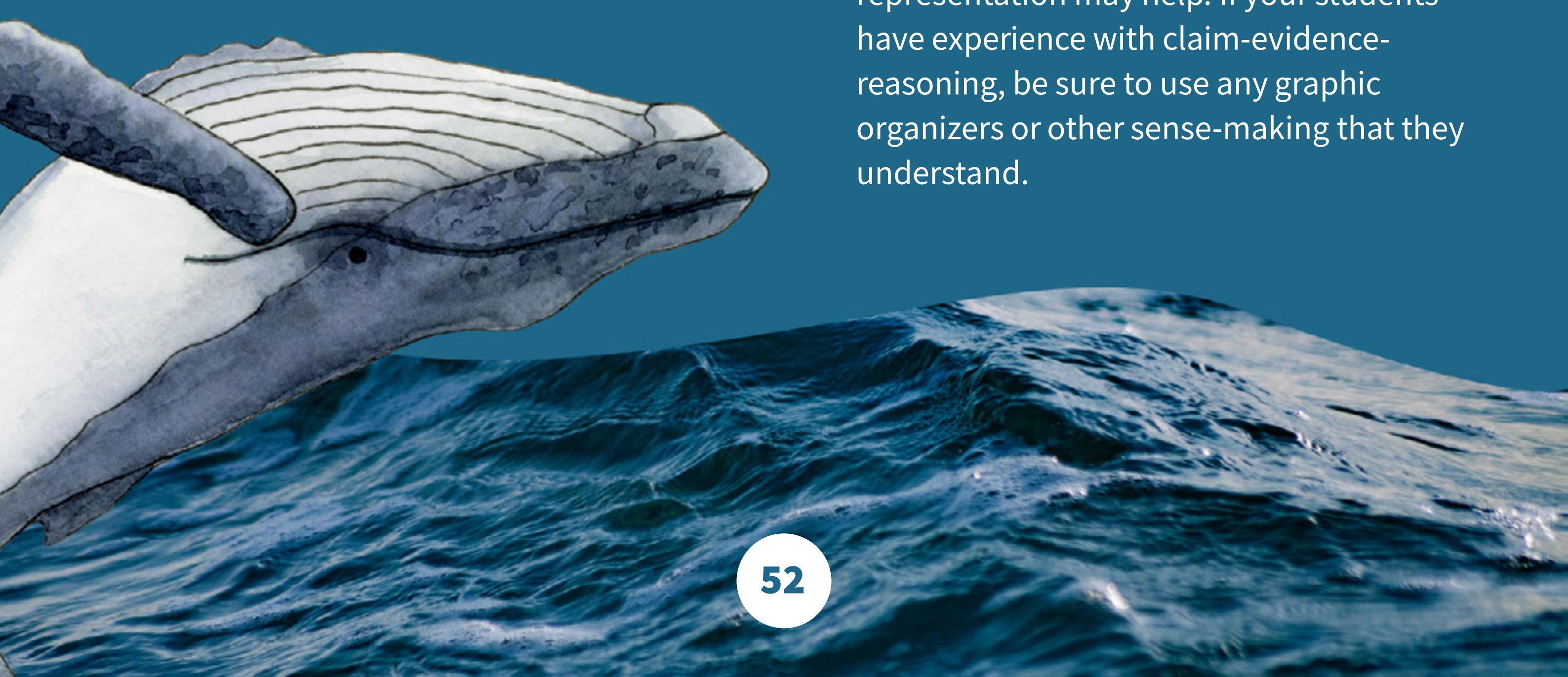
**Step 10**. Once students have had a chance to read, form small expert groups of students who read the same section. This should represent one student from each home group. Keep the groups to no more than 3 or 4 students to allow all students to participate and share. In a class of 30 students, this will mean that there are multiple expert groups for the same reading. Give the expert groups a few minutes to discuss what they read, focusing on making sure they know the important points to share with their home groups.

**Step 11**. Have students rejoin their home groups from step 9. Each home group will have at least one expert on each of the three readings. Allow time so that students can share about the sections they read. Remind them to share the important points they discussed in their expert groups. Tell students that they should listen carefully and be prepared to describe all the ways that whales might understand the migration routes.

**Step 12**. Briefly discuss each of the three sections of reading.

- When the class discusses the "communication" reading, consider sharing some recordings of humpback whales from Eavesdropping on Whales (https://sanctuaries.noaa.gov/news/feb21/eavesdropping-on-whales.html). Under the "Make Some Noise" subheading, there are three short recordings of humpback whales communicating.
- As the class discusses the "magnetic field" reading, show a compass or compass application on a smartphone so that students can see how it changes as a person faces different directions.
- During the discussion about whales using noises to sense structures on the ocean floor, be sure that students understand that we can never know exactly what a whale can or cannot see, but using technology scientists can guess what whale vision might be like.

**Step 13**. Write the question "how do whales know where to migrate?" on the board. Ask students to make a claim and offer evidence and reasoning to describe what they learned. Share that drawing a representation may help. If your students have experience with claim-evidence-reasoning, be sure to use any graphic organizers or other sense-making that they understand.



## EXTENSION

- If students have questions about the Earth's magnetic field, the ESRI Story Map titled The Earth's Magnetic Field: The Force That's Always With You (https://noaa.maps.arcgis.com/apps/MapJournal/index.html?appid=3b9045c4d1aa408694d3759d1aa5ede4) offers an explanation of why it is important for many of the phenomena we see in our lives.
- Students may be interested in learning more about humpback whales using the Hawaiian Islands Humpback Whale National Marine Sanctuary's website (https://hawaiihumpbackwhale.noaa.gov/). This site includes videos, history, activities, conservation actions, and other information to allow students to learn more about many different connections with humpback whales.

**Lesson 5 NOAA References**

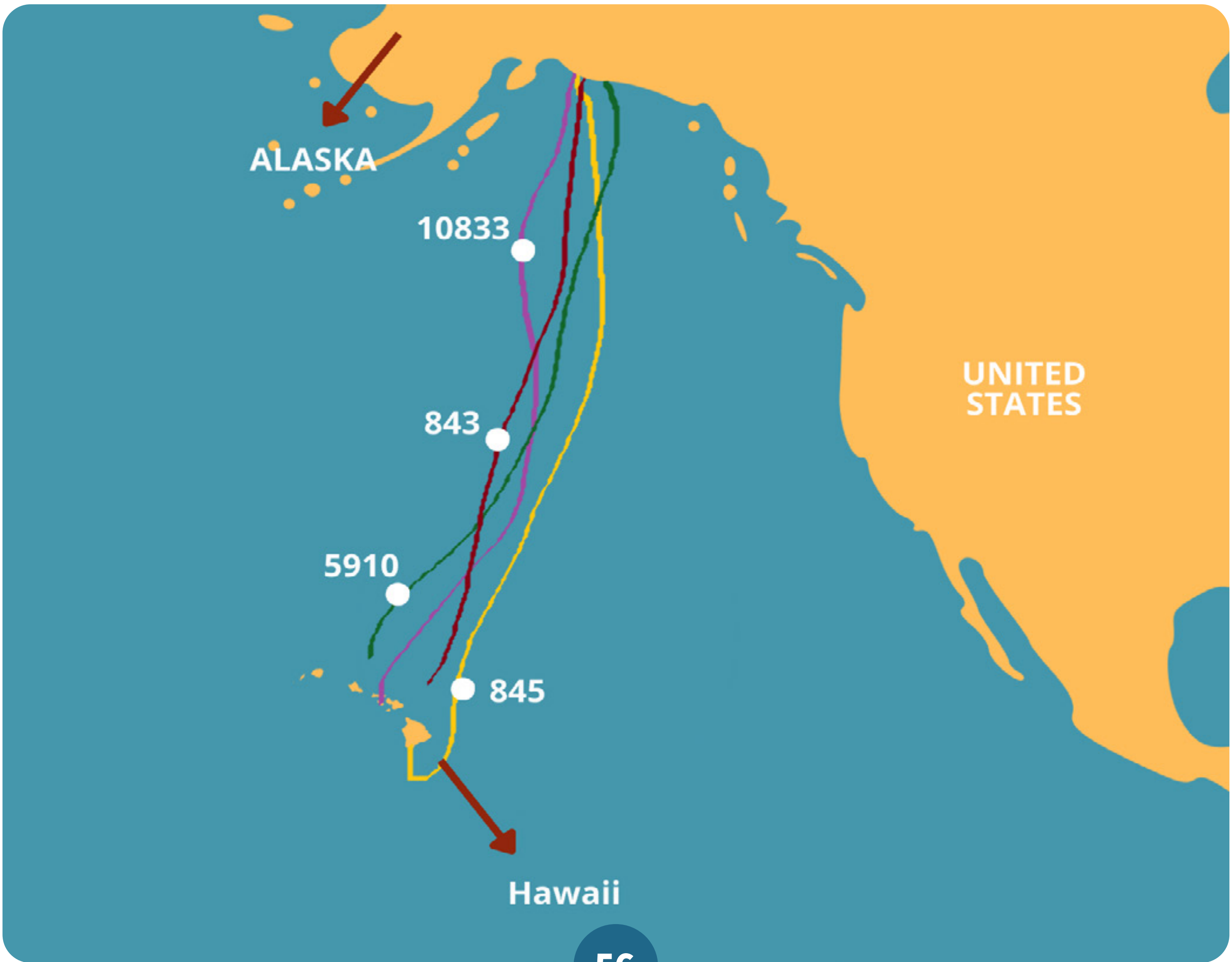

- National Marine Sanctuaries, Eavesdropping on Whales (https://sanctuaries.noaa.gov/news/feb21/eavesdropping-on-whales.html)
- NOAA National Centers for Environmental Information (NCEI), The Earth's Magnetic Field: The Force That's Always With You (https://noaa.maps.arcgis.com/apps/MapJournal/index.html?appid=3b9045c4d1aa408694d3759d1aa5ede4)
- Hawaiian Islands Humpback Whale National Marine Sanctuary (https://hawaiihumpbackwhale.noaa.gov/)

All images on page 54 and page 55
belong to NOAA

## WHALE TRACKING DATA

Scientists have tracked many whales over the years. In 2014 and 2015, scientists observed 20 whales that were in the ocean near Alaska in November. The scientists tracked where the whales swam in the next 1-2 months. The table and map show data for 4 of the whales.

| Whale Tag # | Date migration started | Date of last data collected | Total days tracked | Total distance migrated |
|---|---|---|---|---|
| 843 | November 25, 2014 | December 18, 2014 | 31 | 4,372 km / 2,717 miles |
| 845 | December 2, 2014 | January 8, 2015 | 37 | 4,744 km / 2,948 miles |
| 5910 | November 19, 2014 | December 13, 2014 | 30 | 4,389 km / 2,727 miles |
| 10833 | November 28, 2015 | January 13, 2016 | 46 | 4,303 km / 2,674 miles |



### Communication

Imagine walking with a group of people in the dark. The first person has a flashlight but the rest of you do not. The leader might call out when there is a curb or a rock so you are aware of it.

Scientists think that humpback whales make sounds to communicate as they migrate. One idea is that the leaders in the front of the group call out to other whales. This helps them find their way.

Scientists know that some of the sounds whales make can be heard for about 5 miles. Even if the whales are not traveling in a pod, these sounds might help them know the right way to go or if there are any dangers ahead.

### Magnetic Fields

A compass is a simple tool that can help people find their way. Compasses have a needle that always points north. People can use a compass and a map to help them navigate where they want to go.

The needle in a compass points to the north because it is a small magnet. It points in the same direction because the Earth has a magnetic field that causes it to act as a magnet, too.

Humpback whales have magnetic material in their brains. This may help them sense the Earth's magnetic field and know where to migrate. Because the magnetic field has specific patterns around the planet, whales may be able to sense the different patterns and use that information to know their location.

### Mapping the Seafloor

Just like on dry land, the floor of the ocean has mountains, valleys, and other forms. These landmarks may help whales know which way to go.

Compared to humans, whales have poor eyesight. They do not see color and their vision is probably between 10 and 100 times worse than what humans can see.

But, humpback whales have another way to "see" structures in the ocean. They can use clicks and other sounds to help them detect objects in the water. It is likely that they can listen to echoes from the sounds they make to determine where landforms are in the ocean. In this way, they may be able to navigate based on landmarks they pass on their migrations.

# LESSON 6: FISHING FOR SOLUTIONS

## INTRODUCTION

Fishing is an important industry, providing both food security and income for many people. At the same time, overfishing is one of the threats to our oceans if people are not careful of the impact of their actions while fishing.

## LESSON SUMMARY

In this lesson, students work in small groups to learn about different fishing methods. They demonstrate these methods to the class and share the strengths and limitations of each method. Based on their understanding, they make a recommendation about the best fishing methods, then watch a video about American Samoa to learn how this community uses responsible and sustainable fishing methods to support the people who live there.

## OBJECTIVES

- Students will learn about different methods of fishing and the impacts those have on the animals that live in the ocean.
- Students will explore how humans in different parts of the world make use of resources from the ocean to survive.

## ESTIMATED TIME

60 minutes. If you wish to divide this lesson over multiple days, there are a few opportunities to pause the learning. Consider breaking the lesson up at any of the following points: after step 4; at steps 6–8, sharing a few fishing methods the first day and a few on the second day;  or between steps 10 and 11.

## STANDARDS ADDRESSED

**Science (NGSS):** 4-ESS3-1. Obtain and combine information to describe that energy and fuels are derived from natural resources and their uses affect the environment.

5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

## OCEAN LITERACY PRINCIPLES

6 The ocean and humans are inextricably interconnected.

**Geography:** Standard 14 How human actions modify the physical environment.

Standard 16 The changes that occur in the meaning, use, distribution, and importance of resources.

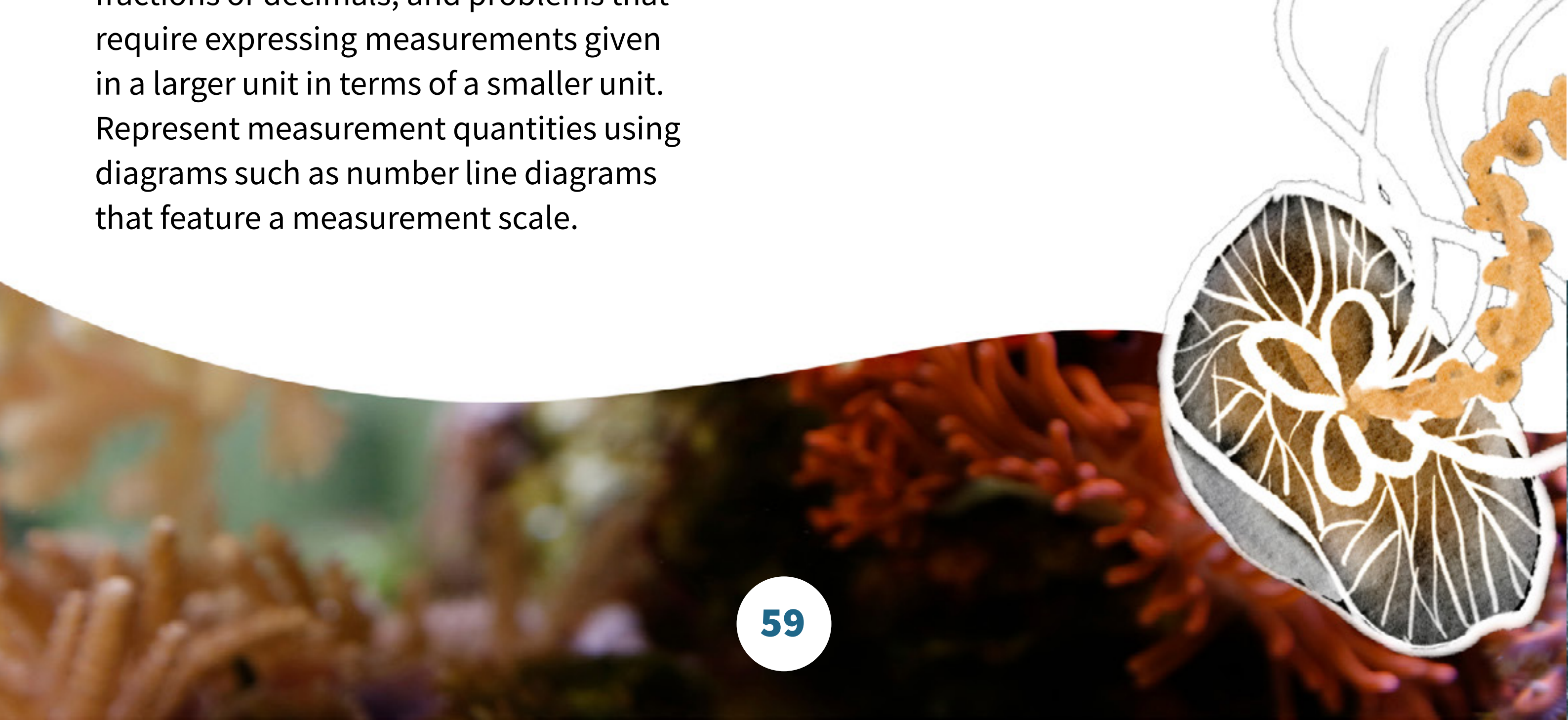
**Mathematics (CCSS):** 4.MD.A.2 Use the 4 operations to solve word problems involving distances, intervals of time, liquid volumes, masses of objects, and money, including problems involving simple fractions or decimals, and problems that require expressing measurements given in a larger unit in terms of a smaller unit. Represent measurement quantities using diagrams such as number line diagrams that feature a measurement scale.

4.OA.C.5 Generate a number or shape pattern that follows a given rule. Identify apparent features of the pattern that were not explicit in the rule itself.

**English Language Arts (CCSS):** SL.4.1.D Review the key ideas expressed and explain their own ideas and understanding in light of the discussion.

## MATERIALS

- Small objects for each group, such as coins, paper dots from a hole punch, paper clips, or others, approximately 50 objects per group of 3 students
- Yarn (enough to supply approximately 12" to each group of students)
- Methods of Fishing handout, enough copies for each group of 3 students to get information about one method (See Preparation section)
- Analyzing Fishing Methods handout, one per student
- Materials for either writing or drawing in step 10
- Method for showing the video in step 11



## PREPARATION

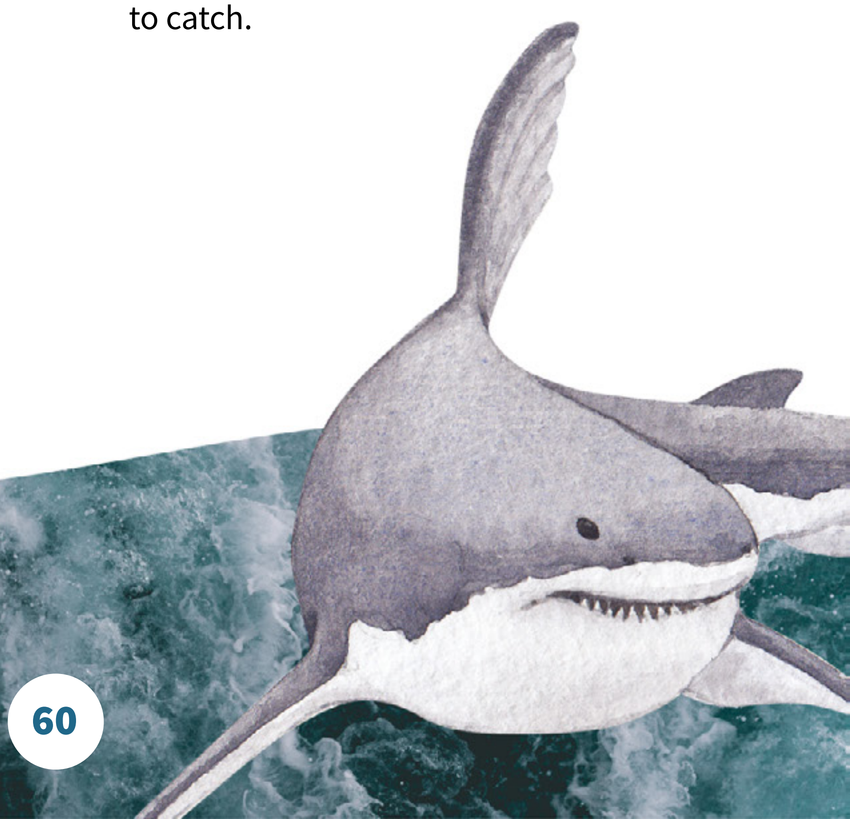
- Cut yarn into lengths approximately 12” long. Each group will need one length of yarn.
- Divide small objects into cups or small bags to make it easy to distribute them to groups. Each group needs approximately 50 objects, but this number does not need to be exact.
- Print copies of the Methods of Fishing handout and cut apart the information about the methods.
- Preview the video “Northeast Surveys: The Fisheries We Count On” (https://videos.fisheries.noaa.gov/detail/videos/sustainable-fisheries/video/6274478742001/northeast-surveys:-the-fisheries-we-count-on?autoStart=true) in the Extension to decide if you would like to use it. Plan on showing the whole video, but if time is short, consider showing from the beginning to timestamp 1:38.

## FACILITATION

**Step 1**. Ask students what comes to mind when they hear the word “fishing.” They are likely to share ideas such as a family member with a fishing rod, going to a creek near their homes, or simply an image of a person catching a fish. Depending on their experiences, they may also have ideas about fishing boats or commercial fishing. Accept all answers at this point as this step is to get students thinking about fishing.

**Step 2**. Tell students that fishing is a major source of food and money for people around the world. Many of those people are involved in commercial fishing, where they are working to catch fish that will be sold in restaurants and markets. Today they are going to have a chance to learn more about different methods of commercial fishing.

**Step 3**. Divide the students into groups of 3. Distribute the small objects, yarn, and one Method of Fishing reading per group. Tell groups that they should start by reading about the fishing method, then use the materials to represent that method of fishing. The small objects represent fish, and the yarn might represent a net or fishing line. The students should represent the person fishing. One word that the students will need to know for the reading is “bycatch.” Write this word where students can see it and explain that it is the other fish and animals that are caught, that were not the kind of fish fishers were trying to catch.



**Step 4**. As students work, circulate around the room to make sure they understand the fishing method that they read about and what their materials should represent. For example, if they read about purse seine fishing, students might demonstrate that method by showing the objects in a group and wrapping the yarn around the outside of the group, then pulling it into a tighter circle. Tell students that they should be ready to share their fishing method with other groups and give them an opportunity to ask any questions before they begin their presentations.

**Step 5**. Distribute copies of the Analyzing Fishing Methods handout to each student.

**Step 6**. Ask for a volunteer group to describe the fishing method they learned about and share their representation. If you have more than one group who studied that method, ask other groups to share their representation as well and to add any additional information.

**Step 7**. Once all the groups have shared about one fishing method, ask students to complete the section for that method on the Analyzing Fishing Methods handout. Tell students that the questions are to help them think about the methods overall and there is not necessarily one specific answer. Give them some time to work individually, then to discuss with their groups.

**Step 8**. Complete steps 6 and 7 for each remaining fishing method.

**Step 9**. Hold a class discussion about the fishing methods. Discuss each of the following points.

- Have students talk about whether there are methods that seem like they might take all the fish from an area, which would not leave enough to have baby fish that grow up and repopulate the area.
- Ask students which methods seem to be able to collect specific kinds of fish and why that might be important. To help you with the discussion, commercial fishers generally only fish for certain fish. If they catch other types of fish, those fish are likely to be discarded, so it is better to use fishing methods that are specific.

- Discuss which methods seem to limit the number of fish that people can catch. Ask students what they think is important about this idea. To support the discussion, help students understand that commercial fishers need to make enough money to support their families and that markets and restaurants need enough fish to meet their customers' needs. If the fishers cannot catch enough fish, then they cannot meet these goals.

**Step 10**. Once students have discussed the different fishing methods, ask them to think about which fishing method they would recommend as one that makes sure the fish that are caught are used, that does not wipe out all the fish, and that allows people fishing to catch a reasonable number of fish. Ask students to share their ideas through either writing a paragraph, making a claim with evidence and reasoning, drawing a representation, or other appropriate means of sharing their ideas.

**Step 11**. Share with students that American Samoa is a U.S. territory about halfway between Hawaii and New Zealand and that fishing is a big part of life there. Show the video We Fish! American Samoa (https://videos.fisheries.noaa.gov/detail/videos/sustainable-fisheries/video/6238536283001/we-fish-american-samoa?autoStart=true) to students and ask them to write down any connections between what they have been learning and life in American Samoa.

**Step 12**. Hold a class discussion about the video to allow students to connect the ideas from the video to the importance of the fishing methods they learned about. Tell them that when we eat seafood that has been raised and caught responsibly—in ways that keep the ocean healthy—it is referred to as sustainable seafood. Share the FishWatch (www.fishwatch.gov) website with students and tell them that it is an excellent resource for helping to make choices about seafood. If there is time, consider having students go to the website and look up a type of fish to see the information that the website offers.

## EXTENSION

Share with students that these ideas of catching fish in the ocean and making sure that fishing methods maintain fish populations fall under the guidance of “fisheries.” The word fishery can refer to the area of the ocean where fish are caught or the business of catching them. To learn more about how fisheries scientists know what is happening with fish populations, have students watch the NOAA video Northeast Surveys: The Fisheries We Count On (https://videos.fisheries.noaa.gov/detail/videos/sustainable-fisheries/video/6274478742001/northeast-surveys:-the-fisheries-we-count-on?autoStart=true). Ask students what they noticed or was interesting to them in the video. Consider finding out their ideas not only about the type of information scientists collect and why it is important, but also whether this fits with students’ ideas of what scientists do. This is an excellent link for showing the variety of careers that are available in STEM fields.

**Lesson 6 NOAA References**

- NOAA Fisheries video We Fish! American Samoa (https://videos.fisheries.noaa.gov/detail/videos/sustainable-fisheries/video/6238536283001/we-fish-american-samoa?autoStart=true)
- NOAA FishWatch website (www.fishwatch.gov)
- NOAA Fisheries video Northeast Surveys: The Fisheries We Count On (https://videos.fisheries.noaa.gov/detail/videos/sustainable-fisheries/video/6274478742001/northeast-surveys:-the-fisheries-we-count-on?autoStart=true)

### Bottom Trawling

This method of fishing involves using a net that one or two boats pull along the bottom of the ocean. The bottom edge of the net has weights on it. The top edge of the net has floats attached to it. Bottom trawling catches everything in its path and there tends to be a lot of bycatch. Fisheries scientists have worked to make bottom trawling safer for turtles by making nets that allow turtles to escape. Bottom trawling can seriously damage habitats on the ocean floor.

### Purse Seine

When people fish by purse seine, they start by finding a school of fish. They may watch where seabirds are gathering, search for active dolphins, or use helicopters to find the school. The seine is a large net that the boat uses to circle around the school. The fishers pull the net closed at the top to create a kind of "purse" that contains the fish. This technique can catch other animals but because it focuses on a school of fish, there are usually fewer bycatch fish.

### Gillnets

Gillnets are nets that hang in the water, like a wall with holes in it. Gillnets do not need to be attached to a boat, which can make them easier to use. The mesh that makes up the net can be different sizes, depending on what fish the fishers are trying to catch. This also helps to not catch young, small fish. Fish swim into the net and get caught. Other animals can also get caught, so there is a risk of more bycatch. Often gillnets become "lost" at sea by fishers and float aimlessly through the water, killing turtles and many other marine creatures.

### Longline Fishing

Longlines are very long fishing lines with baited hooks every few feet. They can be miles long. The average length in the U.S. is 28 miles. In some areas, there is not much bycatch. In other areas, not only can the hooks catch other fish, they may also catch turtles, sharks, and seabirds.

### Pole and Line Fishing

Pole and line fishing is a person with a fishing pole catching individual fish. There is no bycatch because fishers can immediately throw back anything that is not what they were trying to catch. The number of fish that a fisher can catch is much lower than the number that one person could net.

### Midwater Trawling

In midwater trawling, a boat pulls a net through the water without touching the bottom of the ocean. This means that the nets do not damage habitats at the seafloor. There can be bycatch because the net captures anything that is swimming in the water at the time. The size of the mesh for the net can be different, so some smaller fish may be able to escape. Trawling used to be very dangerous for sea turtles, but fishery scientists have worked to make nets that allow them to escape.

### Traps and Pots

Traps and pots are generally used to catch crabs and lobsters. They are similar to small cages that are dropped to the bottom of the ocean with bait that attracts the animals. They crawl in to get the bait and cannot crawl back out. Fishers on boats come back later and pull the pots in. There is almost no bycatch because the fish may not be attracted to the bait and they cannot get into the trap easily. Sometimes the gear can get swept away by strong currents or storms, or the fishers can forget where they placed the traps and pots.

### Diving

In diving, a fisher swims into the water to collect animals. This is a popular way to gather sea urchins and other bottom-dwelling seafoods. There is no bycatch because the divers can immediately see what they catch and release it if it is not the right kind of animal. Divers cannot collect as many animals as they might with a net.

| Method | Does the method leave fish in an area to continue the population? | Does the method catch specific kinds of fish? Is there a lot of bycatch? | Do fishers bring in many fish at one time or just a few using this method? |
|---|---|---|---|
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# LESSON 7: FOOD MATTERS

## INTRODUCTION

We often think of food webs on land. There are interesting food webs in the ocean, too. This lesson explores how scientists know that matter flows from food to the animals eating it, then links to the idea that this transfer of matter means that plastics in the ocean are a reason for concern.

## LESSON SUMMARY

In this lesson, students learn about basic fish anatomy and use data to determine what happens to the food that an animal eats once it is in their bodies. Using this information, students consider what happens when an animal eats microplastics and share ways to keep plastics out of the ocean.

## OBJECTIVES

- Students will be able to describe how matter flows through food webs in the ocean.
- Students will be able to explain the impact of plastic in the ocean on the animals that live there.

## ESTIMATED TIME

60 minutes. If you would like to break this lesson up over multiple days, consider pausing between steps 8 and 9.

## STANDARDS ADDRESSED

**Science (NGSS):** 5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

## OCEAN LITERACY PRINCIPLES

5 The ocean supports a great diversity of life and ecosystems.

6 The ocean and humans are inextricably interconnected.

## FOCUS QUESTION

What happens to the “stuff” that makes up food when an animal eats it? What happens if an animal eats something it should not?

## MATERIALS

- Fish Anatomy handout, one per student
- Fish Anatomy handout, one copy to display (optional)
- Different-colored pens or pencils
- What Happens to Food? master, one copy to display
- Ocean Food Web master, one copy to display
- NOAA resource on the Great Pacific Garbage Patch, see Preparation section

## PREPARATION

Read through the lesson in advance. In step 11, there is a choice of resources to use with your students. Determine which resource(s) you would like to use with your students. If you choose to use the video, make sure you have the materials you will need to show the video in class. If you prefer to use one or both of the readings, consider if you will print copies or display them for students to read.

## FACILITATION

**Step 1**. Start the lesson by asking students what they think happens to the food that they eat. They may share different ideas, including our bodies using it for energy, the food leaving the body as waste, it getting “digested,” or others. Accept all answers at this point, paying attention to those ideas that may represent a partial understanding.

**Step 2**. Distribute the handout, Fish Anatomy, to students. You may also wish to display a copy of the handout so you can point out the different labeled parts of the fish. Share with students that scientists wanted to understand what happens to food when an animal eats it. Scientists have a way to mark the food that fish eat so they can trace where that food ends up. Tell students to think of it as soaking something in glow-in-the-dark paint so that the paint soaks into every part of the object. These markers stay on food particles, even when they break down.

**Step 3**. Tell students that they are going to have a chance to think about the different results a scientist might see, depending on what food gives to our bodies. Give each group one of the following scenarios and ask them to use a colored pen or pencil to draw small circles to indicate where scientists might find the labeled food in the fish if the scenario is correct. Consider writing each scenario on a small piece of paper to give to students so the group can continue to refer to it. If other ideas came up in Step 1 that would be good for students to think about, you may wish to include those.

For your own information as you facilitate this lesson, the third statement about food breaking down into smaller pieces and becoming part of the body is correct. It represents what the scientists found in their investigations. The other statements are based on common conceptions that students may have.

- We eat food to fill our stomachs so we can be strong.
- We eat food to give us energy. Energy moves out of food particles from the digestive tract into the body.
- We need food to grow and maintain our bodies. Food breaks down into smaller pieces, which move into the body and become part of it.
- We need vitamins from food. The vitamins move out of food particles from the digestive tract and into the body.
- We eat food to help us stay strong. Food breaks into smaller pieces of protein which then move into the muscles to build them up.

**Step 4**. As students work, circulate around the room to make sure students are on the right track. Once groups have had a chance to finish drawing where they think the food would be found in the fish. The following table is to support you in helping the students.

| SCENARIO | WHERE LABELED FOOD WOULD BE |
|---|---|
| We eat food to fill our stomachs so we can be strong. | Students should draw small circles in the stomach and/or along the whole digestive system |
| We eat food to give us energy. Energy moves out of food particles from the digestive tract into the body. | Students should draw small circles within the digestive system. |
| We need food to grow and maintain our bodies. Food breaks down into smaller pieces, which move into the body and become part of it. | Students should draw small circles through the whole fish body. |
| We need vitamins from food. The vitamins move out of food particles from the digestive tract and into the body. | Students should draw small circles within the digestive system. |
| We eat food to help us stay strong. Food breaks into smaller pieces of protein which then move into the muscles to build them up. | Students should draw small circles in the muscles on the diagram. They may also draw them in the digestive system to show the labeled food after the fish ate it and before it broke down. |

**Step 5**. Ask each group to share the scenario they worked on and what they drew on the fish. If more than one group had the same scenario, have them compare what they drew on the fish.

**Step 6**. Have students begin a legend for their fish figure by drawing a small circle in the color they have been using and writing "prediction from scenario" next to it. Then ask them to choose a different colored pen or pencil for the next part of the activity.

**Step 7**. Divide students into new groups so that each group has one student who was exploring each scenario. If you did not add any additional scenarios, each group will have 5 students. Have the students sit close to each other to form the new groups.

**Step 8**. Tell students that you are going to share what scientists found about what happens to food. Display the master, What Happens to Food? Ask students to take a minute to observe the representation quietly. Have them add what they see to their fish graphic by drawing triangles with the new color of pen or pencil. Ask them to add to the legend to show that the triangles represent what scientists found. Then have students talk with their groups to see which scenario it seems to match. Students should find that the image matches that food breaks down and becomes part of the body. Hold a class discussion about their ideas, pointing out that the food became part of all the different tissues in the body. Describe how food breaks down and then becomes part of the matter—the particles—that make up the body of the animal that ate the food.

**Step 9**. Show students the master, Ocean Food Web. Share that this web shows several of the relationships between animals that live in the ocean. When animals eat food, they get energy and matter from the food. Have students choose one food chain from the web, starting with plankton. Explain that this is one set of animals that get energy and matter from each other in order—the same way a grasshopper gets energy and matter from grass and then a bird can get energy and matter from the grasshopper. The bird does not eat the grass directly, but the grass, grasshopper, and bird make a food chain. Ask them to draw the food chain they chose. Encourage them to draw the animals fairly large because they will need to add to them.

**Step 10**. Tell students to imagine that the plankton is all labeled to see where its matter goes. Ask them to draw colored triangles to show that the plankton is labeled. Then ask them to add in the label where they think they would eventually see it. After giving students some time, hold a class discussion to make sure students understand that the matter from the plankton would be incorporated not only into the next animal, but that once that animal became food, the label would become part of the third animal as well. Each of the three animals should have colored triangles when students have completed their drawings.

**Step 11**. Share with students that one of the things scientists have found in recent years is a lot of plastic in the ocean. Show students the NOAA video, Trash Talk: What is the Great Pacific Garbage Patch (https://marinedebris.noaa.gov/videos/trash-talk-what-great-pacific-garbage-patch-0)

If you are unable to play the video for your students, consider using one or both of the following NOAA resources.

- What is the Great Pacific Garbage Patch?
- How Big is the Great Pacific Garbage Patch?: Science vs. Myth

If you use these resources, orient students to the map to show that the continental United States is on the right side of the graphic and Hawaii is visible just west of the label, "Eastern Garbage Patch." Have students use a reading strategy, such as popcorn reading or read-summarize by paragraph, to share the information with the class. Share that plastics have been found throughout the ocean, not just in these patches.

**Step 12**. Remind students that many animals live in the ocean. Others migrate through different parts of the ocean, such as humpback whales making seasonal migrations from Alaska to Hawaii. Highlight the last sentence of the reading that animals may ingest, or eat, plastics. Have students think about what this means for food chains and food webs, based on what they have been learning. Then have them discuss their ideas in their small groups.

**Step 13**. Hold a class discussion about what may happen when animals eat plastics. They should come to understand that the plastic may become part of their bodies and may be passed on to other animals in the food web. Ask students to discuss ideas of how they can help keep plastics out of the ocean. The end of the video in step 11 focused on prevention and you can use those ideas to guide the discussion.

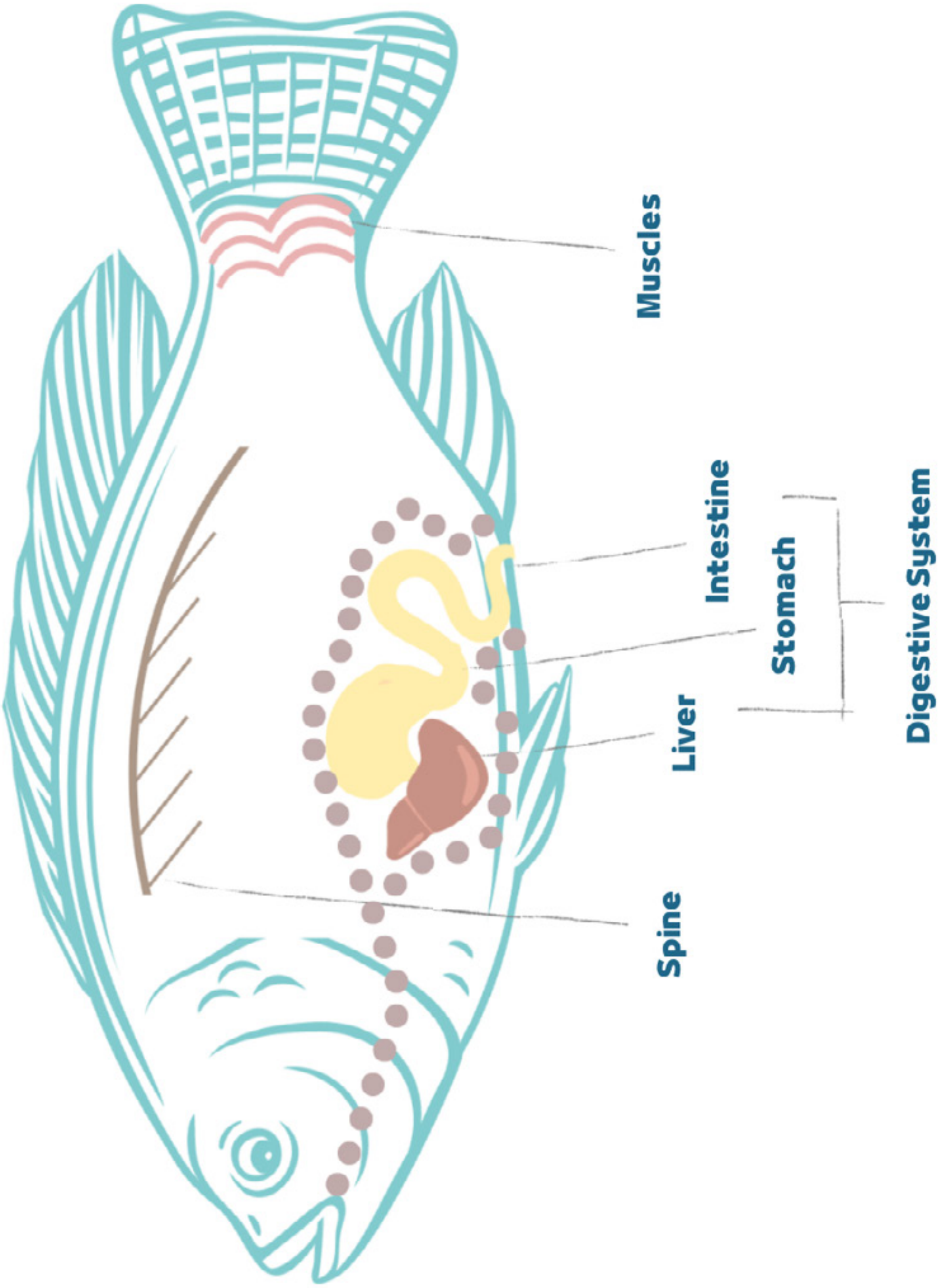
## EXTENSION

NOAA's Marine Debris Program has many resources for teachers and students at https://marinedebris.noaa.gov/activities-and-curricula . Consider expanding this lesson to focus students on other aspects of marine debris and its impacts using the resources there.

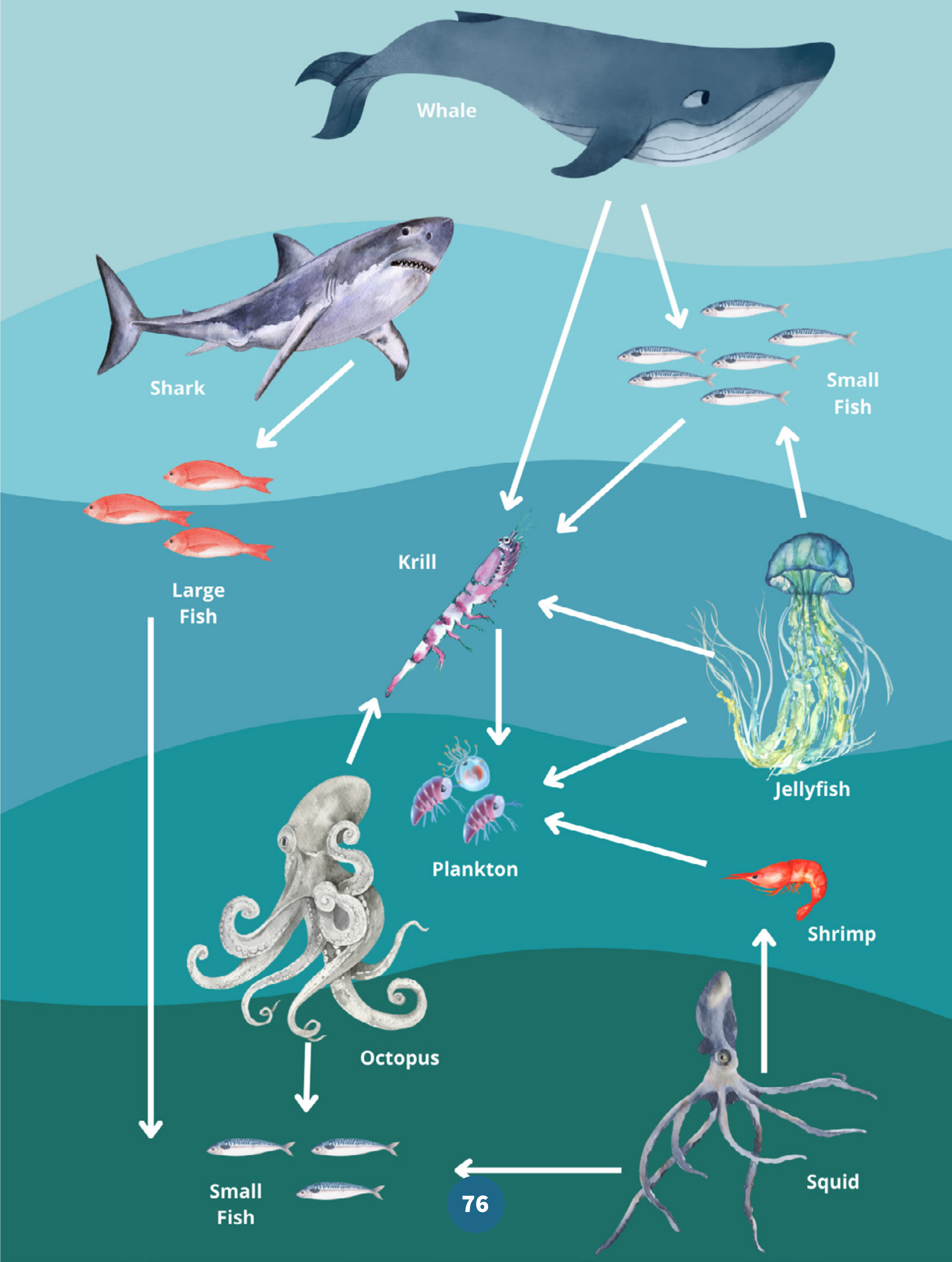
The NOAA Ocean Today Video Collection: Every Full Moon - Trash Talk is a series of 15 videos discussing marine debris in more detail: what it is, where it comes from, how it harms animals, activities students can do in the classroom, and what students can do on their own to address the problem.

**Lesson 7 NOAA References**

- NOAA Marine Debris Program video Trash Talk: What is the Great Pacific Garbage Patch (https://marinedebris.noaa.gov/videos/trash-talk-what-great-pacific-garbage-patch-0)
- NOAA Ocean Service, What is the Great Pacific Garbage Patch? (https://oceanservice.noaa.gov/facts/garbagepatch.html)
- NOAA Office of Response and Restoration, How Big is the Great Pacific Garbage Patch? Science vs. Myth (https://response.restoration.noaa.gov/about/media/how-big-great-pacific-garbage-patch-science-vs-myth.html)


Muscles
Intestine
Stomach
Digestive System
Liver
Spine

# OCEAN FOOD WEB



# LESSON 8: CYCLES IN THE OCEAN

## INTRODUCTION

Scientific drawing can often help students understand science ideas in ways that examining a figure does not. In this lesson, students will have an opportunity to develop a scientific drawing as a model to explain the ocean cycles that affect global climate.

## LESSON SUMMARY

In this lesson, students use a directed drawing to develop a model of how water moves around the world. Students read a scientific reading that describes one major ocean current system and how it may be slowing down. They consider what the impacts would be if this system were to slow significantly or stop moving water.

## OBJECTIVES

- Students will use scientific drawing to understand how water moves in the ocean and the impacts of that movement.
- Students will explain how changes to a major ocean current would impact the Earth.

## ESTIMATED TIME

60 minutes. If you wish to complete this lesson over multiple days, divide the lesson to do steps 1 through 7 on day 1 and the remainder of the lesson on day 2.

## STANDARDS ADDRESSED

**Science (NGSS):** 5-ESS2-1. Develop a model using an example to describe ways the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

## OCEAN LITERACY PRINCIPLES

3 The ocean is a major influence on weather and climate.

**Geography**: Standard 7 The physical processes that shape the patterns of Earth's surface.

Standard 15 How physical systems affect human systems.

Standard 18 How to apply geography to interpret the present and plan for the future.

**English Language Arts (CCSS):** W.5.2 Write informative/explanatory texts to examine a topic and convey ideas and information clearly.

## FOCUS QUESTION

What impact would there be on plants and animals if a major ocean current slowed down or stopped?

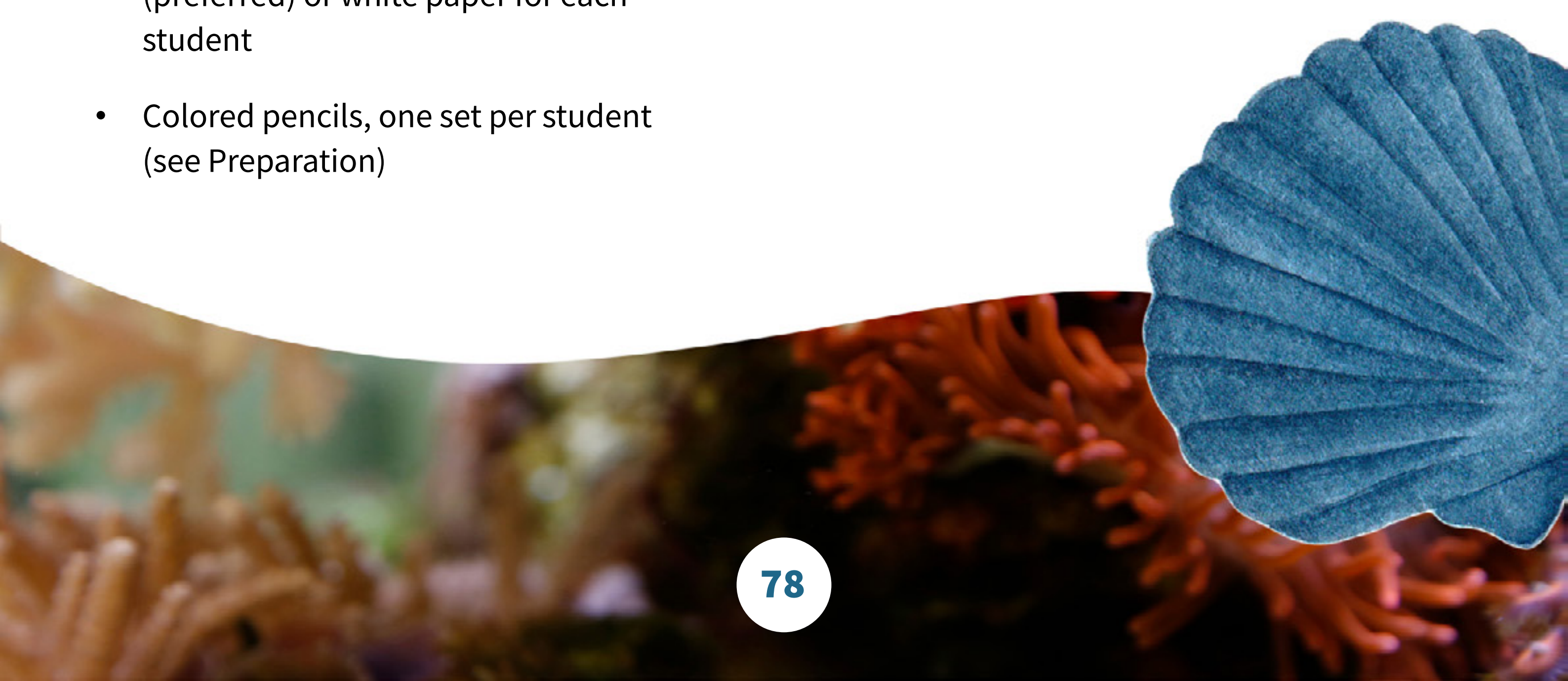
## MATERIALS

- Paper, one or two pieces of light blue (preferred) or white paper for each student
- Colored pencils, one set per student (see Preparation)
- Chart paper
- Markers
- Scientific Drawing: Ocean Currents master, one copy to use for facilitation
- Rulers, a few for the class
- Ocean Conveyor Belt master, one copy to display
- Science News, one copy per student

## PREPARATION

In this activity, it will be difficult for students to share sets of colored pencils because the scientific drawing will ask them to use certain colors for some parts of the drawing. It will save time if each student has a set of colored pencils, so students do not have to wait on each other to finish with a color.

Lesson 4 "Ocean Currents" is also about thermohaline circulation. Consider previewing the activities and resources in that lesson to determine if you would like to use any of them in conjunction with this lesson.



## FACILITATION

**Step 1**. Share with students that sometimes people think that if you like science, you cannot like things like art or music or that you must grow up and be a doctor or a scientist. But that is not true! In this activity, they are going to have an opportunity to learn science while exploring an area that combines science and the arts. This activity focuses on scientific illustration to learn about some processes that happen in the ocean.

**Step 2**. Distribute one piece of light blue or white paper and a set of colored pencils to each student. Place chart paper in a landscape orientation in a place where everyone can see it. Ask students to turn their paper in a landscape orientation.

**Step 3**. Tell students that they are going to have a chance to do a scientific drawing to show how large ocean currents work to affect the whole planet. Share that you will take them through the scientific drawing step-by-step because they will be learning and illustrating at the same time.

**Step 4**. Use the Scientific Drawing: Ocean Currents master to guide students through the drawing. The left column describes a possible narrative for the steps. The right column has an example of what the drawing might look like. As you go through each step, students should add to their own drawings on the blue or white paper. At the same time, complete a drawing of your own on the chart paper. In some cases, such as step 1 of drawing the horizontal line, you might do the drawing first. In other cases, such as drawing arrows, you might wish to have students come to consensus on where/how to draw on the chart paper or you might have a student come up to draw at that point.

**Step 5**. Share with students that the type of current that they have illustrated is an example of thermohaline circulation. This is a process which drives large masses of water throughout the ocean on a current known as “The Great Ocean Conveyor Belt.” Display the Ocean Conveyor Belt master and have them compare what they drew to the image of the thermohaline circulation process. Students should recognize that there are places where warm water is rising and cool water is sinking as it traverses the globe.

**Step 6**. Once students have completed their initial drawing, have them work in pairs or small groups to share the “story” of their drawing with a partner or small group. Ask each student to use the scientific drawing to explain how ocean currents move water around the world and why they function the way they do. After each student explains the process, have the small group share any feedback that could make the drawing clearer or more accurate.

If students are not used to offering feedback to one another, you may need to give examples and non-examples of constructive feedback to help them. Sentence stems may help guide students in giving feedback.

**Step 7**. Give students a few minutes to make any revisions to their drawings based on the feedback they received. Share that the drawing they have is a model of how water and heat move around the world, and there are different kinds of currents and water "conveyor belts" around the globe so they are going to have a chance to learn more about a real system in the ocean.

**Step 8**. Distribute copies of the handout, Science News, to students. Ask them to read the brief article. Support them by suggesting a reading strategy if your students would benefit from using one.

**Step 9**. Ask students to summarize the article. This could be in small groups or as a class. Then ask them to use their models to show why the Earth getting warmer would keep the current from flowing.

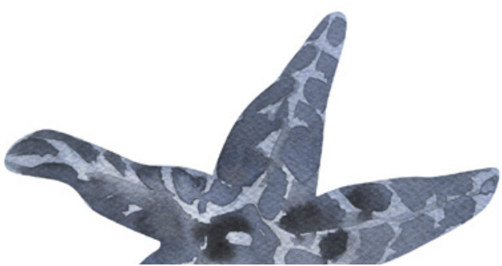
If you would like additional information about thermohaline circulation to help you lead the discussion, two resources that may be useful are

- The Global Conveyor Belt, a clickable animation with descriptions of the stages of water movement (https://oceanservice.noaa.gov/education/tutorial_currents/05conveyor2.html) and
- What is a Current, a video which presents the thermohaline circulation process in its third section (https://oceanservice.noaa.gov/facts/current.html).

**Step 10**. Ask students to develop an explanation to answer the question, "What impact would the AMOC slowing or stopping have on plants and animals?" (Atlantic Meridional Overturning Circulation, or AMOC for short) Encourage students to think about the different points in the article, such as salt, temperature, nutrients, and other substances, such as waste. Each student can pick one area, but across the class encourage different focuses for the explanations.

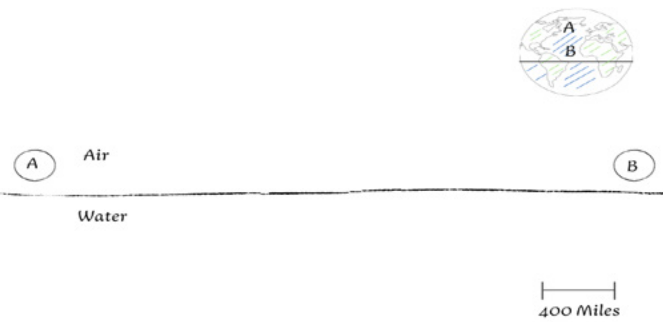
If students have done claim-evidence-reasoning before, ask them to use the format they have used. If they have not created explanations previously, offer more guidance to help them with the process. The following points may support them in developing their explanations.

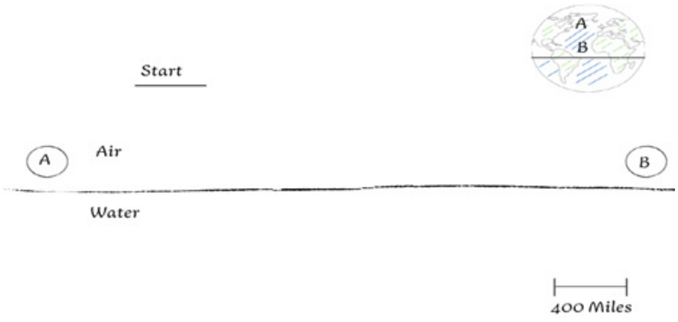
- A claim is an answer to a question. It should be specific, such as, "If the AMOC stopped flowing, the Earth would be too cold in some places for plants and animals to live and too warm in other places," rather than a general statement such as, "If the AMOC switched to weak circulation it would affect plants and animals."
- Explanations use evidence. Students should be able to point to specific points on their drawings that would be different. Describing what they see on the drawings that would be different represents evidence.
- Reasoning links the evidence to science ideas. Students should be able to explain the impacts each piece of evidence would have on the Earth.

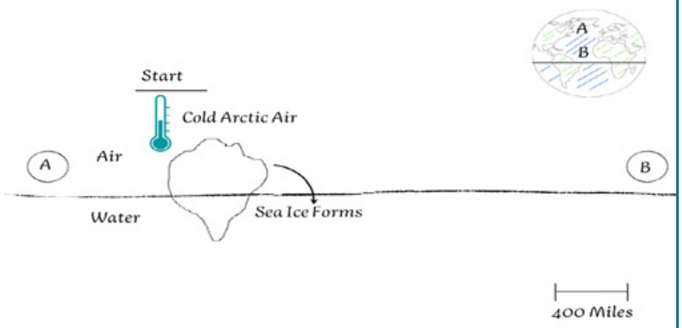


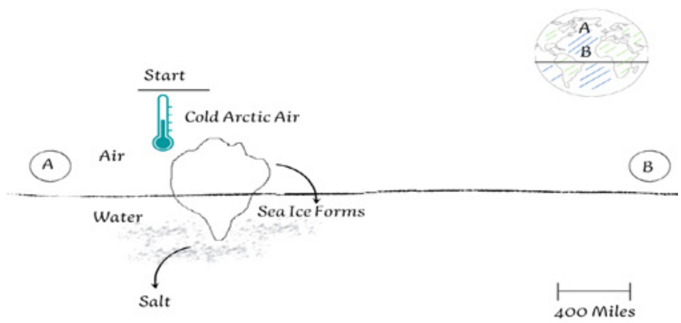
## EXTENSION

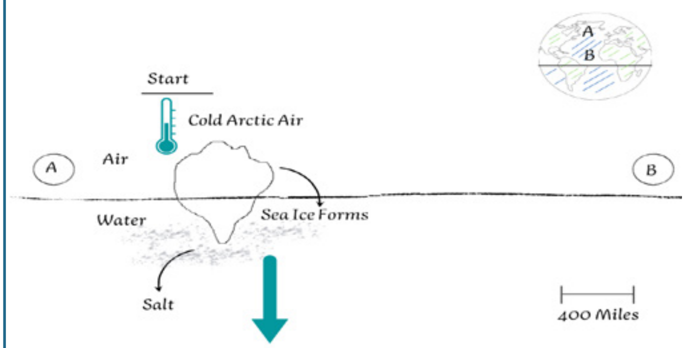
NOAA has many resources about the impacts of climate change. Preview the information and resources at Climate Change Impacts (https://www.noaa.gov/education/resource-collections/climate/climate-change-impacts). Decide if you would like students to use any of the lessons, videos, or other resources to further explore how climate may change and affect global currents.

| Possible Narrative | Example of Drawing |
|---|---|
| With your page landscape (the long side going from left to right), draw a horizontal line near the center of the page. This represents where the ocean meets the atmosphere. The line does not have to be perfect, because the ocean does not have a straight, flat surface. Do not draw waves or ripples, though because we are looking at a side view across thousands of miles. Above the line, write a label that says “air” and below the line write a label that says “water.” |  |
| Next, we need to orient people to where we are on Earth and what they are looking at. Often, when we are looking at a representation of thousands of miles along the Earth’s surface, we are looking at something like a globe or a world map. In this case, so far we just have the air and the water. Let’s make sure we are helping people know what they are looking at. I am going to have you draw a rough sketch of the Earth in the upper right corner.<br><br>• It should start with a circle that is about 1 ½ inches in diameter.<br>• Draw a line across the middle to (equator).<br>• Draw a rough outline of North and South America—it does not need to be perfect, but just show land that crosses the equator and spans from north to south.<br>• Sketch in a few lines of blue in the ocean and a few lines of green on the land.<br>• Now put an A in the ocean near the north part of the land and a B near the equator.<br>• On the main part of your picture, put an A at the far left near the line and a B at the far right near the line.<br><br>What does this tell us about the orientation of our picture compared to the globe? We should also add something to show the scale of this drawing. It is around 4,500 miles from the equator to the Arctic Circle so we will use that as a guide. If we say that A is close to the Arctic Circle and B is at the equator, and your paper is 11 inches from side to side, that means 1 inch is about 400 miles or so. Draw a line that is about 1 inch and label it as 400 miles. |  |

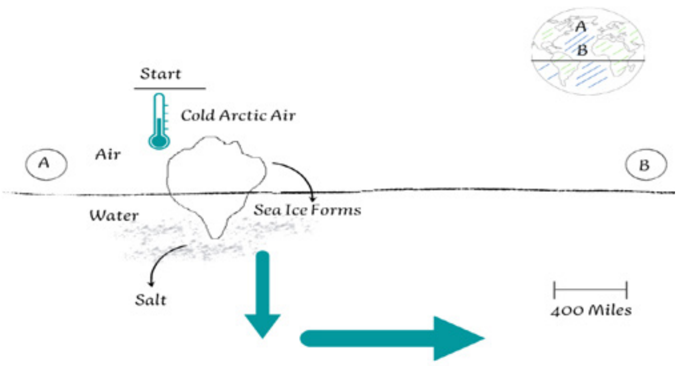
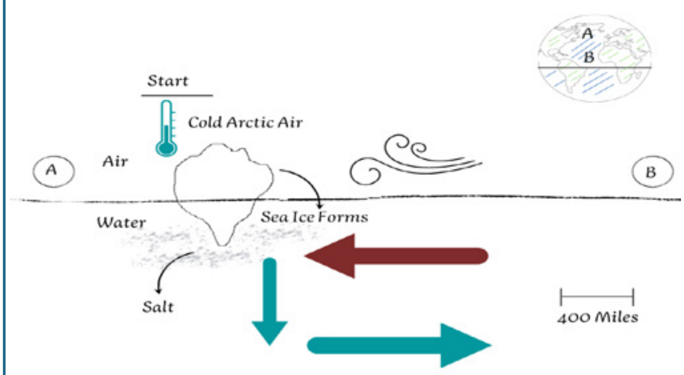
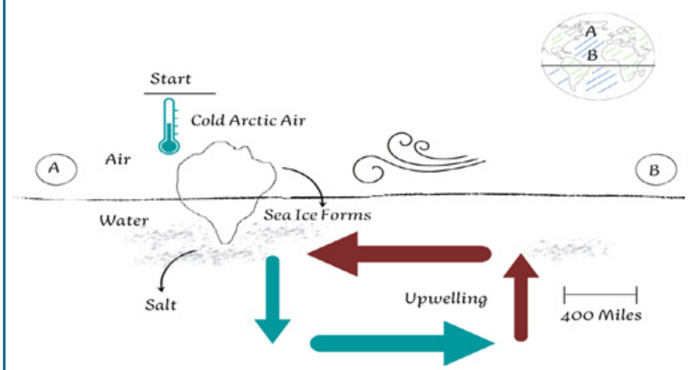
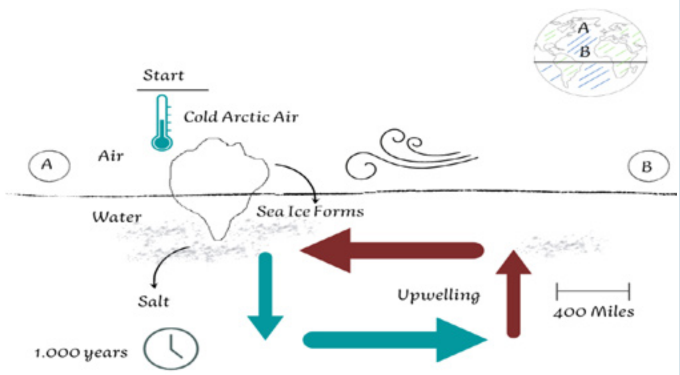
<table>
<tr><th>Possible Narrative</th><th>Example of Drawing</th></tr>
<tr><td>Today, we are going to be creating a model for the “global conveyor belt” currents in the ocean. These are the currents that move water around the globe. Our description of the conveyor belt is going to start near our “A” label. Make a symbol or write the word “start” to show where our description will begin.</td><td>


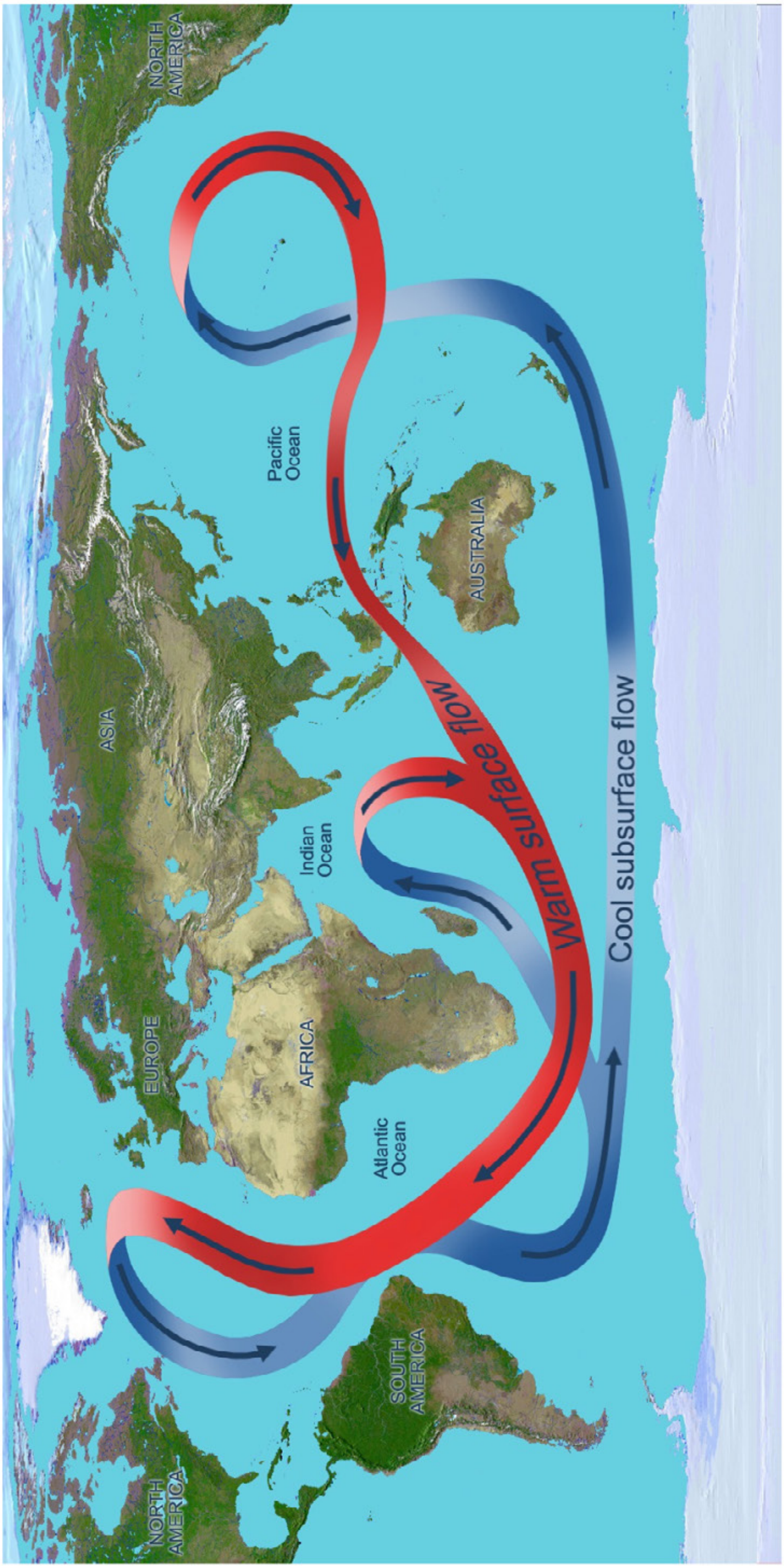
</td></tr>
<tr><td>In the arctic, it is very cold. That starts to chill the water near the surface and sea ice starts to form. I am going to draw a thermometer that is blue to show how cold the air is and label it, “cold arctic air.” Then I am going to draw some sea ice in the water and label it with, “sea ice forms.”</td><td>


</td></tr>
<tr><td>When the sea ice forms, it is only the water that freezes. It leaves behind the salt, which stays in the water around the ice. Let’s draw some salt in the water here to show that there is extra salt. Remember we are doing scientific drawing to help explain this concept, so we will need to label it as, “salt.”</td><td>


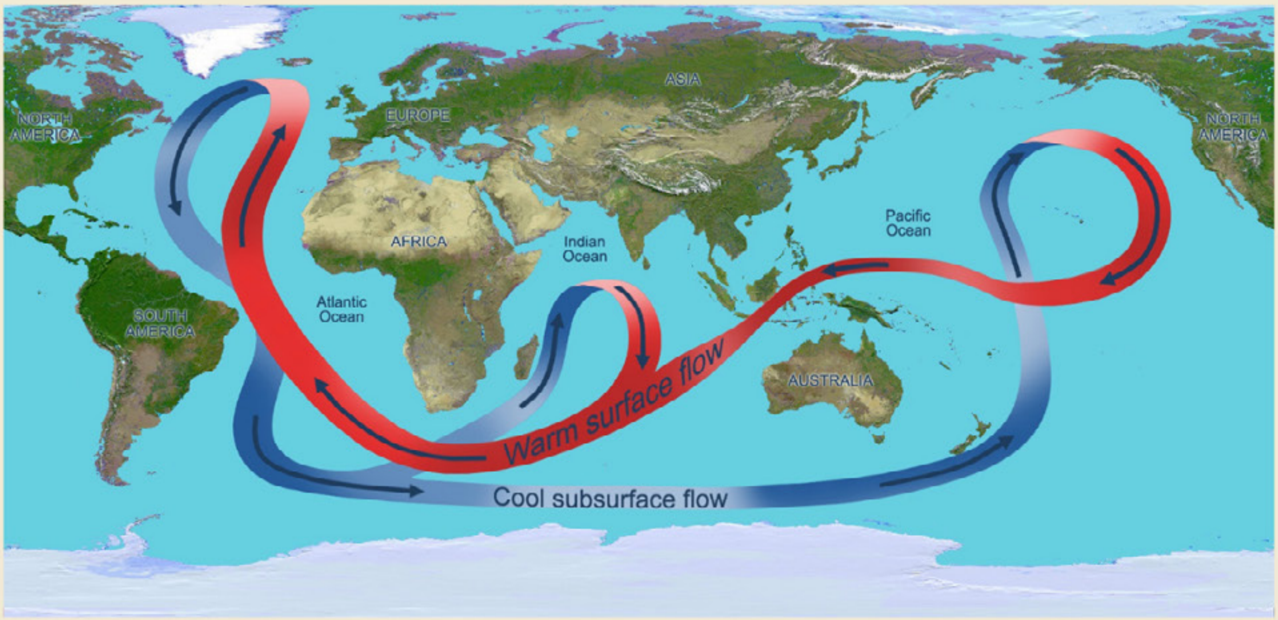
</td></tr>
<tr><td>Now we have sea ice surrounded by water that has extra salt in it. That water is heavier because it does have more salt. It is also very cold from being near the surface with the cold air.<br><br>Have you ever heard the idea that hot air rises, like with a hot air balloon? The same idea applies to liquids where warm liquids rise, and cold liquids fall. Now this water is not only colder than the water below it, but it is also heavier. What do you think will happen? (The water will start to sink toward the bottom of the ocean.) Let’s draw a big blue arrow to show that this water is sinking toward the bottom.</td><td>


</td></tr>
</table>

| Possible Narrative | Example of Drawing |
|---|---|
| As the water sinks, it pushes the water that was already on the ocean floor to the side. The water becomes warmer and less salty because it mixes with other water. But, the water on the floor begins moving out of the way. Draw a blue arrow along the ocean floor to show that this water is still cooler and is moving toward B. Which direction is that on our globe up here in the corner? (to the south) |  |
| At the same time, new water must replace the water that sank toward the bottom. This water is helped by winds on the surface. It is mostly coming from the south, so it is warmer. Let's draw some winds on the surface as well as a red arrow to show that warmer water is moving into the arctic area. |  |
| Now we have water moving near the bottom of the ocean toward warmer areas of the Earth, near the equator. We also have water moving from those warmer areas toward the arctic. As the water warms up, it is going to begin to rise toward the surface and complete this cycle. Let's draw a red arrow to show warmer water rising toward the surface. This is called upwelling so let's label it with that word. We want to remind ourselves that the water is not as salty here, so add something to show that the water is salty, but not as much as it is near A where we have the sea ice forming. |  |
| This type of current moves water and heat around the world. Let's add that to the drawing. The other thing we will want to add to give people a sense of how this works is to add time. Scientists say that if you followed one particle of water around through a current like this, it would take 1000 years to make it all the way through the cycle. It moves a lot of water, but it is not moving really fast. Let's put something on our scientific drawing to show that it is roughly 1000 years to go through the whole cycle. |  |


NORTH AMERICA
ASIA
Pacific Ocean
AUSTRALIA
Warm surface flow
Cool subsurface flow
Indian Ocean
EUROPE
AFRICA
Atlantic Ocean
SOUTH AMERICA
NORTH AMERICA

# SCIENCE NEWS




● An illustration of the AMOC and its place within large-scale global ocean circulation

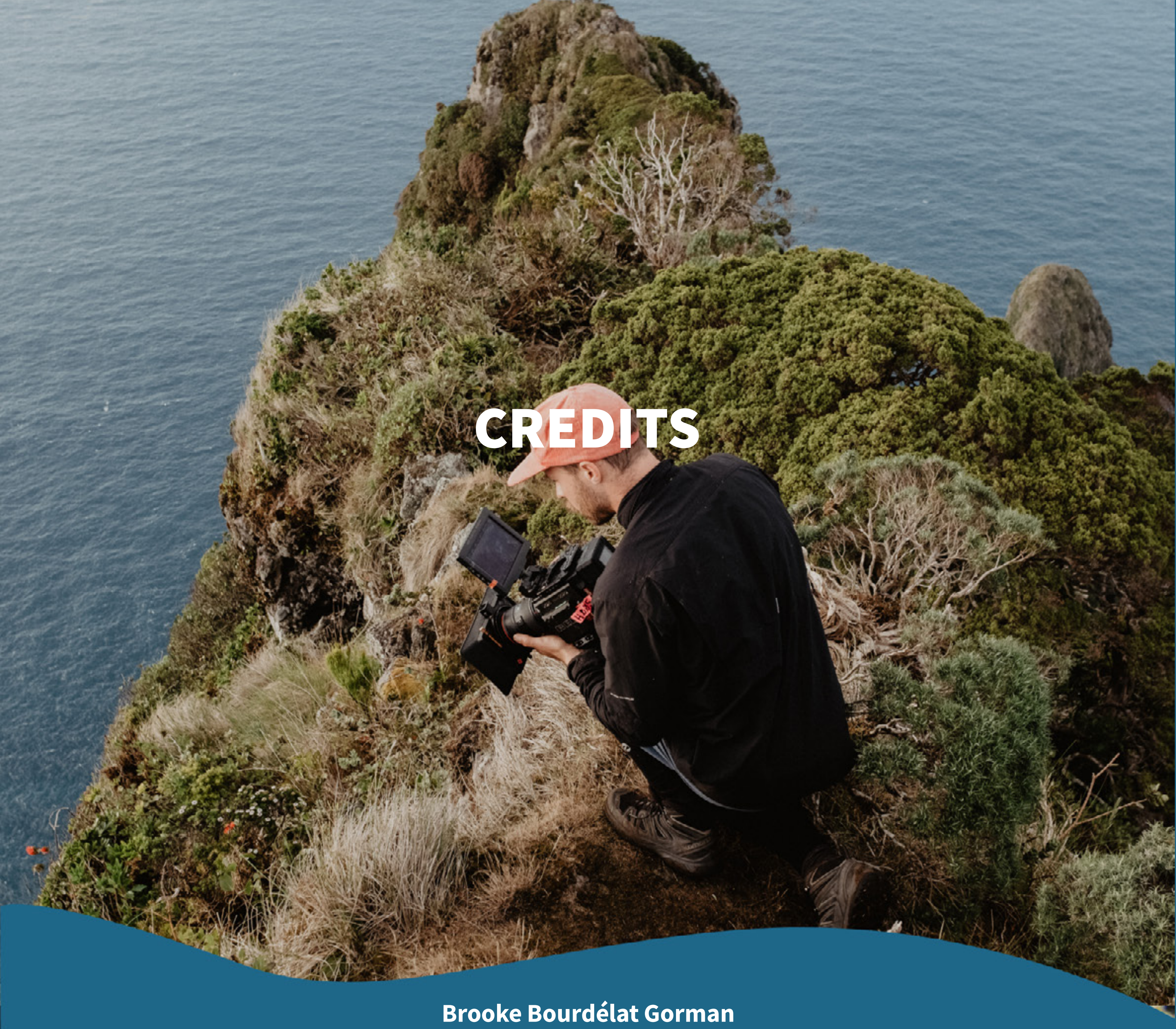
## THE AMOC

The "Atlantic Meridional Overturning Circulation," or AMOC for short, is a system of ocean currents. It runs from the northern part of the Atlantic Ocean around South America, Australia, and Africa.

The AMOC moves a lot of water! Salt moves with it and mixes with other water that is less salty. This helps to keep parts of the ocean from becoming too salty for living things. The AMOC also carries heat. Areas around the equator get a lot of direct sunlight, so there is a lot of heat there. The AMOC helps to distribute the heat to other parts of the globe. This makes the poles warmer as the heat moves toward them. It also makes the area around the equator cooler because heat does not build up.

Parts of the AMOC can move nutrients and other substances around in the ocean so they do not build up. The water carries nutrients to living things in different areas. Other substances, such as waste, become more spread out and do not build up in one area.

Like a gyre, the AMOC depends on the cooling that happens at the surface of the water in the North Atlantic. If the climate of the Earth changes and temperatures become warmer, the surface water will not cool. Sea ice will not form. Scientists think that this could slow down the AMOC making it much weaker. Some scientists think that in the future, the AMOC might stop circulating.



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Graphic Design

Ocean Odyssey is a K2 Studios release of a Wild Pacific Media and Definition Films production.

# APPENDIX

All URLs have been verified at the time of publication.

**Next Generation Science Standards (NGSS):**

https://www.nextgenscience.org/

The Next Generation Science Standards are K–12 science content standards, developed by states. All the standards noted in this document can be found in their entirety by typing in the standards "code" associated with each lesson into the keyword search box on the website.

**Ocean Literacy Principles (OLP):**

https://oceanservice.noaa.gov/education/literacy.html

A practical resource for educators, this guide outlines the knowledge required to be considered ocean literate. Many scientists and educators collaborated to produce these resources, building on efforts to define ocean literacy and identify the principles and concepts that should be included in K-12 curricula.

**Common Core State Standards (CCSS):**

**English Language Arts** http://www.corestandards.org/ELA-Literacy/

**Mathematics** http://www.corestandards.org/Math/

The Common Core State Standards is a set of high-quality academic standards in mathematics and English language arts/literacy (ELA). These learning goals outline what a student should know and be able to do at the end of each grade. The standards were created to ensure that all students graduate from high school with the skills and knowledge necessary to succeed in college, career, and life, regardless of where they live.

**National Geography Standards:**

https://www.nationalgeographic.org/standards/national-geography-standards/

The National Geography Standards represent the consensus of the geography education community around what students should know and be able to do by the time they graduate from the 12th grade. More information about the standards is available from the National Council for Geographic Education (https://ncge.org/).

**This Educator's Guide was supported by NOAA Planet Stewards**

https://oceanservice.noaa.gov/education/planet-stewards