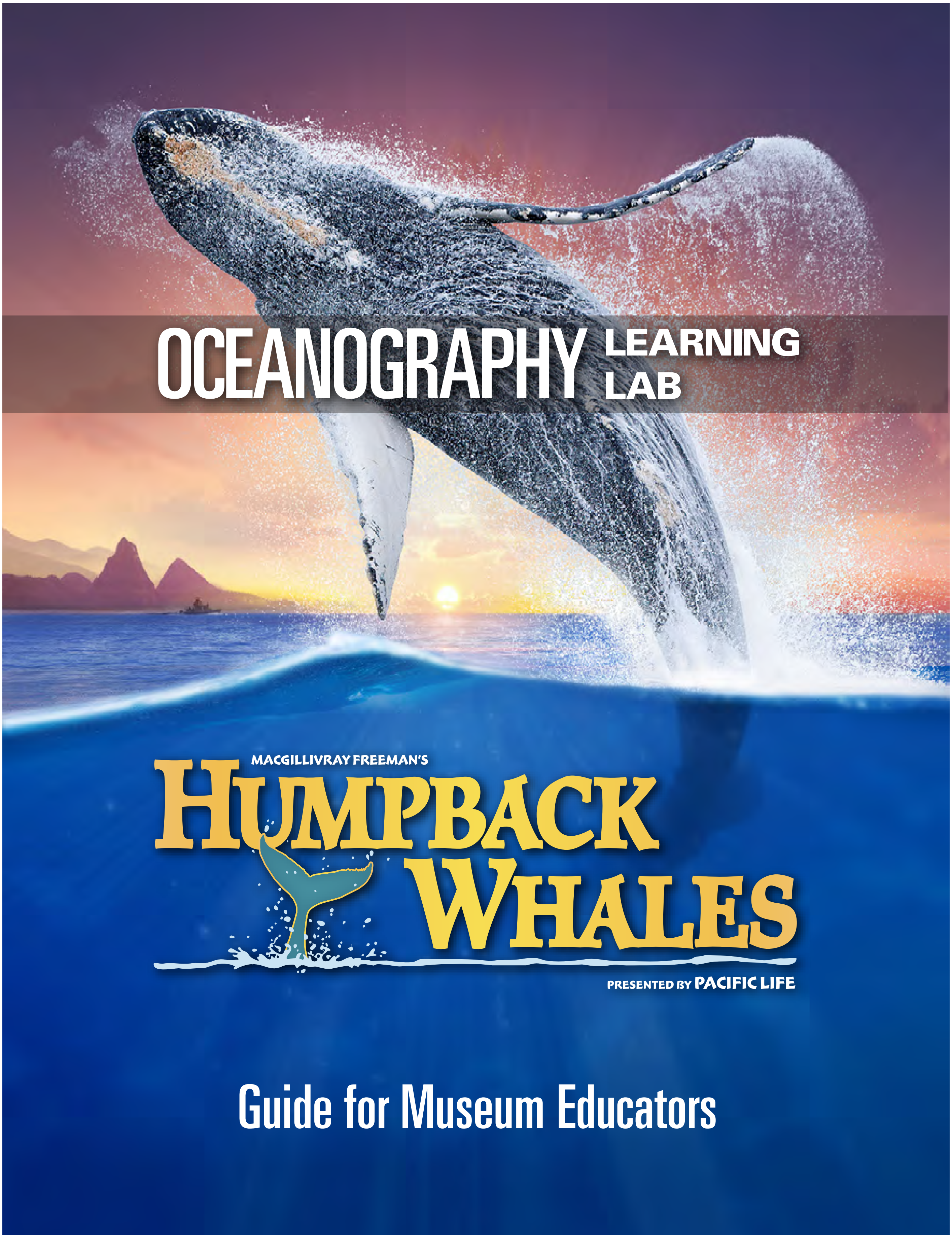

OCEANOGRAPHY LEARNING LAB

MACGILLIVRAY FREEMAN'S

HUMPBACK WHALES

PRESENTED BY PACIFIC LIFE

Guide for Museum Educators

Developed by

Reuben H. Fleet Science Center

With Funding Provided by

MacGillivray Freeman Films Educational Foundation

Orange County Community Foundation

In Association With

MacGillivray Freeman Films

Pacific Life

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Humpback Whales Learning Lab Overview

Introduction

In this guide, you will find six learning lab station activities that are designed to provide educational experiences to pair with the film, *Humpback Whales*. Accompanied by an introduction PowerPoint presentation, these hands-on activities align with Next Generation Science Standards, are appropriate for students in third through eighth grades, and last 10-15 minutes each.

Stations

The station activities could be used as a set or individually as components in your summer camps, overnight programs, scout programs, and school workshops. As a learning lab for schools or the public, one example for using these materials would be to begin with the PowerPoint introduction, followed by students rotating through three stations set up in your classroom. This scenario would be approximately 45 minutes, but you could choose to make it shorter or longer by changing the number of stations.

The stations are designed for groups of 8-10 students, however, several stations would benefit from having multiple sets of materials at the station so that all students may participate in the allotted time. Refer to the Helpful Tips section of the Museum Educator Guides for these suggestions.

Many of the stations utilize materials you may already have at your museum! Depending on which ones you choose, setting up individual stations could cost as little as $35, or up to $200. Ward's Science and Carolina Biological are noted as possible places to obtain science supplies, but please note that a simple internet search may yield comparable prices!

Room Set Up & Staffing Recommendation

Each activity that you choose to implement should be set up at a different table, or "station," with adequate space to accommodate up to ten students at a time. One adult should be present at each station.

Most activities are student directed, however two of them are specifically adult-led demonstrations which involve handling materials such as dry ice and hot water. Each lab activity also concludes with a group discussion, which would be best facilitated in the presence of an adult leader.

A Guide to the Learning Lab Documents

A Breakdown of the Documents

Humpback Whales PowerPoint

The Humpback Whales PowerPoint presentation is provided for use as an introduction to humpback whales. The content coincides with the topics available in the various learning lab activities. The PowerPoint is accompanied by scripted notes for the museum educator.

Museum Educator Guides

Museum Educator Guides provide basic set-up notes for the museum educator. Refer to the Helpful Tips section to guide you to making informed decisions about the quantity of materials you will need to accommodate large student groups.

Task Cards

Task Cards list step-by-step activity procedures for students. Print and laminate the Task Cards and place them at the station so that students may refer to them for directions.

Lab Sheets

Lab sheets are tools students can use to collect and synthesize their data. Lab sheets may be given to students as individual loose pages, or they may be combined with each other to form a booklet. For your convenience a cover for the student booklet is included on page 9.

Discovery Sheets

Discovery Sheets provide background information and definitions pertaining to the station. You could send them to teachers as a reference tool in advance, or laminate them and have them available at the stations for students and chaperones to use as a helpful reference guide.

Printables

Printables are supplemental information sheets that should be printed, laminated, and made available to students at the station. They mostly contain supplemental visuals that pertain to the individual activity being presented. They pair beautifully with the Discovery Sheets, but may also be provided to students in isolation.

Experiment Procedures

Experiment Procedures specifically accompany only two of the learning lab stations: Convection Currents and Ocean Acidification. These two stations are demonstrations that must be led by an adult! Experiment Procedures provide specific step-by-step directions for the adult leader. Be sure to thoroughly brief the adult leading each of these two stations prior to dispersing students into rotations.

Humpback Whales
Introduction PowerPoint Script

1. Humpback Whales

Welcome students, teacher, and chaperones to your museum. Introduce yourself and any accompanying staff. Make any other announcements pertinent to your museum.

2. Creature Features

*"The scientific name for the humpback whale comes from Latin words meaning **giant wings**. Can you guess why they are called giant wings?* (Allow students to make a guess.)

Giant wings *refers to the humpback's large pectoral fins, which are about as long as one third of the whale's body. These long pectoral fins are one of the most recognizable features that people notice when they spot humpback whales."*

*"The common name **humpback** comes from the small dorsal fin on its back, and the appearance of a **hump** it creates when the whale arches its back."*

"Although they may look like a giant fish, a shark, or maybe even a bird that flies underwater, humpback whales are actually mammals, just like us."

"Think about it: What do you already know about mammals?" (Call on students to share what they know about mammals, and then summarize by mentioning characteristics that they did not know.) *"Characteristics include: are vertebrates, are endothermic, have a 4 chambered heart, have hair, give birth to and nurse live young, breathe air."*

Point out the features that have been labeled on the slide.

"Baleen whales have 2 blowholes, while toothed whales have just one!"

Students may wonder where the hair is. Tell students:

"The bumpy tubercles on a whale's head each contain a hair follicle and some have bristles (like a hair) coming out of them!"

3. Voluntary Breathers

Play the clip of a humpback breathing/spouting.

"On average, an adult humpback whale can hold its breath between 7 and 15 minutes."

"Calves need to breathe every 3-5 minutes."

"Some humpback whales can amazingly hold their breath for up to 45 minutes at a time!"

4. Now Try This

Distribute the lab sheet titled, "Hold Your Breath Like a Humpback Whale" or direct them to turn to that page in their booklet (if a booklet has been created).

Guide students through the activity. Start the stopwatch once you direct students to begin holding their breath.

5. Songs in the Sea

*"Humpback whales are best known for their **songs**. The vocalizations, or sounds that they make, travel great distances in the ocean. Sound waves travel faster in water than they do in air!"*

"It may surprise you to learn that only the male humpback whales sing! They do it with their head facing down too!"

"One way scientists are able to study humpback whales is by recording their songs and vocalizations with special underwater microphones called hydrophones!"

Click the link to listen to a whale song. Direct students to look at the spectrogram, so they can 'see' the song as it is being sung.

6. Diet

"You may wonder what kinds of foods are needed to give such a large active whale the energy it needs to sing, swim, migrate, dive, and display surface behaviors."

"A humpback whale's diet consists mainly of small crustaceans called krill that are about the size of a paper clip!"

"Krill are a mere 2 inches in length, but when consumed in large quantities (up to 4,000 pounds at a time)*, they provide the essential nutrients that these great whales need to survive."*

7. Baleen

"Humpback whales are baleen whales. Instead of teeth, they have a series of flexible plates called baleen attached to their jaws. It may look a little like hair, but it is not. It is actually made up a material called keratin. Keratin is the same material our fingernails are made of!"

"Baleen whales feed by first swallowing a mouthful of water containing their prey. They then use the baleen in their mouths like a sieve to filter out the food from the ocean water."

Note: If you have a real whale baleen sample for the Catching Krill activity, you may choose to show the baleen to the whole class at this time!

8. Bubble Netting

"Humpback whales are usually solitary creatures, but they have been known to come together with other humpbacks to accomplish a unique feeding strategy called bubble netting."

"One humpback will swim below a school of krill and blow bubbles in a circle to enclose its prey. The krill get captured within the bubbles, and the whales waiting below swim upwards, engulfing the krill!"

Play the animation of the bubble netting behavior.

9. Food Chains vs. Food Webs:

"Food chains and food webs are diagrams that represent feeding relationships. Essentially, they show who eats whom. In this way, they model how energy and matter move through ecosystems. A food chain is a series of living things in which each one uses the next lower living thing as a source of food, while a food web represents multiple pathways through which energy and matter flow through an ecosystem. It includes many intersecting food chains."

Ask students to think about whether this diagram is a food chain or a food web, and how they know. (It is a food chain, because it shows only one species consuming another one species.) Explain the components of the food chain represented using the prompts below.

"Humpback whales are part of a food chain with only three links!"

"Plankton (meaning drifter) *are the microscopic organisms that drift around in the ocean's currents. All forms of life in the ocean depend upon plankton for food."*

"Phytoplankton (plant-like plankton) *are used by krill for food, and krill become the food for humpback whales!"*

10. Whales Are Important!

"When it comes to the environment and the health of the ocean ecosystem, whales are important! They help regulate the flow of food by helping maintain a stable food web. Imagine what would happen to the food web if there were no whales."

"At first, you may think that krill and small fish would benefit from not having to face a predator, but over time these animals would overpopulate and possibly destroy the populations of other species they feed on."

"When humpback whales feed, they drive their prey to the surface making it easier for seabirds to catch fish!"

"Even whale poop plays a large role in the environment! Phytoplankton can feed on some of the nutrients found in whale poop, and more phytoplankton means more carbon can be pulled from the atmosphere to provide a cleaner and healthier breathing environment for all animals! Phytoplankton feed fish, which in turn feed other species that require fish to survive, therefore keeping the food chain stable!"

"Now can you see just a few ways whales are important to the health of the ocean ecosystem!"

11. What We Do Today Impacts the Future!

"An ecosystem is everything that exists in a particular environment. Humpback whales are part of a marine (ocean) ecosystem."

"Humans affect the marine ecosystem in many ways. Human impacts have the potential to not only upset the balance of food chains and the health of ocean animals, but to also alter the physical components of ocean water."

"What happens to the future of the oceans, the Earth, and all the living things within it depends on what we do today!"

"Each person in this room can make a difference in important ways. Simple things we can do to make a positive impact include: conserving energy, putting trash in its place, and conserving water. Larger things we can do include sharing awareness about the importance of whales, buying sustainable seafood, creating whale-safe fishing gear, supporting the ban on whaling, altering shipping lanes to avoid migratory paths and promoting marine reserves. The effects can be large if we each do just a small part and learn how to better care for the environment and natural resources!"

12. Oceanography and Marine Biology

"People who are curious and have a love of the outdoors (especially the ocean) may choose to become a scientist who focuses specifically on studying the ocean."

"Oceanography, also known as marine science, is the scientific study of the physical and biological components of Earth's oceans. Oceanographers are scientists who help us gain a better understanding of how our oceans and the living creatures in them function as an ecosystem."

"Marine biologists study the plants and animals that live in oceans. Marine biology includes the study of everything from small organisms such as plankton right up to very large creatures such as humpback whales!"

13. Learning Labs

"Today each of YOU will have a unique opportunity to explore and make discoveries as marine biologists and oceanographers in these various learning lab stations! Enjoy this opportunity to investigate and discover new things about amazing humpback whales, their ocean habitat, and impacts that threaten their survival."

Indicate which labs have been set out and give a brief overview to introduce them. (Use the objective statements below.)

Tell students that each station has a Task Card with the step-by-step directions for the activity. Their Lab Sheet is where they will make a hypothesis, record their data, and draw conclusions. Most stations have Printables with helpful visuals. Finally, note whether or not a Discovery Sheet (background information) has been provided.

Station Overviews (objective statements)

A Blubbery Discovery: You will conduct a hands-on experiment to explore the insulating properties of blubber!

Catching Krill: You will observe real whale baleen and simulate catching krill as a baleen whale and as a toothed whale.

Food Web Game: You will play a game and see that even small changes in the ecology of the ocean environment can have a large impact!

Focus on Phytoplankton: You will use microscopes to observe phytoplankton, and make connections about the important roles they play in the marine environment.

Ocean Acidification: You will discover the effects of climate change on the ocean and discuss its impacts on marine life and people.

Convection Currents: You will observe a demonstration of convection currents.

Humpback Whales
Learning Lab Booklet

This Learning Lab Booklet Belongs to:

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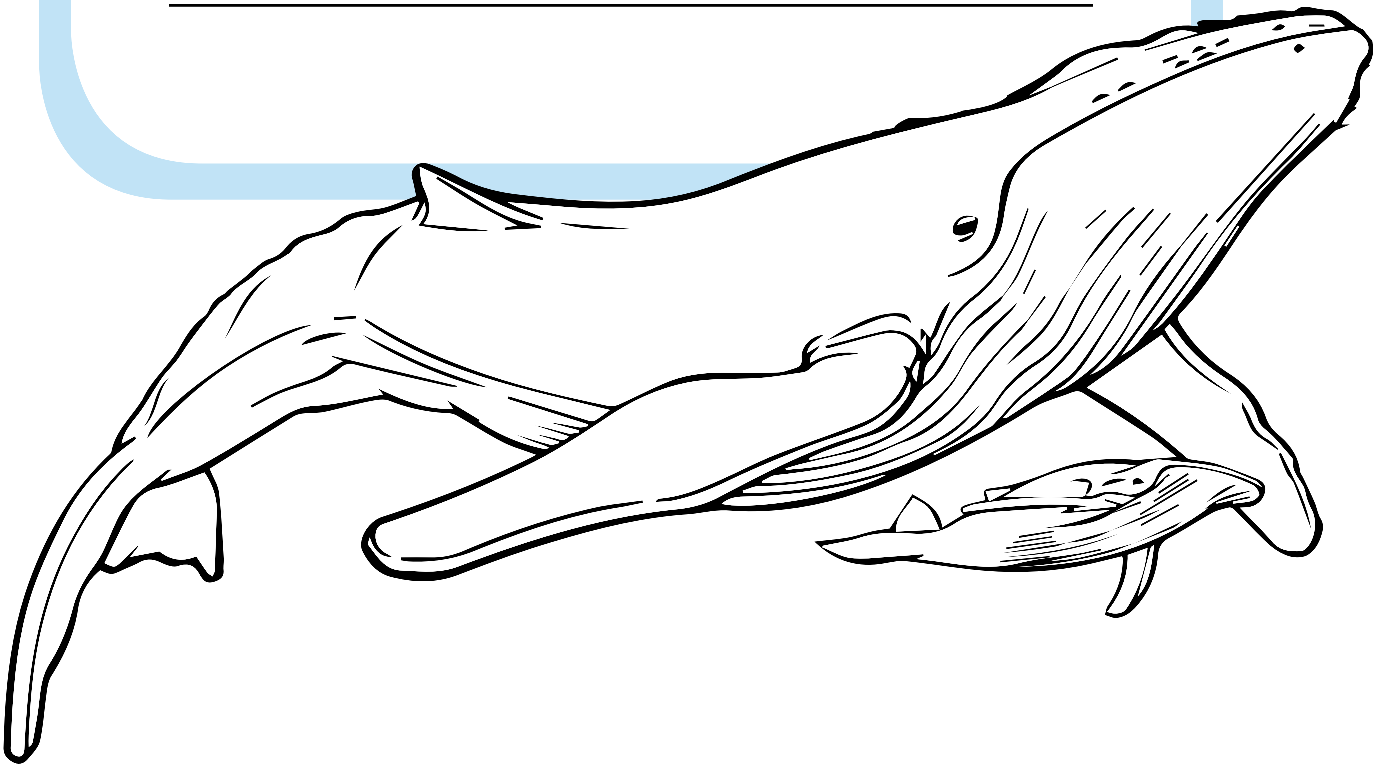

Lab Sheet:
Hold your breath like a humpback whale!

1. Make a Hypothesis

Predict how long you will be able to hold your breath.

____

____

____

2. Collect data

a. I held my breath for this long: ______________

3. Analyze Data and Draw Conclusions

a. Were you close to your prediction? Calculate the difference.

____

b. How did you measure up to a humpback whale?

____

____

____

____

c. Group Discussion
Imagine repeating the experiment while burning more energy. (ie: walking around the room, doing jumping jacks, etc.) How do you think this would affect your ability to hold your breath?

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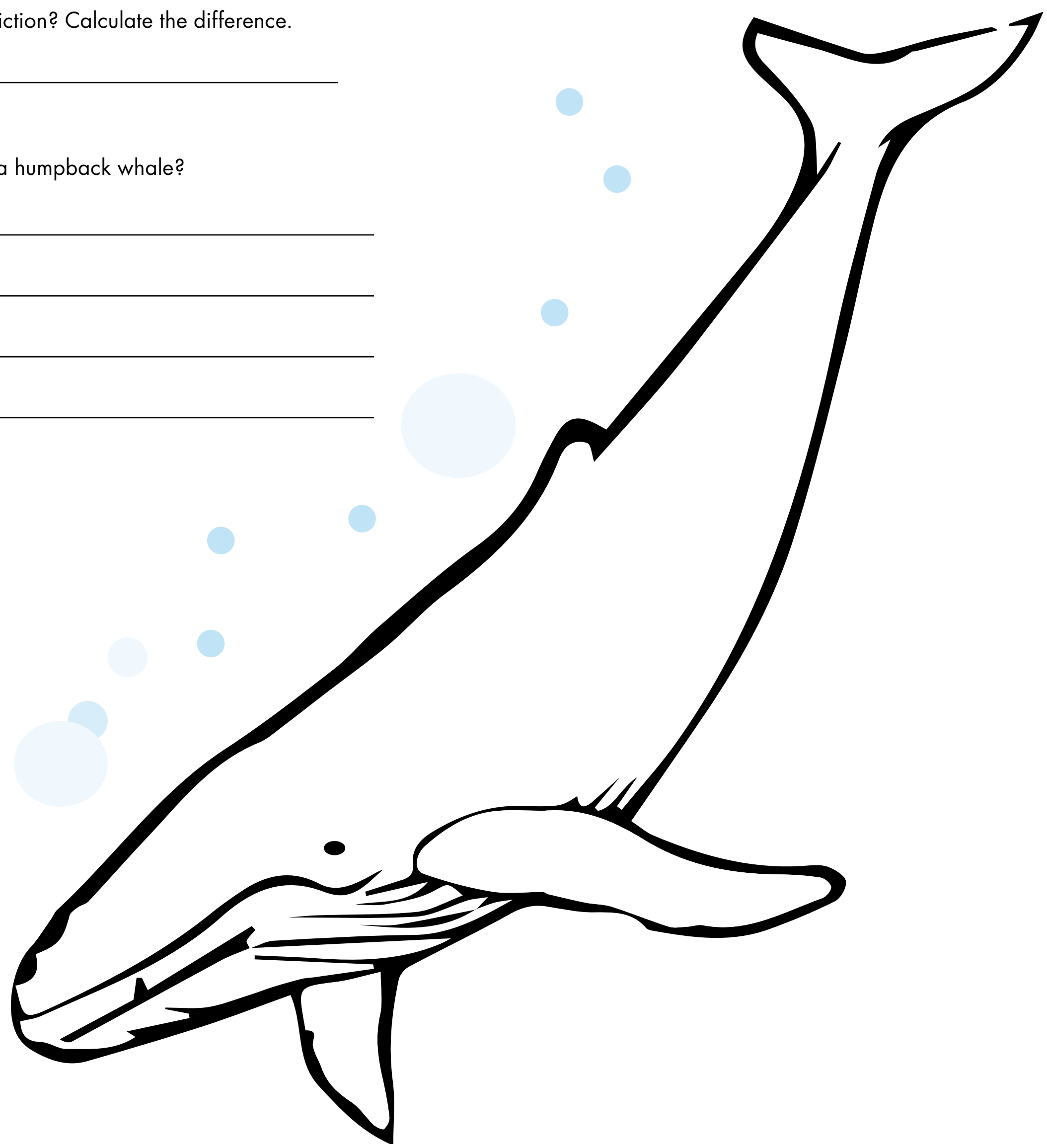


Museum Educator's Guide:
"A Blubbery Discovery"

Station Overview

Students will conduct a hands-on experiment, exploring the insulating properties of blubber.

Next Generation Science Standards

4 LS 1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior and reproduction.

Disciplinary Core Idea

LS 1.A: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior and reproduction.

Materials

- 4 sturdy quart-sized zipper lock bags
- 4 generous scoops of shortening or lard
- Spatula or spoon to scoop shortening
- Duct tape
- 16 quart plastic tub
- Cold water
- Ice
- Hand towel(s)
- Large display timer (www.carolina.com)
- Infra-red thermometers (www.carolina.com or www.grainger.com)

Create the Blubber Gloves (1 per pair of students)

1. Turn one zipper lock bag inside out and set aside.
2. Scoop about 4 heaping spoonfulls of shortening into the other zipper lock bag.
3. Put your hand inside the first zipper lock bag (currently inside out), and push it into the shortening-filled zipper lock bag.
4. Spread the shortening all around the inside of the zipper lock bags until the inner bag is covered on all sides.
5. Lock the two bags together by pressing the two zippers together, keeping the shortening between the two. Secure them with duct tape.
6. Fold the edge of the locked bags over and duct tape the fold in place.

Create the Control Gloves (1 per pair of students)

1. Turn one zipper lock bag inside out and set aside.
2. Place the inside out zipper bag inside the other bag, and lock the two bags together by pressing the two zippers together. Press out as much air as you can. You do not want air between the bags.
3. Fold the edge of the locked bags over and duct tape the fold in place.

Create the Ice Baths (1 per 2 pairs of students in a group)

1. Fill the plastic tub halfway with cold water. Add enough ice to the tub to make the water feel "ice cold". Add enough ice so that ice remains in the tub when students do the activity.
2. Affix the "Arctic Ocean Water" signs (half sheets) to the sides of the plastic tub.

Set the Remaining Materials at the Station

1. Set the blubber gloves, control gloves, ice baths, hand towel(s), infra-red thermometers, and large display timer at the station.
2. Place all printed materials at the station.

For each rotation it is optimal to have 1 control glove and 1 blubber glove per each pair of students in a group. An ice tub may be shared between 2 student pairs. The materials list states the number of supplies needed to create 1 control and 1 blubber glove.

Worksheets & Printables List

Sheet	Number to Print
Task Card: A Blubbery Discovery	1 Per Station
Lab Sheet: A Blubbery Discovery	1 Per Student
Discovery Sheet: A Blubbery Discovery	1 Per Station
Printable: Arctic Ocean Signs	1 Per Tub

Task Card:
"A Blubbery Discovery"

Print & Laminate

Task Card:
"A Blubbery Discovery"

Today you will conduct a hands-on experiment to explore the insulating properties of blubber!

1. Make a Hypothesis

Which gloved hand do you predict will last the longest in the Arctic ice water?

2. Experiment Procedures

1. **Find a partner.** One person will start as the recorder and the other person will start as the tester. Then you will switch roles!
2. **Recorder:** Use the infra-red thermometer to measure the temperature of the water. Then measure the temperature of each of the tester's hands before they put them into the gloves, and record this data on their lab sheet.
3. **Tester:** Insert your left hand in the control glove, and your right hand in the blubber glove. When the timer starts, place both gloved hands into the ice water. Keep them in the water until it is no longer comfortable.
4. **Recorder:** Watch the timer with your partner. Note the times he/she pulls each hand out, and record this data on their lab sheet.
5. **Recorder:** Use the infra-red thermometer to measure the temperature of each of the tester's hands after they pulled their hands out of the gloves, and record this data on their lab sheet.
6. **Switch roles!**

3. Clean up Your Station!

1. Dry off the control glove and the blubber glove, and wipe up any water that has spilled.
2. Carefully straighten all materials.

4. Analyze Your Data and Draw Conclusions

Group Discussion: What did you discover about insulation, thermoregulation, and a whale's adaptation of blubber?

Lab Sheet:
"A Blubbery Discovery"

Marine Biologist:

Objective

Today you will conduct an experiment to discover the insulating properties of blubber.

1. Make a Hypothesis

Which gloved hand do you predict will last the longest in the Arctic ice water and explain why?

2. Collect Data

"Arctic Ocean Water" ice bath temperature: ____________

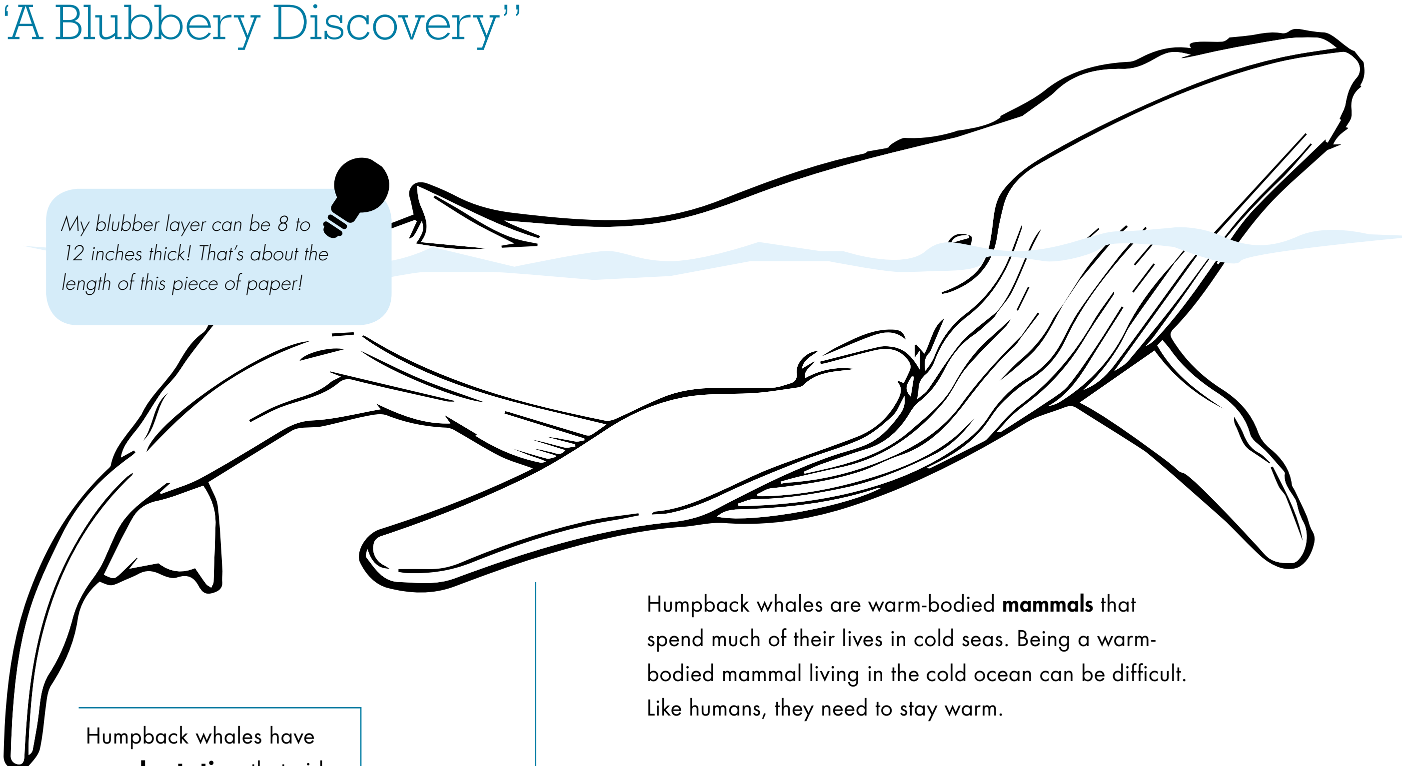
Type of Glove	Temperature of Hand Before	Time Held in Ice Water	Temperature of Hand After
Control (no shortening)			
Blubber (shortening)			

3. Analyze Data and Draw Conclusions

Group discussion: What did you discover about insulation, thermoregulation, and a whale's adaption of blubber?

Draw your conclusion!

Discovery Sheet:
"A Blubbery Discovery"

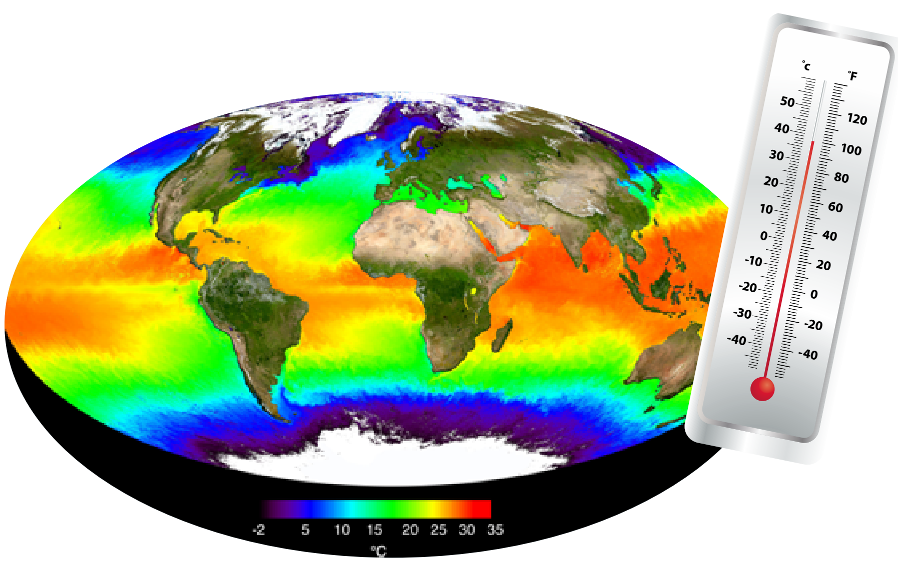


Humpback whales are warm-bodied **mammals** that spend much of their lives in cold seas. Being a warm-bodied mammal living in the cold ocean can be difficult. Like humans, they need to stay warm.

Humpback whales have an **adaptation** that aids in retaining their body heat. Under their skin, humpbacks have a thick layer of fatty tissue called **blubber**. Blubber provides insulation that keeps heat in and cold out.

This **insulation** aids in the process of **thermoregulation**, or the maintenance of internal body temperature within a tolerable range. Humpback whales typically have a core body temperature of 96-99 degrees Fahrenheit. Humans have a similar body temperature of 98.6 degrees Fahrenheit.

Other marine mammals such as dolphins, seals, and manatees also benefit from having a thick layer of blubber.



Global Sea Surface Temperature Map

Definitions

Mammal: any member of the Class Mammalia; they are warm-bodied, have hair, give birth to live young, nurse their young, and breathe with lungs

Adaptation: special traits that help living organisms survive in a particular environment

Blubber: layer of fatty tissue used by marine mammals for insulation and energy storage

Insulation: a material that prevents or reduces the passage, transfer, or leakage of heat

Thermoregulation: the maintenance of internal body temperature within a tolerable range

Arctic Ocean

Attach to water tub

Arctic Ocean

Museum Educator's Guide:
"Catching Krill"

Station Overview

Students will observe real whale baleen and whale teeth specimens, make predictions about which adaptation is most effective in catching krill, and then simulate each adaptation. They will use the data they collect to draw conclusions about which adaptation is most beneficial in catching krill.

Next Generation Science Standards

4 LS 1-1: Construct an argument that plants and animals have internal and external structures that function to support survival, growth, behavior, and reproduction.

Disciplinary Core Idea

LS 1.A: Plants and animals have both internal and external structures that serve various functions in growth, survival, behavior, and reproduction.

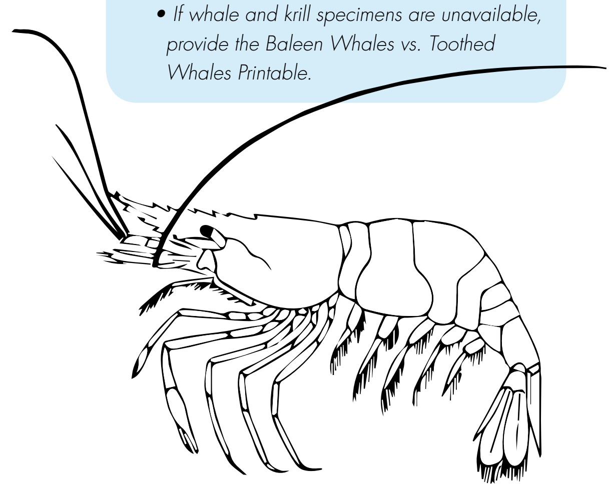
Materials

— Dried rosemary
— 16 oz. clear plastic tub
— Water
— Fine tooth pocket comb (plastic)
— Tweezers
— Hand towel
— Paper towels
— Toothpicks
— *whale & krill specimens:
  – Baleen *(borrow from your local natural history museum)*
  – Whale teeth *(borrow from your local natural history museum)*
  – Krill specimen *(borrow from your local natural history museum) or purchase freeze-dried krill (www.wardsci.com, Item #212830)*

Set Up the Station

1. Place the krill tub at the station.
2. Set out the combs and tweezers.
3. Set out toothpicks, paper towels, as well as a hand towel for any spills.
4. Set out the baleen, whale teeth, and krill specimens.
5. Place all printed materials at the station.

- *For each rotation, it is optimal to have 1 comb, 1 pair of tweezers, and 1 tub per 3 students in the group. Adjust the amount of materials you need accordingly.*
- *Remember to factor in time to request whale and krill specimens from your local loan library (up to 2 weeks).*
- *If whale and krill specimens are unavailable, provide the Baleen Whales vs. Toothed Whales Printable.*



Worksheets & Printables

Sheet	Number to Print
Task Card: Catching Krill	1 Per Station
Lab Sheet: Catching Krill	1 Per Student
Discovery Sheet: Catching Krill	1 Per Station

Task Card:
"Catching Krill"

1. Introdution

1. Look at the real baleen and whale teeth. Compare each to the size of the krill, and think about which adaptation would be the most effective in catching krill.
2. Today you will simulate feeding as these two types of whales!

2. Make a Hypothesis

Which tool do you predict will be the most effective in catching krill?

3. Experiment Procedures

Baleen Simulation

1. In one sweeping motion, skim the plastic comb across the surface of the water to collect as many krill as possible. Do not scoop or pin them against the side of the tub!
2. Carefully move the krill from the comb to the paper towel and count them. Use a toothpick to gently separate the krill to help you count.
3. Dry the comb and pass it to another student.
4. Record the number of krill you captured.
5. Repeat these steps two more times, and record your data.

Teeth Simulation

1. Pinch the tweezers together once to try to catch some krill. Do not pin the prey against the sides or bottom of the tub. It's ok if you are not able to catch any.
2. Carefully move any krill you caught to the paper towel and count them.
3. Dry the tweezers and pass them to another student.
4. Record the number of krill you captured.
5. Repeat these steps two more times, and record your data.

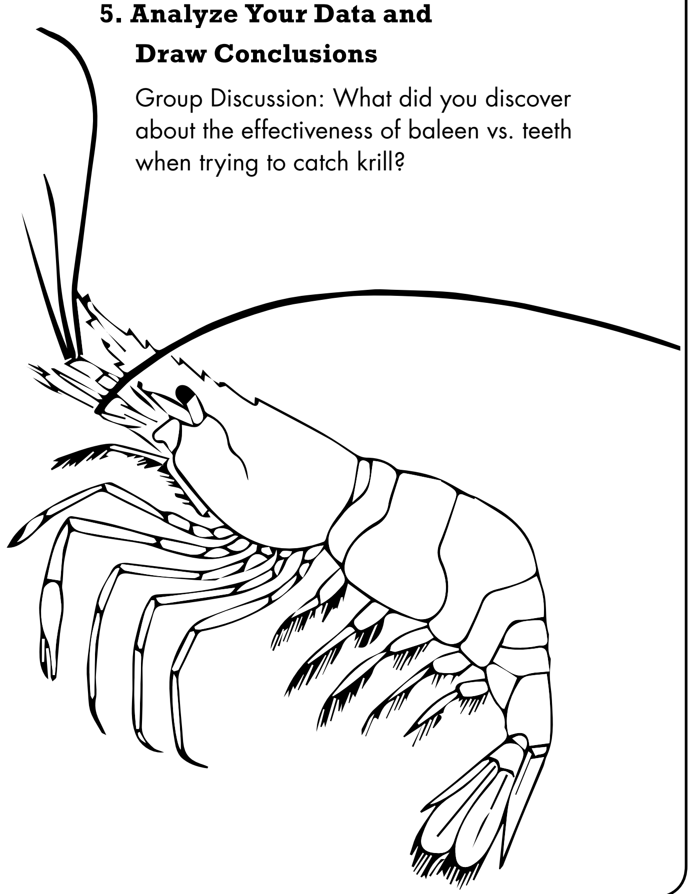
4. Clean Up Your Station!

1. Dry off the tweezers and the comb, and wipe up any spilled water.
2. Place used paper towels and soggy krill in the trash, and carefully straighten up all materials.

5. Analyze Your Data and

Draw Conclusions

Group Discussion: What did you discover about the effectiveness of baleen vs. teeth when trying to catch krill?



Lab Sheet:
"Catching Krill"

Marine Biologist:

Objective

Today you will conduct an experiment to simulate the differences between a whale's ability to catch krill with baleen vs. teeth.

1. Make a Hypothesis

Predict which tool will be the most effective in catching krill.

2. Collect Data

Number of Krill Caught		
Adaptation	**Baleen** (comb)	**Tooth** (tweezers)
Trial 1		
Trial 2		
Trial 3		

3. Analyze Data and Draw Conclusions

Group Discussion: What did you discover about the effectiveness of baleen vs. teeth when trying to catch krill?

BONUS!

Draw and label pictures of the real whale baleen and teeth you observed!

Discovery Sheet:
"Catching Krill"

There Are Two Main Types of Whales

baleen whales and toothed whales. Humpback whales are an example of baleen whales. Instead of teeth, they have an **adaptation** called **baleen**. Baleen are flexible plates attached to the upper jaw. Humpback whales have between 270 and 400 pairs of overlapping baleen plates, with bristled lower edges. Each plate is approximately 2-3 feet long. It looks like a broom and is made of keratin. This is the same material our fingernails and hair are made of!

To feed, humpback whales swim forward and open their mouths. As the water flows in, it expands their accordion-like **ventral pleats** in their throats. This is another adaptation that allows them to gulp prey and water in very large amounts. They then use their tongues to push the water out between the baleen plates and scrape the small fish and krill trapped in the baleen into their mouths.

Humpback whales feed in cooler waters during the spring and summer months when small fish, krill, and plankton are plentiful. Humpback whales can eat as much as 2,000 pounds of food in a day! They store the excess calories in the form of blubber which privides energy and insulate them during their migration to warmer waters in the fall.

This is Baleen from a gray whale. Whale baleen can be black, brown, or cream colored. Some whales have huge baleen. A bowhead whale has baleen plates that are nearly 15 feet long!

- *A humpback whale's esophagus is about the same diameter as a baseball! They are unable to swallow large prey because large pieces of food would not be able to fit down their throats!*
- *2,000 pounds is about the same weight as an African elephant, or 8,000 hamburgers!*

Toothed whales have peg or spade shaped teeth. Some even have tusks!

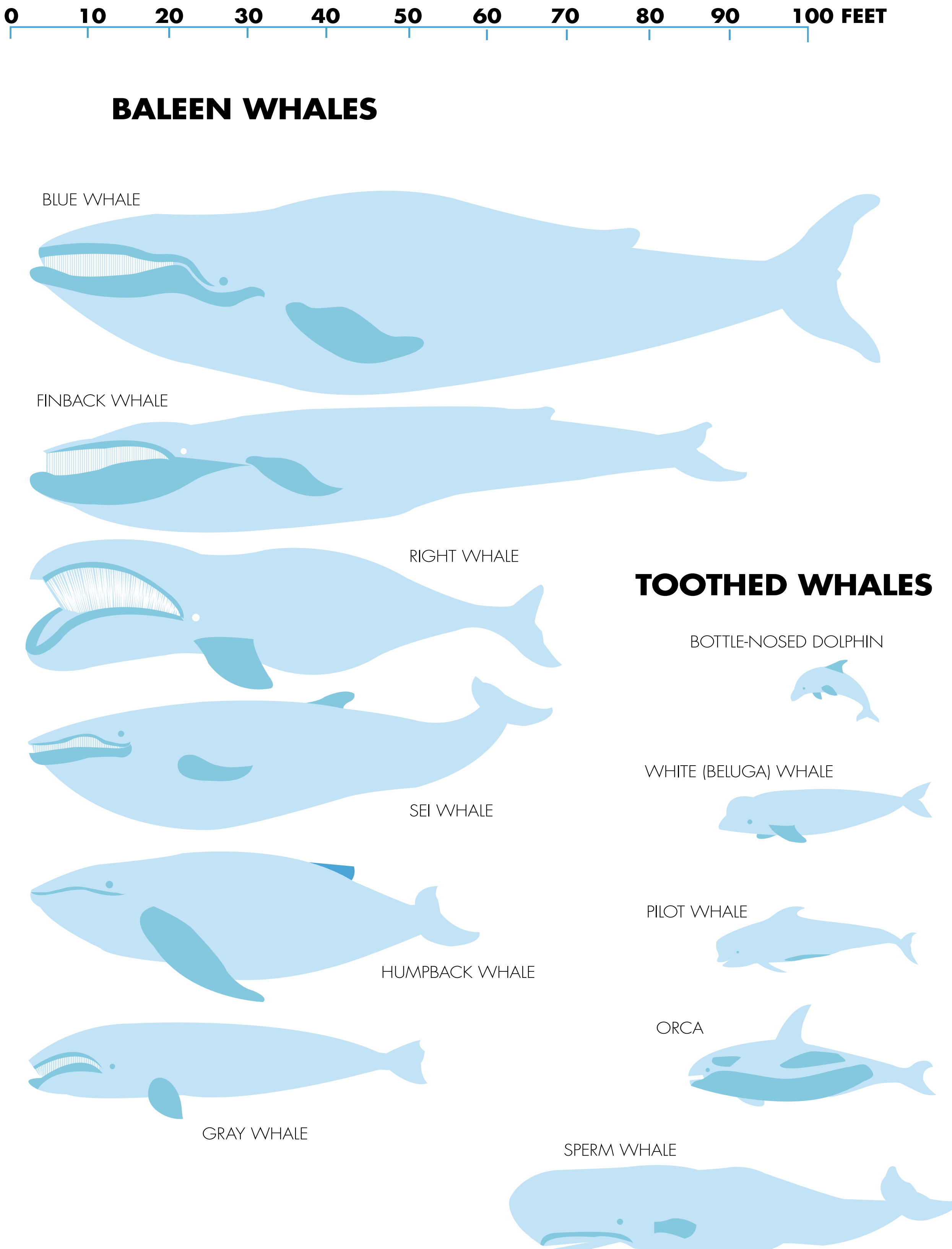
Definitions:

Adaptation: a special trait that helps living organisms survive in a particular environment

Baleen: keratin plates that hang down in fringed, parallel columns from the upper jaw or palate of baleen whales; serve as a strainer that catches plankton and small fish while a whale is feeding

Ventral pleats: long folds in the skin that expand when a whale takes in large amounts of water and food

Discovery Sheet:
"Catching Krill: Baleen vs. Toothed Whales"



Museum Educator's Guide:
"Food Web Game"

Station Overview

Students will see that even small changes in the ecology of the ocean environment can have a large impact!

Next Generation Science Standards

3 LS 4-4: 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.

Disciplinary Core Idea

LS 4.D: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

4 ESS 3-1: Obtain and combine information to describe that energy and fuels are derived from natural resources and that their uses affect the environment.

Disciplinary Core Idea

ESS 3.A: Energy and fuels that humans use are derived from natural sources, and their use affects the environment in multiple ways. Some resources are renewable over time, and others are not.

5 LS 2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Disciplinary Core Idea

LS 2.A: The food of almost any kind of animal can be tracked back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants…Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance or an ecosystem.

MS LS 2-3: Develop a model to describe the cycling of matter and flow of energy among living and non-living parts of an ecosystem.

Disciplinary Core Idea

LS 2.B: Food webs are models that demonstrate how matter and energy are transferred between producers, consumers, and decomposers as the three groups interact within an ecosystem. Transfers of matter into and out of the physical environment occur at every level…The atoms that make up the organisms in an ecosystem are cycled repeatedly between the living and non living parts of the ecosystem.

MS LS 2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

Disciplinary Core Idea

LS 2.C: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Materials

— 1 set of Jenga (www.jenga.com)
— Permanent markers: green, blue, red, and black
— Clear tape
— Cardstock

Preparing the Station

Prepare the Jenga blocks.

1. Use the permanent markers to color the ends of the Jenga blocks as specified below.
   — 21 green (phytoplankton)
   — 12 blue (zooplankton)
   — 12 red (krill and small fish)
   — 9 black (humpback whales)
2. Tape the images from Humpback Whale Food Web Jenga Block Pictures on each of the sides of the blocks, matching them to their corresponding colors.

Worksheets & Printables

Sheet	Number to Print
Task Card: Food Web Game	1 Per Station
Lab Card: Food Web Game	1 Per Student
Discovery Sheet: Food Web Game	1 Per Station
Printable: Food Web Game Jenga Block Pictures	1 Per Game
Printable: Food Web Game Playing Cards	1 Per Game

Task Card:
"Food Web Game"

Print on cardstock & laminate

Task Card:
"Food Web Game"

Today you will discover that even small changes in the ecology of the ocean environment can have a large impact!

1. Set up the Game

1. Build a Jenga food web tower by layering blocks in the following order:
   a. Bottom layer: phytoplankton (green)
   b. Second layer: zooplankton (blue)
   c. Third layer: krill and small fish (red)
   d. Top layer: humpback whales (black)
2. Shuffle the playing cards and stack them face down.

2. Make a Hypothesis

What do you think will happen as you introduce human and environmental impacts into the ecology of the ocean?

3. Play the Game!

1. Pick a card, read it aloud, and follow the instructions on the card. (Note: You are not allowed to hold the rest of the stack together while removing the blocks. Only the block being removed or returned may be touched!)
2. Place the used cards face-up in a discard pile.
3. Create a discard pile for the blocks.
4. Continue to take turns until the food web collapses, or until all cards are used up.

4. Clean up Your Station

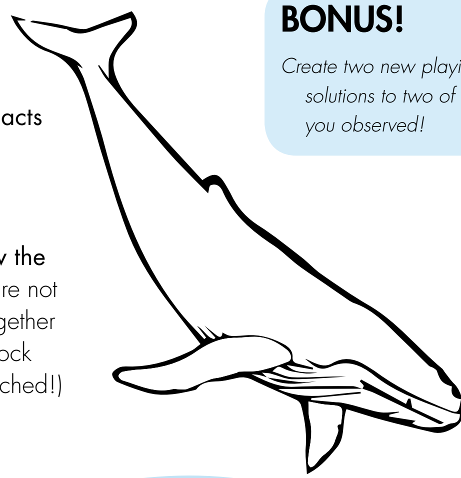
Sort the Jenga blocks into four piles, arranging them by color.

5. Analyze the Results and Draw Conclusions

Group Discussion: What did you discover about human influences on the environment? How could something as large as a humpback whale be impacted by small changes in the ocean? What did this game inspire you to want to investigate further? Brainstorm ways humans can help sustain life in the ocean.

BONUS!

Create two new playing cards that include solutions to two of the human impacts you observed!



Lab Sheet:
"Food Web Game"

Marine Biologist:

Objective

You will see how human and environmental factors affect both the food chain and the food web of humpback whales.

1. Make a Hypothesis

What do you think will happen as you introduce human and environmental impacts into the Ecology of the ocean?

2. Analyze the Results and Draw Conclusions

Group discussion: What did you discover about human influences on the environment? How could something as large as a humpback whale be impacted by small changes in the ocean? What did this game inspire you to want to investigate further? Brainstorm ways humans can help sustain life in the ocean.

BONUS!

- *Think about two solutions to local impacts that YOU could help facilitate.*
- *Create 2 solution "playing cards" that could be added into the game! The top lines should state the solution, and the bottom line should state the action for the level it impacts.*

CARD 1

CARD 1

Discovery Sheet:
"Food Web Game"

A food chain is a series of living things in which each one uses the next lower member as a source of food. A food web shows all the interacting food chains.

Humpback Whale

Humpback whales use baleen, not teeth to catch their prey. They mostly eat krill, but sometimes also consume small fish.

Krill

Krill are an important connection near the bottom of the food chain. They mainly feed on phytoplankton.

Phytoplankton

Phytoplankton are microscopic plant-like organisms. They contain chlorophyll, just like plants do, and use carbon dioxide, sunlight, and water to make their own food through the process of photosynthesis.

A food chain is a series of living things in which each one uses the next lower member as a source of food. Humpback whales feed on krill, and krill feed on plant-like organisms called phytoplankton.

A food web shows all the interacting food chains in an ecological community, such as the ocean. The humpback whale's food chain is part of a larger food web that includes various zooplankton and phytoplankton. The Jenga tower today will represent a food web.

Food webs are part of a greater whole called an **ecosystem**. An ecosystem is a community of living and nonliving things that work together. Everything is connected. Humans can affect the marine ecosystem in many ways, and this has potential of upsetting the ecology of the food chain and food web of humpback whales. If the balance of one level is disturbed too much, the other levels will be affected and the food web could potentially collapse.

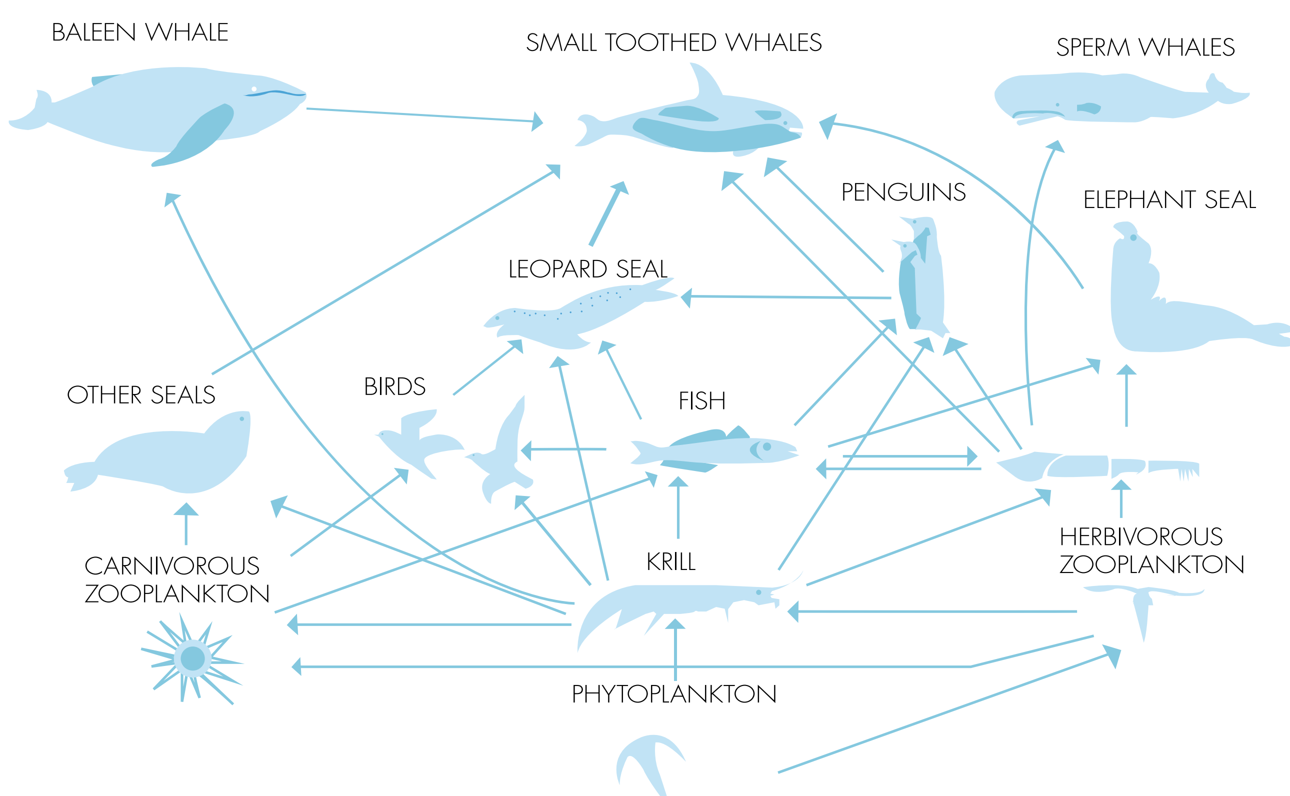
Definitions

Ecosystem: everything that exists in a particular environment

Ecology: the study of the relationships between a group of living things and their environment

Krill average about two inches in length, which is about the size of a paperclip!

Antarctic Food Web



Discovery Sheet:
"Food Web Game Jenga Block Pictures"

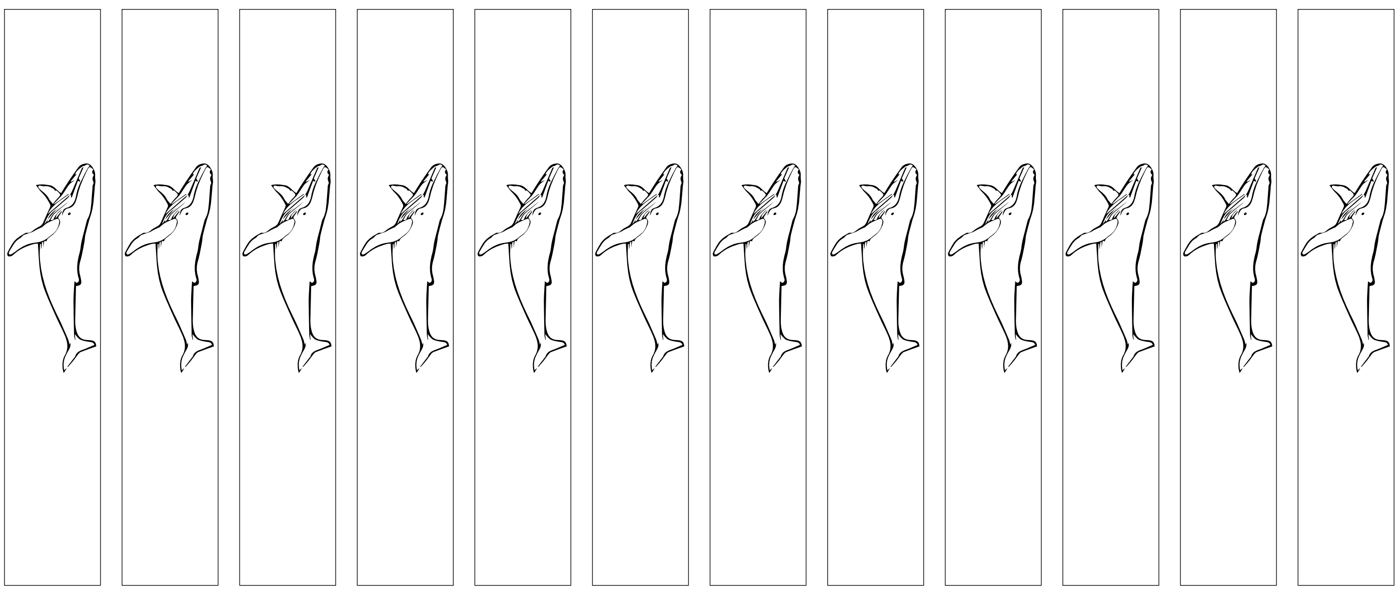
Jenga Game

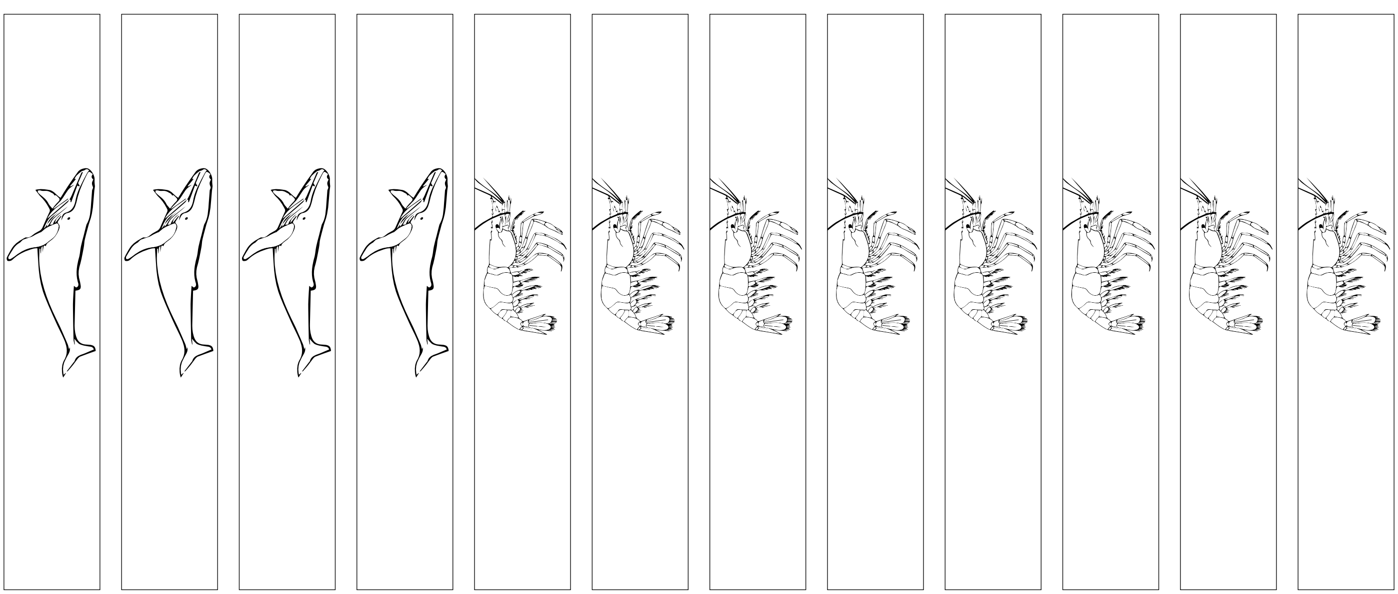
Block Size: 3 x 0.5 inches

You Will Need:

- **9 Humpback illustration**
- **6 Krill illustration**
- **6 Fish illustration**
- **12 Zooplankton**
- **21 Phytoplankton**
  There are more phytoplankton than zooplankton illustrations

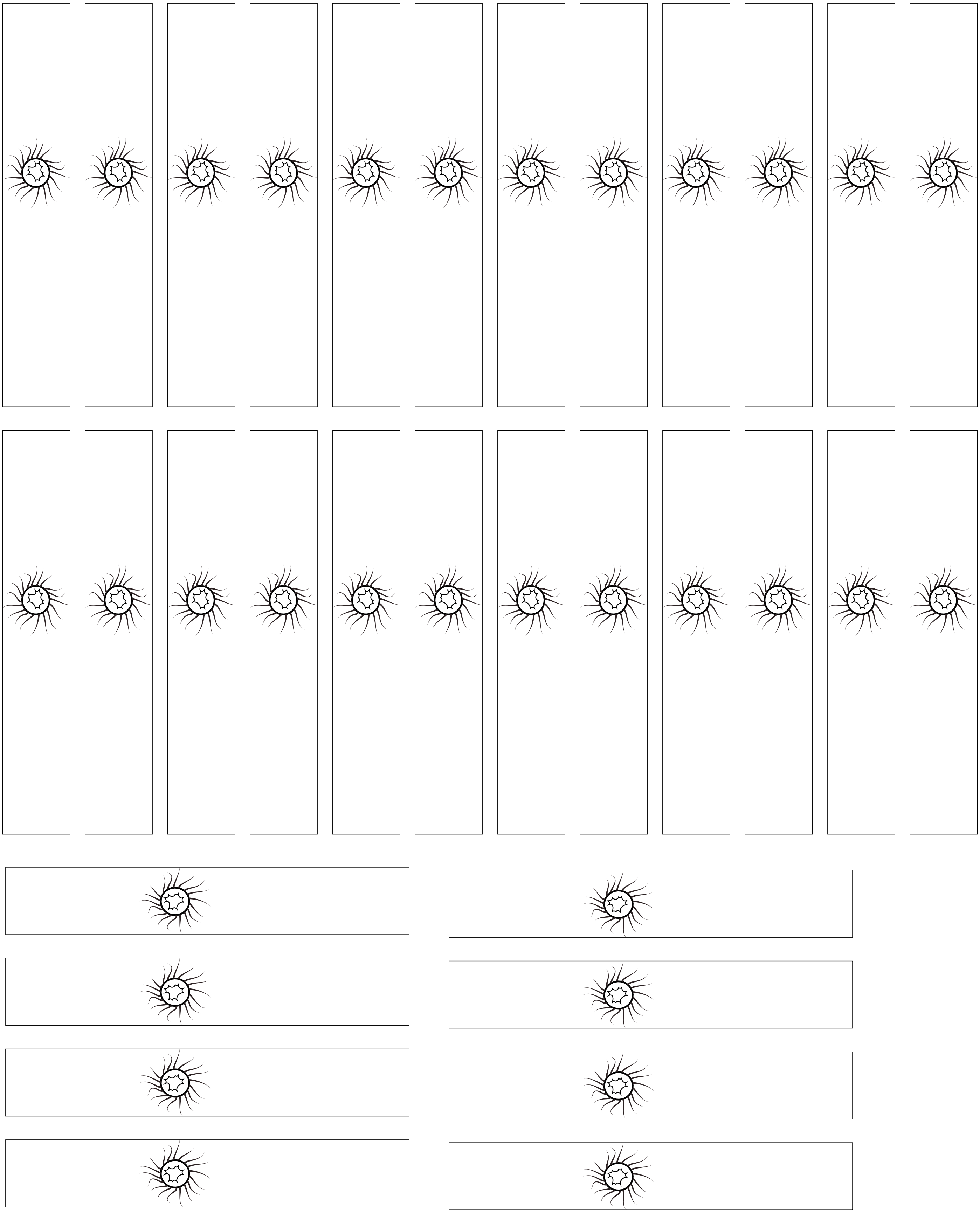
Please Note: there are a few extras of each image.





Discovery Sheet:
"Food Web Game Jenga Block Pictures"

Discovery Sheet:
"Food Web Game Jenga Block Pictures"



Discovery Sheet:
"Food Web Game Playing Cards"

Print on cardstock & laminate

Sunlight reaching the ocean increases.

PUT BACK ONE *GREEN BLOCK*

A storm hits. Pollution from storm drains flow into the ocean.

REMOVE ONE *GREEN BLOCK* *AND* **ONE** *BLUE BLOCK*

Ocean currents change and disperse phytoplankton.

REMOVE ONE *GREEN BLOCK*

Ocean acidification results from an increase in carbon dioxide.

REMOVE ONE *RED BLOCK*

Successful beach clean-up reduces pollutants entering the ocean.

PUT BACK ONE *GREEN BLOCK*

An oil spill occurs in a nearby harbor.

REMOVE ONE *GREEN*, **ONE** *BLUE* *AND* **ONE** *RED BLOCK*

Discovery Sheet:

"Food Web Game: Additional Prompts"

—Too many zooplankton are consumed by invasive filter feeding invertebrates. **Remove 1 blue block**

—Algae pulls oxygen from ocean water. **Remove 1 blue and 1 red block**

—A bloom of harmful algae creates toxins. **Remove 1 blue and 1 red block**

—Oh no! A chemical spill at a factory leaks toxins into the watershed. **Remove 1 green, 1 blue, and 1 red block**

—Whales leave the area to migrate. **Put back 1 red block**

—Changes in ocean currents decrease upwelling of nutrients for zooplankton. **Remove 1 blue block**

—A layer of smog reduces the amount of sunlight able to reach the ocean. **Remove 1 green block**

—An increase in ocean temperature leads to smaller phytoplankton. They are unsuitable as food for zooplankton. **Remove 1 blue and 1 red block**

—Humpback whales remain in an area longer than usual. **Remove 1 red block**

—Ocean temperatures continue to rise. **Remove 1 green, 1 blue, and 1 red block**

—A storm is brewing! The influx of rainwater into the ocean reduces the concentration of phytoplankton. **Remove 1 green block**

—Invasive zooplankton reduce the number of phytoplankton. **Remove 1 green block and put back 1 blue block**

—Loud noises from ship engines harm marine mammals**. Remove 1 black block**

—Sonar testing interferes with whale communication. **Remove 1 black block**

—Oil drilling in the ocean disturbs the ocean environment. **Remove 1 green and 1 blue block**

—A local power plant releases warm water into the ocean, raising water temperatures. **Remove 1 green, 1 blue, and 1 red block**

—A new marine species from a traveling fishing boat is introduced into the local environment. **Remove 1 green block**

—Fishermen dredging the ocean floor disturb the natural habitat. **Remove 1 green block**

—Fishermen over fished an area. **Remove 1 red block and replace 1 green block**

Museum Educator Guide:
"Focus on Phytoplankton"

Station Overview

Students will use microscopes to observe phytoplankton, and make connections about the important roles phytoplankton play in the marine environment.

Next Generation Science Standards

5 LS 2-1: Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.

Disciplinary Core Idea

LS 2.A: The food of almost any kind of animal can be tracked back to plants.

Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants…Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. Newly introduced species can damage the balance of an ecosystem.

LS 2.C: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.
5 ESS 2-1: Develop a model using an example to describe ways in which the geosphere, biosphere, hydrosphere, and/or atmosphere interact.

Disciplinary Core Idea

ESS 2.A: Earth's major systems are the geosphere (solid and molten rock, soil, and sediments), the hydrosphere (water and ice), the atmosphere (air), and the biosphere (living things, including humans). These systems interact in multiple ways to affect Earth's surface materials and processes. The ocean supports a variety of ecosystems and organisms, shapes landforms, and influences climate. Winds and clouds in the atmosphere interact with the landforms to determine patterns of weather.

MS LS 1-6: Construct a scientific explanation based on evidence for the role of photosynthesis in the cycling of matter and flow into and out of organisms.

Disciplinary Core Idea

LS 1.C: Plants, algae (including phytoplankton), and many microorganisms use the energy from light to make sugars (food) from carbon dioxide from the atmosphere and water through the process of photosynthesis, which also releases oxygen. These sugars can be used immediately or stored for growth or later use.

Materials

**Note: There are two options for obtaining phytoplankton. Pick one that best suits your program*

–Compound microscopes (www.wardsci.com / www.carolina.com)

–Basic Microscope Slide Poster Plankton (www.enasco.com; Product #: SB47107M)

Option 1:

– Wet Mount Slides: (order phytoplankton online)

– Marine Plankton (www.wardsci.com; Item #: 680028)

– Flat microscope slides (www.wardsci.com / www.carolina.com)

– Cover slips (www.wardsci.com / www.carolina.com)

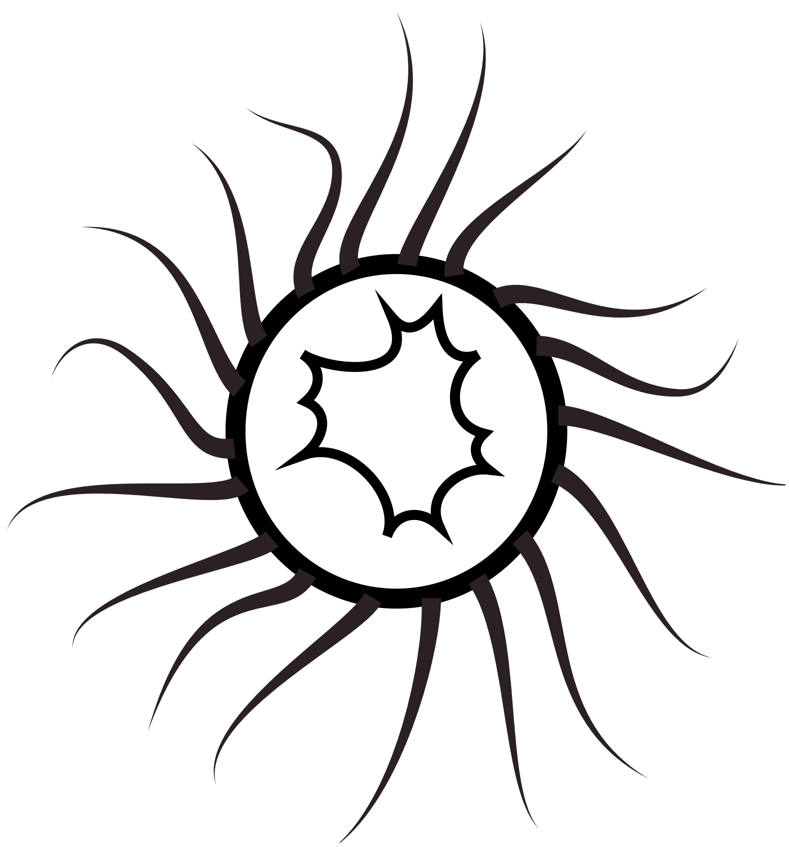
– Eye dropper

Option 2:

Prepared Slides:

– Elementary Microscope Slide Set – Plankton (www.enasco.com; Product #: SL10000M)

(**Note:** This set includes phytoplankton & zooplankton samples. Only provide the phytoplankton slides to students for this activity! These slides will perfectly match the Plankton poster noted above.)



Museum Educator Guide:
"Focus on Phytoplankton"

Preparing the Station

Create wet mount slides ***(Materials Option 1)***

1. Use an eye dropper to place one drop of the marine water sample onto the microscope slide.
2. Place the coverslip at a 45 degree angle (approximately) with one edge touching the water drop and then gently let go. Performed correctly the coverslip will perfectly fall over the specimen.

Purchase the prepared slides ***(Materials Option 2)***

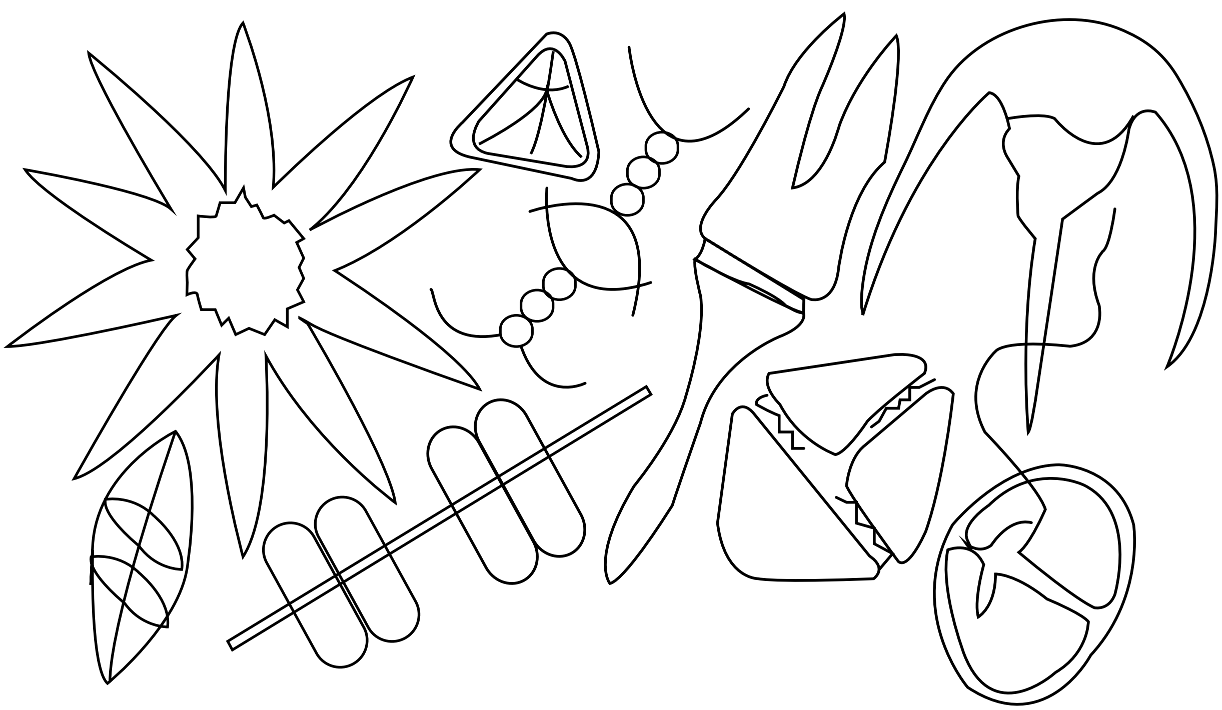
1. Factor in order and delivery time!
2. Sort out the phytoplankton slides from the zooplankton slides. Only provide the phytoplankton slides to students.

Set up the Station

1. Set up the microscopes at the station (1 per student in each rotation).
2. Set the lens on the lowest objective setting.
3. Place a slide on the stage, and secure it with the stage clips.
4. Bring a phytoplankton into focus.
5. Place all printed materials at the station.

Worksheets & Printables

Sheet	Number to Print
Task Card: Focus on Phytoplankton	1 Per Station
Lab Card: Focus on Phytoplankton	1 Per Student
Discovery Sheet: Focus on Phytoplankton	1 Per Station



Task Card:
"Focus on Phytoplankton"

Print on cardstock & laminate

Task Card:
"Focus on Phytoplankton"

Phytoplankton are microscopic plant-like organisms that live in the ocean. Phytoplankton act as the primary food source for marine species, and through the process of photosynthesis, also supply about half of the world's oxygen supply.

Today You Will Use a Microscope to Observe Phytoplankton!

1. Make a Hypothesis

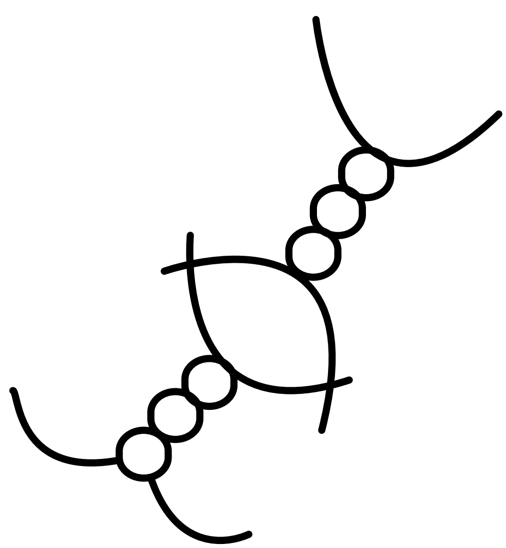
What do you predict the phytoplankton will look like?

2. Experiment Procedures

1. Observe your phytoplankton sample for the following:
   - color, shape, structure
2. Record the following information on your lab sheet:
   - a detailed drawing of the specimen and identification label (use the Plankton Identification Poster as a reference)
3. **Bonus:** If given permission, you may observe your sample under the different power objectives. If you are able to do this step, be sure to return the microscope lens to the original setting when you are done!

3. Analyze Your Data and Draw Conclusions

1. Draw and label the food chain of the humpback whale.
2. Group discussion: Phytoplankton act as the primary food source for marine species, and also supply about half of the world's oxygen supply. What problems could you predict if phytoplankton populations were to decrease?



Lab Sheet:
"Focus on Phytoplankton"

Marine Biologist:

Objective

You will use a microscope to observe phytoplankton.

1. Make a Hypothesis

What do you predict the phytoplankton will look like?

2. Collect Data

Group Discussion: What did you discover about human influences on the environment? How could something as large as a humpback whale be impacted by small changes in the ocean? What did this game inspire you to want to investigate further? Brainstorm ways humans can help sustain life in the ocean.

3. Analyze Data and Draw Conclusions

1. Draw and label the food chain of the humpback whale. Include the specimen you observed today as your image for phytoplankton!

2. Group discussion: Phytoplankton act as the primary food source for marine species, and also supply about half of the world's oxygen supply. What problems could you predict if phytoplankton populations were to decrease?

Discovery Sheet:
"Focus on Phytoplankton"

The word plankton is derived from a Greek word meaning "drifter." **Plankton** are the organisms that drift around in ocean currents. **Phytoplankton** are plant-like organisms, while **zooplankton** belong to the animal kingdom. Most forms of life in the ocean depend either directly or indirectly upon plankton for food.

Phytoplankton produce their own food through the process of **photosynthesis**. Since they need sunlight to photosynthesize, phytoplankton are generally found near the surface of the ocean. Phytoplankton use carbon dioxide and water to produce food. As part of this process, they release oxygen into the water and into the atmosphere. Half of the world's oxygen is produced via phytoplankton photosynthesis.

Phytoplankton form the base of the food chain in the ocean. A food chain is a series of living things in which each one uses the next lower member as a source of food. Nearly all phytoplankton species are used by zooplankton as food. Krill feed on phytoplankton, and even some forms of zooplankton, and they become the food for humpback whales.

Definitions

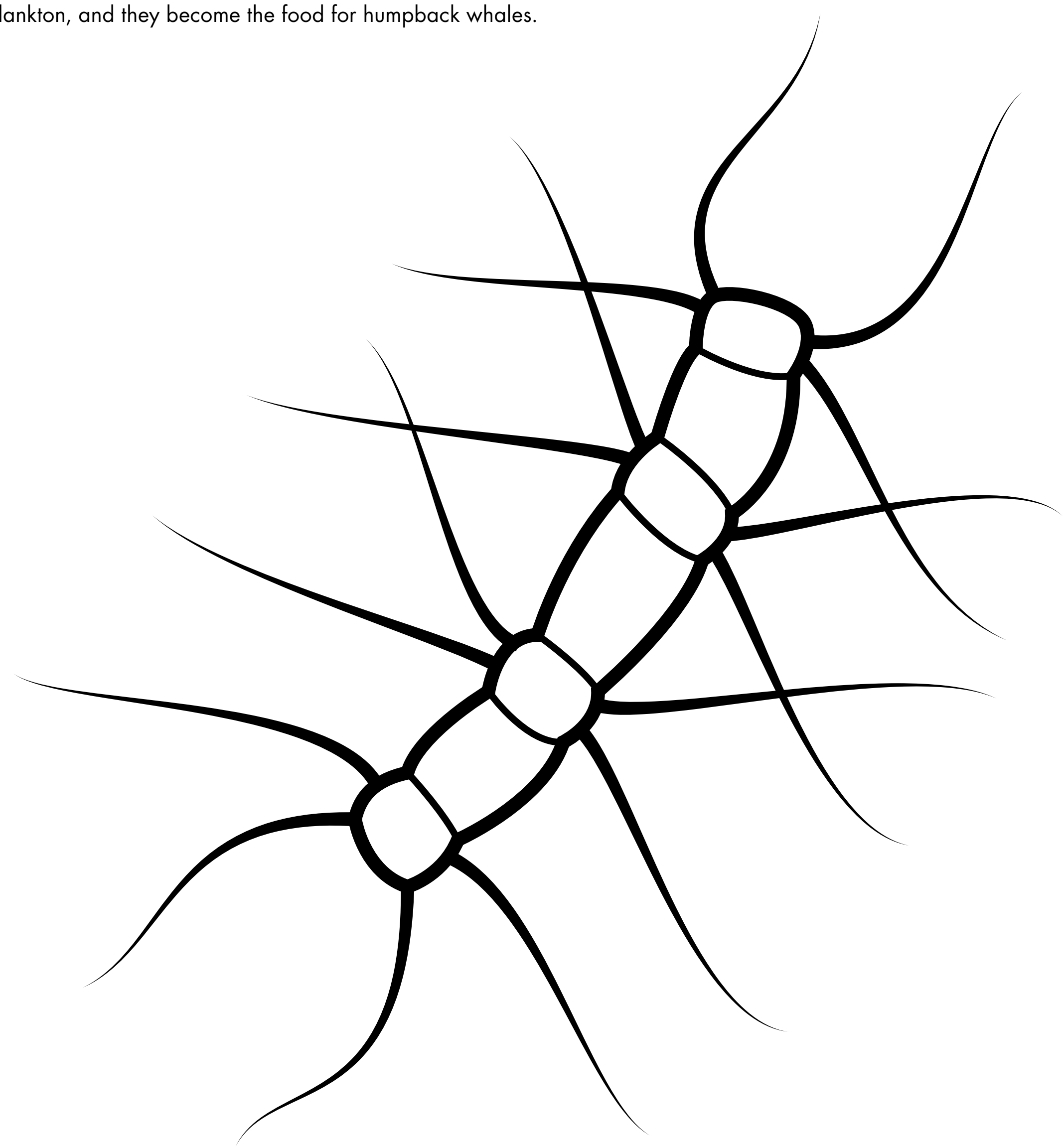
Plankton: "drifters;" the organisms drifting or floating in the sea or fresh water

Phytoplankton: microscopic plant-like plankton; examples include diatoms and dinoflagellates

Zooplankton: plankton consisting of small animals and the immature stages of larger animals; examples include copepods and jellyfish

Photosynthesis: the process by which plants and some organisms use sunlight to synthesize foods from carbon dioxide and water; it involves the green pigment chlorophyll and generates oxygen as a byproduct

Food chain: a series of types of living things in which each one uses the next lower member of the series as a source of food



Museum Educator Guide:
"Ocean Acidification"

ADULT-LED DEMONSTATION

Station Overview

Students will discover the effects of climate change on the ocean and discuss its impacts on marine life and people.

Next Generation Science Standards

3 LS 4-4: 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.

Disciplinary Core Idea

LS 4.D: Populations live in a variety of habitats, and change in those habitats affects the organisms living there.

5 ESS 3-1: Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

Disciplinary Core Idea

5 ESS 3.C: Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

MS LS 2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations.

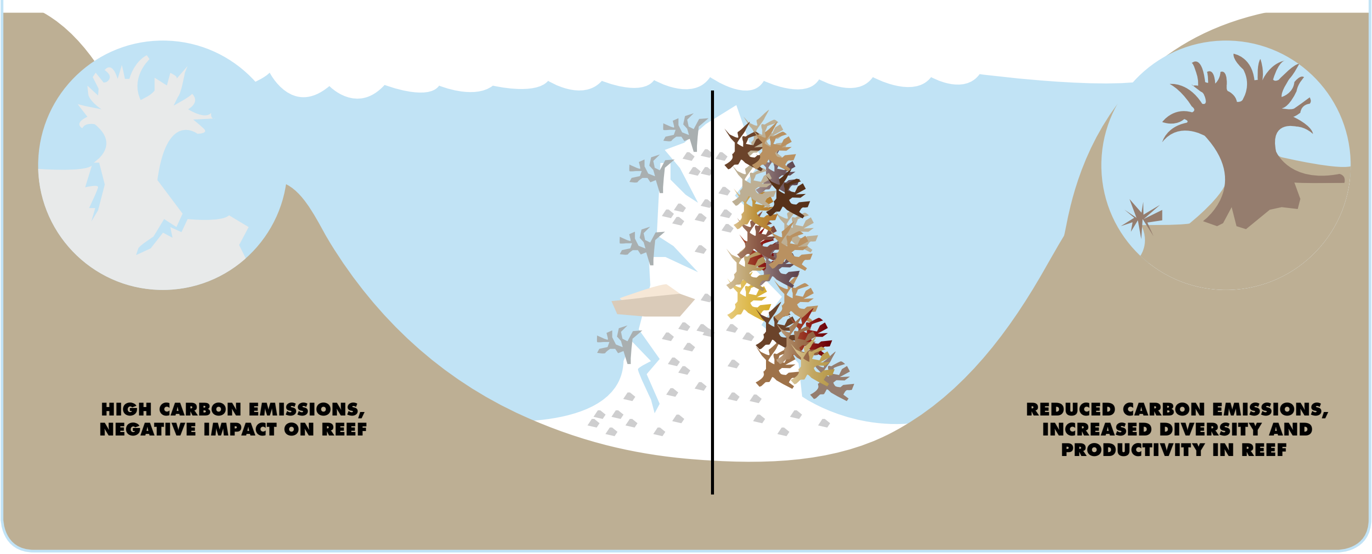
Disciplinary Core Idea

LS 2.C: Ecosystems are dynamic in nature; their characteristics can vary over time. Disruptions to any physical or biological component of an ecosystem can lead to shifts in all its populations.

Materials

— Beaker, 1000mL (www.wardsci.com / www.carolina.com)
— Water
— Bromothymol blue, 0.04% Aqueous (www.wardsci.com / www.carolina.com)
— A stirring implement
— Dry ice (www.dryiceideas.com)
— Protective gloves (www.wardsci.com / www.carolina.com)
— Tongs (www.wardsci.com / www.carolina.com)
— Goggles for each student & adult (www.wardsci.com / www.carolina.com)
— Colored pencils
— 2 similar shells (e.g. slipper, scallop, ark, or small clam shells) (www.amazon.com)
— Small bowl
— White vinegar
— 2 petri dishes with covers (www.carolina.com or www.wardsci.com)
— Magnifying glasses

Carbon Emissions and Changing Reef Environments



Museum Educator Guide:
"Ocean Acidification"

ADULT-LED DEMONSTRATION

Preparing the Station:

Prepare the shells (Up to 1 day in advance).

1. Start by soaking one of the two shells in vinegar. Initially you will notice bubbles forming. Check back every several hours for noticeable changes. Depending on the size and thickness of your shell, let it soak for several hours, but note it may take up to a day to see noticeable changes!
2. A degraded shell will be dull, pitted, translucent, thin, or even cracked. When the shell is visibly degraded, drain and rinse off the vinegar.
3. Place each shell in its own petri dish, and label them respectively: non-acidified shell and acidified shell.

Create "the Ocean" (1 "ocean" per rotation).

1. Fill the beaker with 500 mL of water.
2. Add about 30 drops of Bromothymol blue and stir well.
3. Set the beaker at the station.

Prepare the Dry Ice (1 chunk of dry ice per rotation).

*Safety Note: Whenever handling dry ice, wear gloves and goggles for protection!

1. Put on protective gloves and goggles.
2. Break off a chunk of dry ice (approx. 1-2 inches on all sides).
3. Place the tongs, gloves, goggles, and dry ice at the station.

Set Remaining Materials at the Station

1. Set out the colored pencils, magnifying glasses, and shells (in petri dishes) at the station.
2. Place all printed materials at the station.

Materials Disposal

1. At the end of all rotations, dilute the bromothymol blue solutions in the beakers with water, and pour down the drain.
2. Wash all beakers thoroughly.

Worksheets & Printables

Sheet	Number to Print
Experiment Procedures: Ocean Acidification	1 for the Adult Leader
Task Card: Ocean Acidification	1 Per Station
Lab Sheet: Ocean Acidification	1 Per Student
Discovery Sheet: Ocean Acidification	1 Per Station
Printable: Bromothymol Blue	1 Per Station
Printable: Ocean Acidification: Before & After	1 Per Station

Experiment Procedures:
"Ocean Acidification (Demonstration)"

FOR ADULT LEADER

**Safety Note: Dry ice should be handled by an adult only!* Wear protective gloves and goggles! All students should put on goggles before the experiment begins.

Introduction

1. Tell students that the blue water in the beaker represents "ocean" water. A solution called Bromothymol blue has been added to it. That is what gives it the blue color!
2. Show students a chunk of dry ice and explain that it is cooled and compressed carbon dioxide.
3. Before you add it to the beaker, encourage students to share their predictions about what will happen when the dry ice is added to the ocean.

Add the Dry Ice

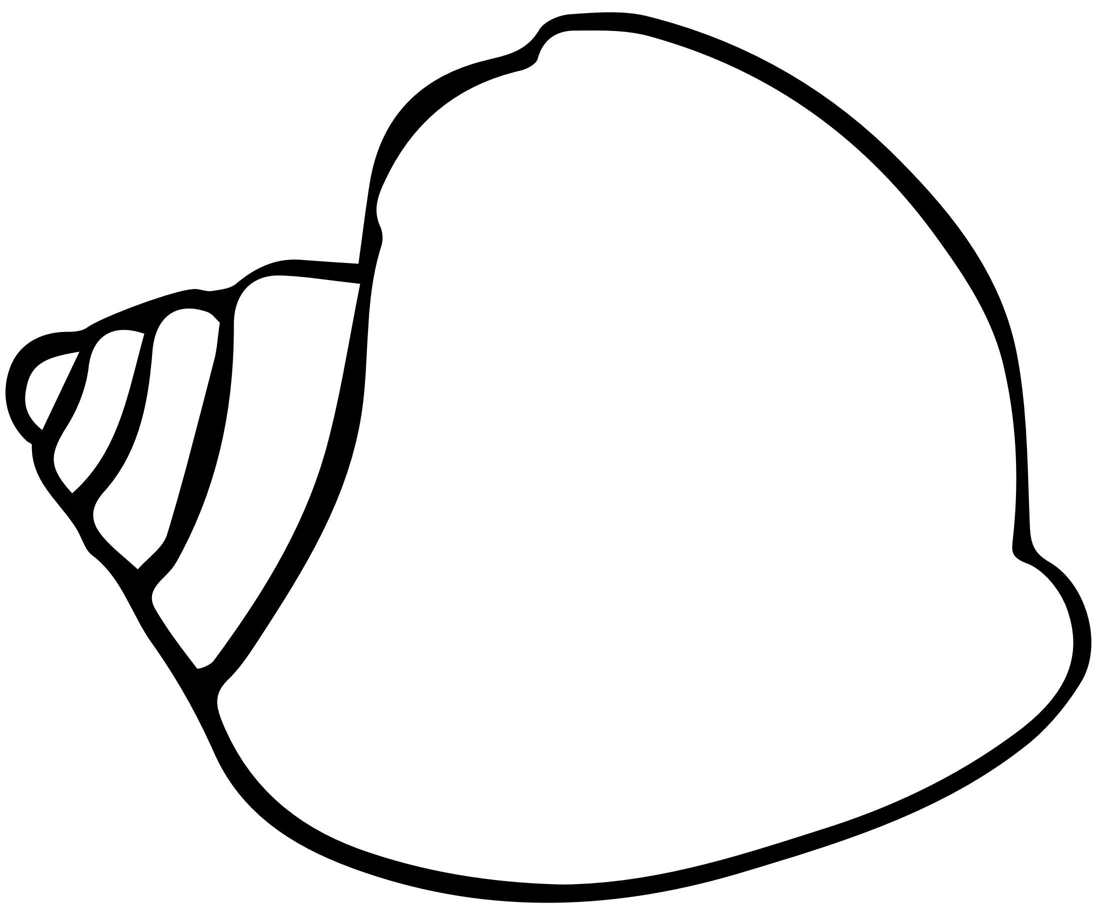
4. Using the tongs, carefully lower the chunk of dry ice into the beaker.
5. Encourage students to share their observations.
6. Direct students' attention to the Bromothymol Blue printable. Point out the indicator and pH scale, and direct them to record their data on their lab sheet.
7. Explain: As the dry ice went from a solid to a gas, carbon dioxide bubbles entered the "ocean," making it more acidic.

Observe Acidification Effects on Shells

8. Direct students' attention to the two shell samples. One has been exposed to acidification, while the other has not. Direct students to use the magnifying glass to get a closer look at each of the shells. Discuss observations, and encourage students to record their data.

Clean Up Procedures

9. The museum educator will dispose of beaker contents.
10. A new beaker should be used for each rotation.



Task Card:
"Ocean Acidification (Demonstration)"

Print on cardstock & laminate

Task Card:
"Ocean Acidification"

Today you will discover the effects of climate change on the ocean and marine life!

1. Make a Hypothesis

What do you think will happen to the ocean when an excess of carbon dioxide is introduced to it?

2. Experiment Procedures

1. Put on your goggles!
2. Observe ocean acidification in action!
3. Look at the Bromothymol blue pH indicator chart. Note the pH levels of each of the colors you observed in today's experiment, and record your data.
4. Look at the two shell samples. Use a magnifying glass to get a closer look! What do you notice?

3. Clean Up Your Station!

Replace all goggles at the station.

6. Analyze Your Data and Draw Conclusions

Group discussion: How do you think the effects of ocean acidification can cause problems for marine life and humpback whales in particular? How do you think it could impact people? Brainstorm solutions that could help reduce the amount of carbon dioxide being released into the environment.

Lab Sheet:
"Ocean Acidification (Demonstration)"

Oceoanographer:

Objective

Today you will discover the effects of climate change on the ocean and discuss the impacts on marine life and people.

1. Make a Hypothesis

What do you think will happen to the ocean when an excess of carbon dioxide is introduced to it?

___

___

___

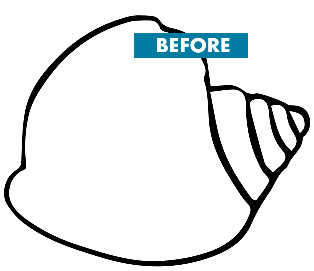
___

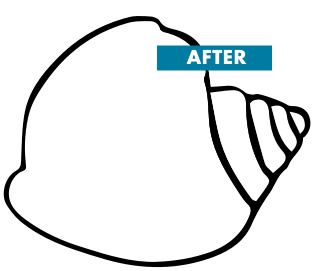
2. Collect Data

Draw and label your observations in the two blue boxes!

IMPACTS ON SHELL

Draw the effects of the ocean acidification on the shells





What did you notice when you observed the two shell samples?

___

___

___

___

___

___

3. Analyze Data and Draw Conclusions

Group discussion: How do you think the effects of ocean acidification can cause problems for marine life and humpback whales in particular? How do you think it could impact people? Brainstorm solutions that could help reduce the amount of carbon dioxide being released into the environment.

___

___

___

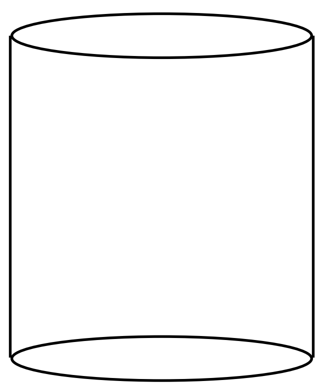
___

IMPACTS ON THE OCEAN

Draw what you see

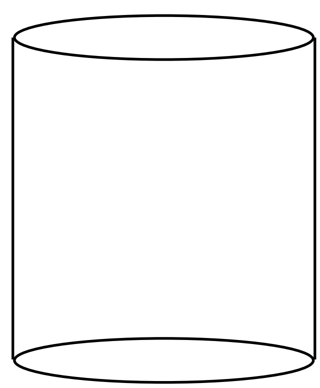
1. The ocean **before** carbon dioxide is introduced.

pH: ___



2. The ocean **after** carbon dioxide has been introduced.

pH: ___



3. **Circle** the ocean that is more acidic!

Discovery Sheet:
"Ocean Acidification"

Carbon is an element that's found all over the world and in every living thing. Oxygen is another element that's in the air we breathe. When carbon and oxygen bond together, they can form a colorless, odorless gas called carbon dioxide, which is a heat-trapping **greenhouse gas**. This process is known as the Greenhouse Effect. Whenever we drive our cars, use electricity, or make new products in factories, we are burning fossil fuels and producing carbon dioxide.

Greenhouse gases trap heat in the atmosphere, which makes the Earth warmer. Most of the carbon dioxide that is released into the atmosphere ultimately ends up in the oceans. Heat trapped in the atmosphere is needed to sustain life on Earth. However, when we produce too much carbon dioxide, problems can start to arise. This is happening faster than natural processes can remove it. The increase of the Earth's average surface temperature, due to a build-up of greenhouse gas, is a component of **climate change**.

Carbon dioxide not only increases temperature, but it also has the ability to change the **pH** of the ocean. The pH of a substance refers to how acidic or basic it is. When the carbon dioxide we add to the air mixes with the water at the surface of the ocean, they blend together and form an acid that changes the ocean's pH. One of the major concerns scientists have is that the most vulnerable species to **ocean acidification** are also some of the most important for healthy marine ecosystems.

Studies have shown that a more acidic environment has a dramatic effect on some calcifying species, including oysters, clams, sea urchins, and corals. These organisms have a shell or skeleton made of calcium carbonate, which often breaks down in acid. When organisms are at risk, the entire food web may also be at risk. Ocean acidification may also adversely impact some plankton species, and their loss would ripple through food webs to impact larger animals like fish and whales.

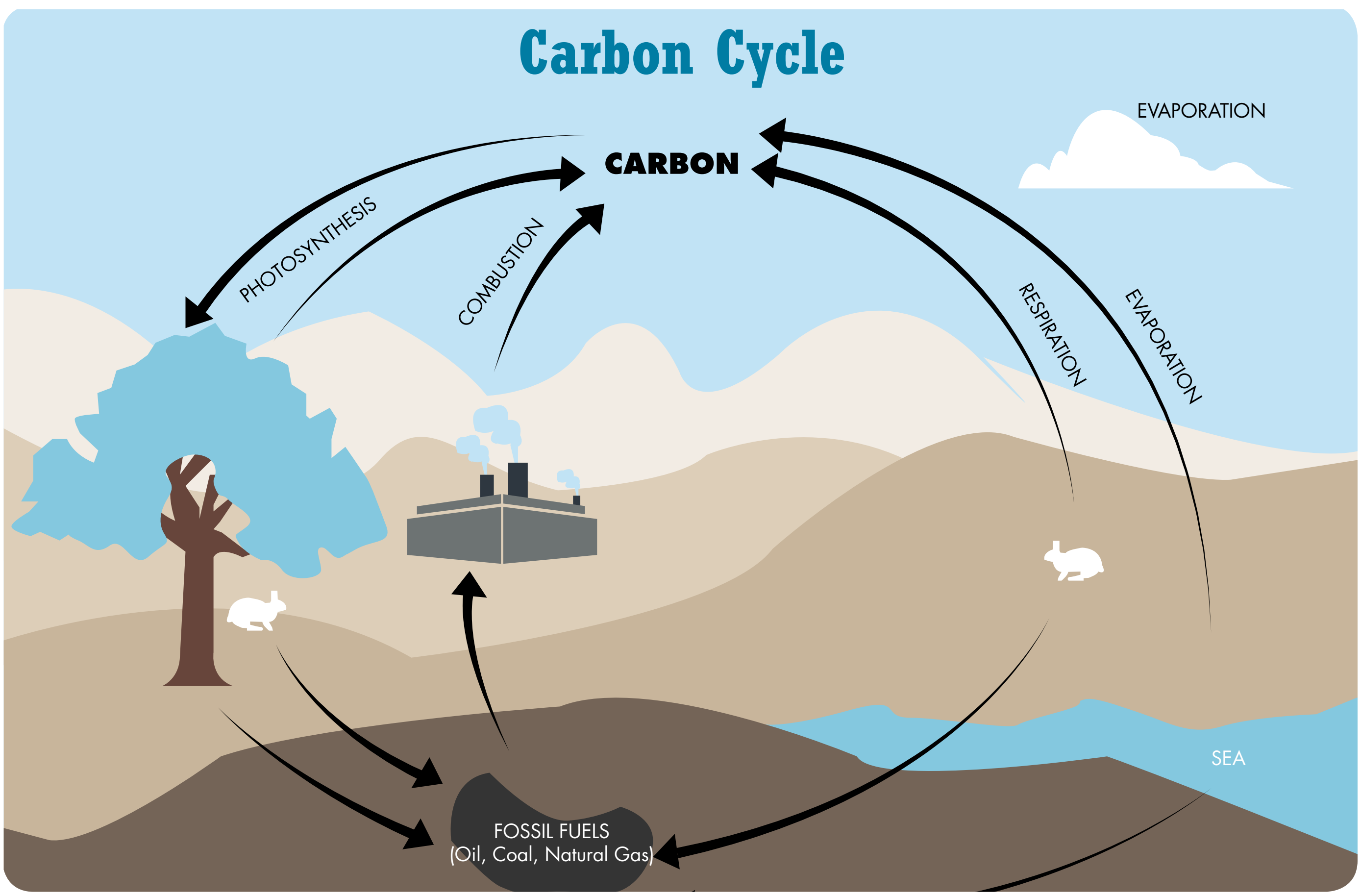
Definitions:

Greenhouse gas: a gas that contributes to the greenhouse effect by absorbing infrared radiation, i.e. carbon dioxide and chlorofluorocarbons

Climate change: any significant change in the measures of climate lasting for an extended period of time. Climate change includes major changes in temperature, precipitation, or wind patterns, among other effects, that occur over several decades or longer

pH: a scale that refers to how acidic or basic a liquid is

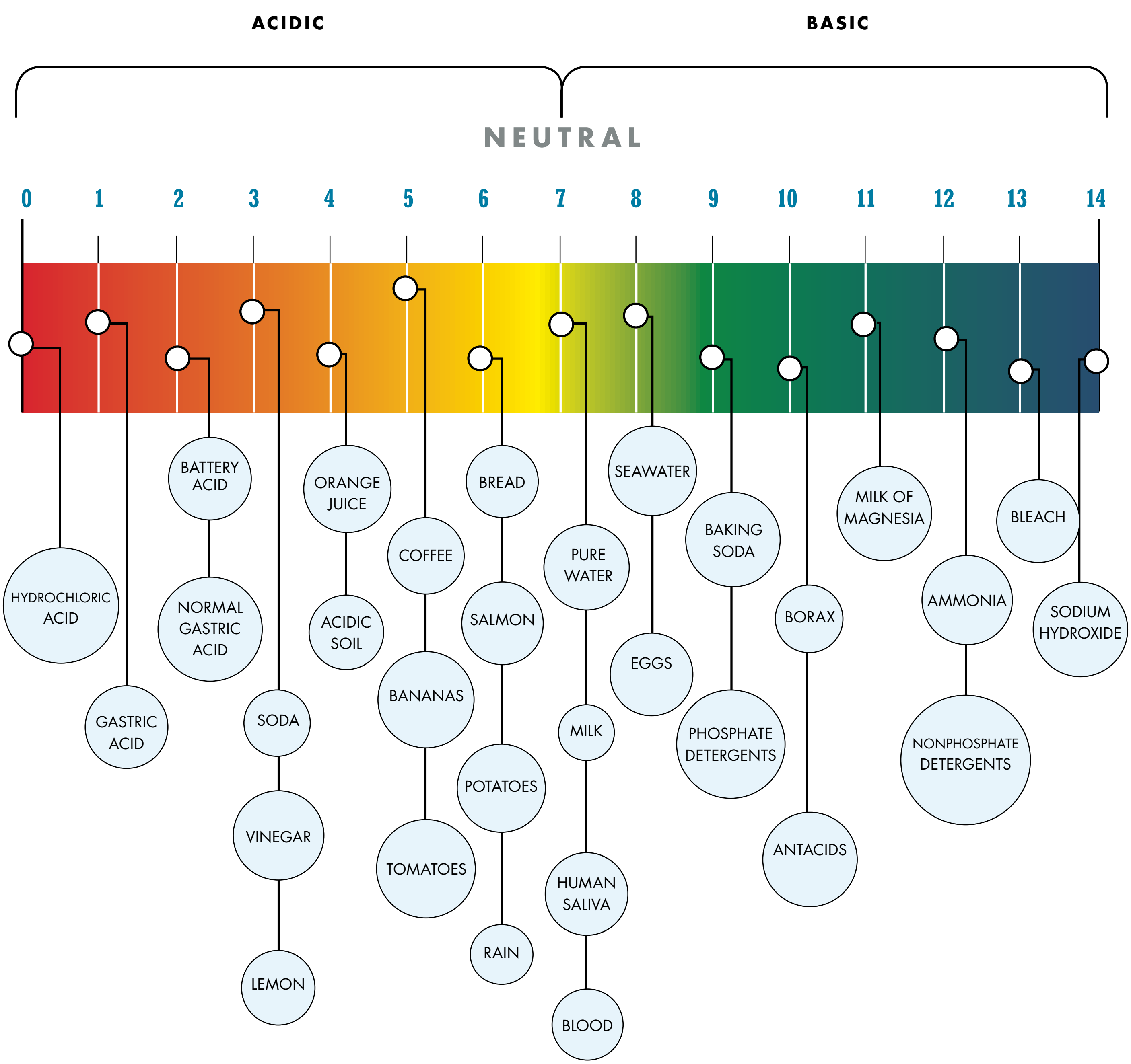
Ocean acidification: an effect caused by carbon dioxide entering the ocean, combining with seawater, and producing carbonic acid, which increases the acidity of the water, lowering its pH



Printable:
"Ocean Acidification: Bromothymol Blue"

The pH scale measures how acidic or basic a substance is. The pH scale ranges from 0 to 14. A pH of 7 is neutral. A pH less than 7 is acidic. A pH greater than 7 is basic. Note the pH levels of each of the colors you observed in today's experiment.

pH SCALE



Discovery Sheet:
"Ocean Acidification: Before & After"

BEFORE

AFTER

Museum Educator Guide:
"Convection Currents"

FOR ADULT LEADER

Station Overview:

Students will observe a convection current, seeing how warm water rises and cooler water sinks.

Next Generation Science Standards

MS ESS 2-6: Develop and use a model to describe how unequal heating and rotation of the Earth cause patterns of atmospheric and oceanic circulation that determine regional climates.

Disciplinary Core Idea

ESS 2.C: Variations in density due to variations in temperature and salinity drive a global pattern of interconnected ocean currents.

Materials

- 5 gallon tank or clear plastic 16 qt. tub (you may want to have 3 of these)
- Short baby food jar
- Tongs
- Electric tea kettle (hot pot, or alternate way to heat water to a very hot temperature)
- Water
- Red food coloring
- Blue food coloring
- Ice cube tray and freezer
- A small cooler or ice chest
- Colored pencils
- A latex glove
- Hand towel
- White paper
- Aluminum foil
- Rubber band
- Long bamboo skewer (available at most grocery stores)

Preparing the Station

Prepare the ice (1-2 cubes per rotation).

1. Dye water blue and freeze in an ice cube tray.
2. Place prepared ice cubes in a small cooler to prevent melting.

Prepare the Water Tank (1 tank per rotation)

1. Fill up the water tank in advance, so the water comes to room temperature and is "calm." Place it at the station.
2. Tape white paper along the back side of the tank. This provides better viewing for students later on.

Prepare the Jar (1 jar per rotation)

1. Add water to the hot pot. Heat it up just prior to students arriving. The adult at this station can reheat it to the desired "very hot" temperature, as needed.
2. Punch a small hole in the lid of a baby food jar.
3. Add 6 drops of red dye into the jar.

Set Materials at the Station

1. Place the cooler, electric tea kettle, jar and lid, tongs, hand towel, and water tank at the station.
2. Place all printed materials at the station.

Worksheets & Printables

Sheet	Number to Print
Experiment Procedures: Convection currents	1 for the Adult Leader
Task Card: Convection currents	1 Per Station
Lab Sheet: Convection currents	1 Per Student
Discovery Sheet: Convection currents	1 Per Station

Experiment Procedures:
"Convection Currents"

FOR ADULT LEADER

Prepare the Hot Water

1. Heat the water in the hot pot.
2. When the water becomes very hot, carefully pour the water into the baby food jar (which already has red dye in the bottom).
3. Fill the jar to the very top (nearly overflowing) with hot water. Carefully cover the jar with a piece of aluminum foil and secure with a rubber band.

Place the Red Jar in the Tank

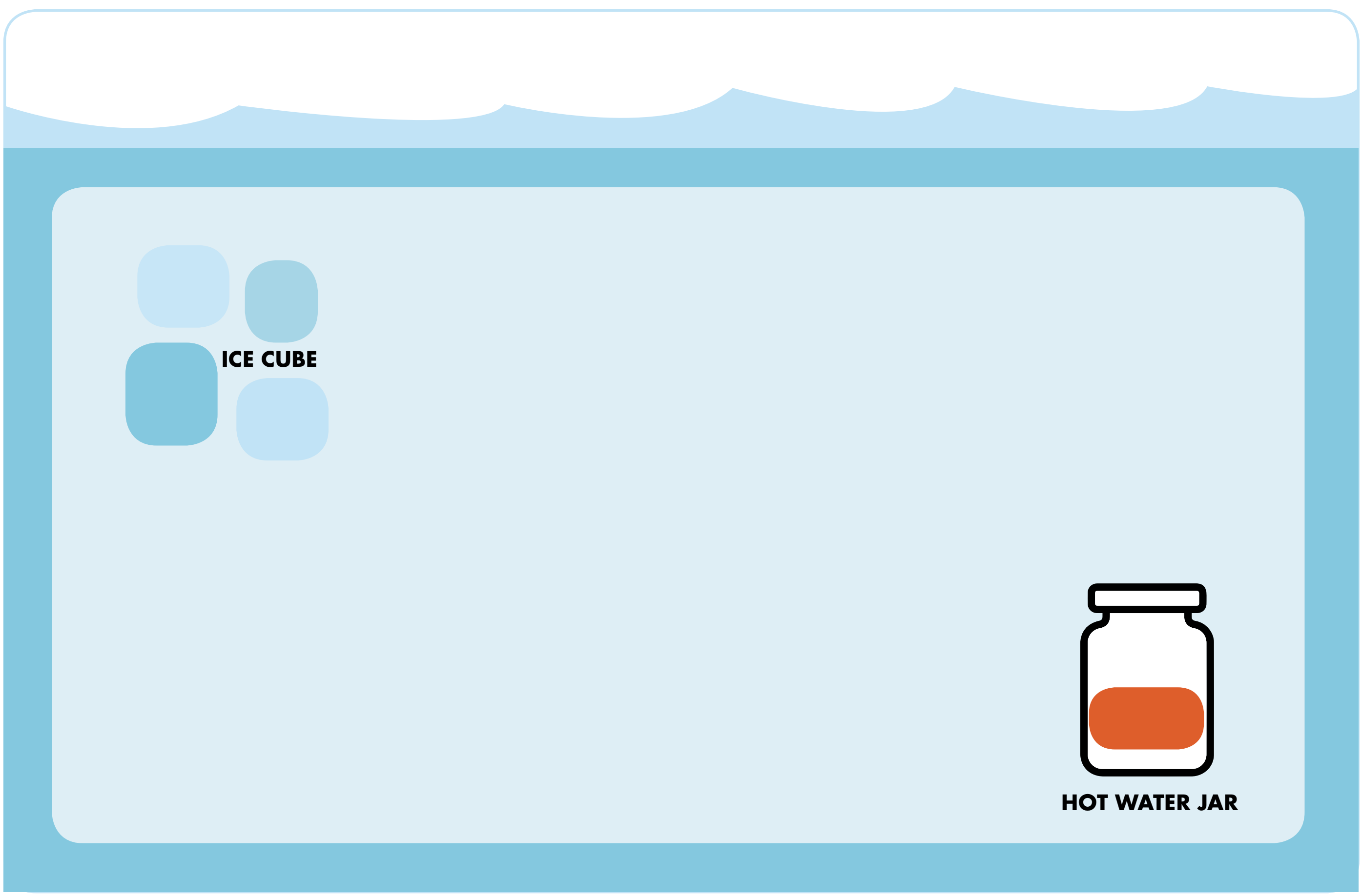
1. Use the tongs to carefully place the filled jar at the bottom of the tank, near one side. Try not to disturb the calmness of the water.
2. Use a long wooden skewer to poke a few holes in the top of the aluminum foil. The more holes, the more dyed red water will be visible.
3. Direct students to make observations, and connect what they see to the relationship between temperature and density. They may record their observations on their lab sheet.

Place the Blue Ice Cube in the Tank

1. Put on the glove (to keep the dye off your fingers) and carefully place a blue ice cube on top of the water on the opposite side of the tank (away from the baby food jar). Keep the cube on one side of the tank.
2. Direct students to make observations, and connect what they see to the relationship between temperature and density. They may record their observations on their lab sheet.
3. A second ice cube may be added if the first one melts too quickly, or all students are unable to see the stream of blue from the first one.

Clean Up!

1. Each new rotation will receive a fresh tank for the demonstration.
2. Ask the museum educator to refresh the supplies for you.



Task Card:
"Convection Currents"

Task Card:
"Convection Currents"

Today You Will Observe a Demonstration of Convection Currents!

1. Make a Hypothesis

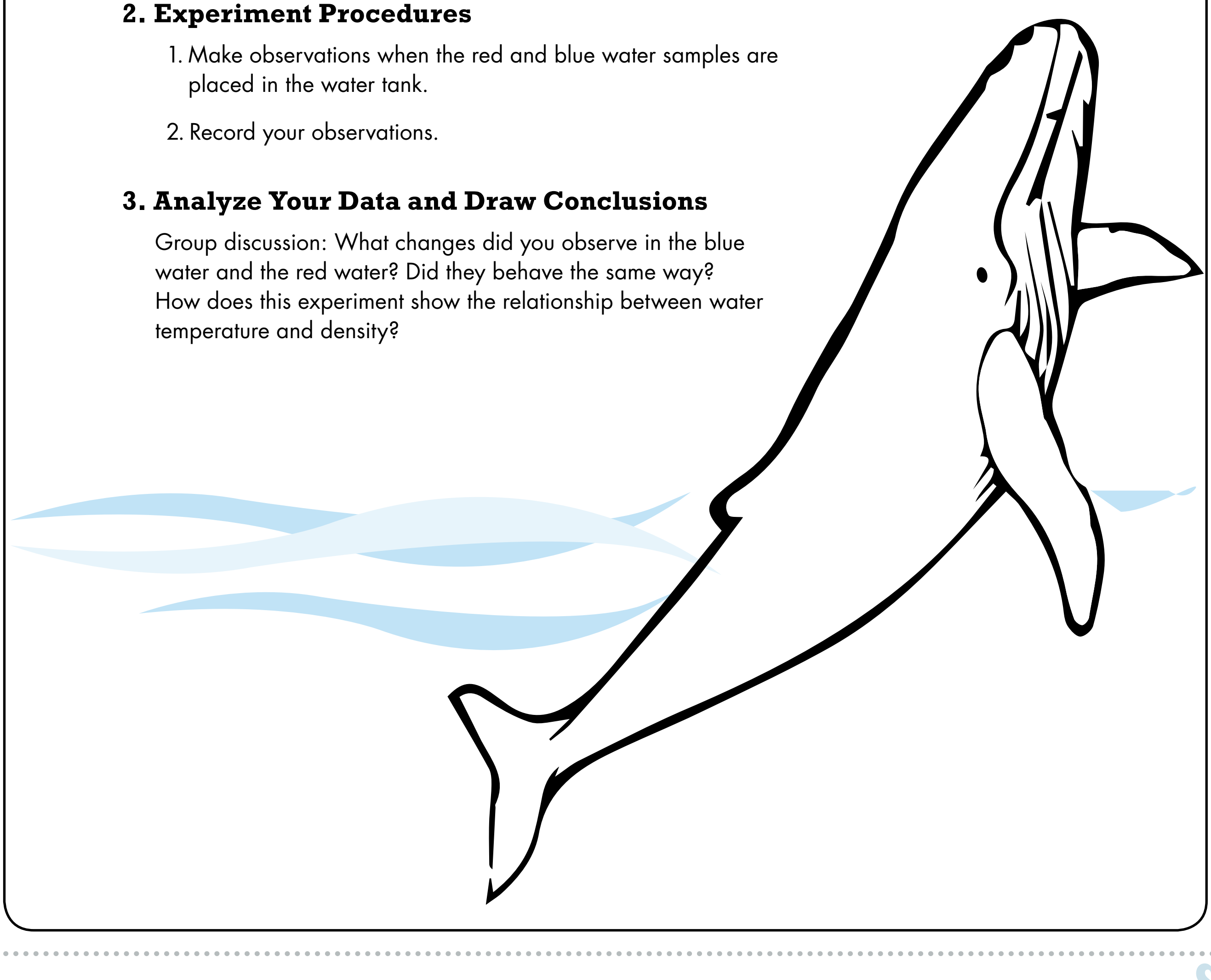
What will happen when an ice cube is placed in the water tank? What will happen when a jar of hot water is placed in the water tank?

2. Experiment Procedures

1. Make observations when the red and blue water samples are placed in the water tank.
2. Record your observations.

3. Analyze Your Data and Draw Conclusions

Group discussion: What changes did you observe in the blue water and the red water? Did they behave the same way? How does this experiment show the relationship between water temperature and density?



Lab Sheet:
"Convection Currents"

Oceanographer:

Objective

Today you will obeserve a demonstration of convection currents.

1. Make a Hypothesis

What will happen when ice cube are placed in the water tank? What will happen when the warm red water is released into the tank?

2. Collect Data

Draw and label your observations in the tank below!

3. Analyze Data and Draw Conclusions

Group Discussion: Why did the blue water sink while the red water flowed upwards? Draw conclusions about the relationship between water temperature and density.

How do convection currents relate to the ocean and humpback whales?

Discovery Sheet:
"Convection Currents"

Ocean water moves from place to place in ocean **currents**, which are like rivers in the ocean. Ocean currents transport water, heat, nutrients, sediments, animals and plants, and even ships from place to place in the oceans! In general, ocean currents carry heat from the tropics to the poles. This helps distribute and equalize the amount of heat throughout the planet.

As wind blows over the ocean, it tugs on the surface of the ocean, moving the ocean surface water. These are called surface currents. Not all currents in the ocean are driven by wind across the surface, though.

Some currents are found deep in the ocean where the wind does not affect them. These deep ocean currents are one component of global ocean convection currents. Water **density** drives these currents. Different parts of the ocean have different densities, and the differences in density form convection currents .

Water density depends on its temperature and its **salinity**. Temperature is how hot or cold something is, while salinity is the amount of salt dissolved in a solution. As the temperature of water increases, its density decreases. As the salinity of water increases, its density increases.

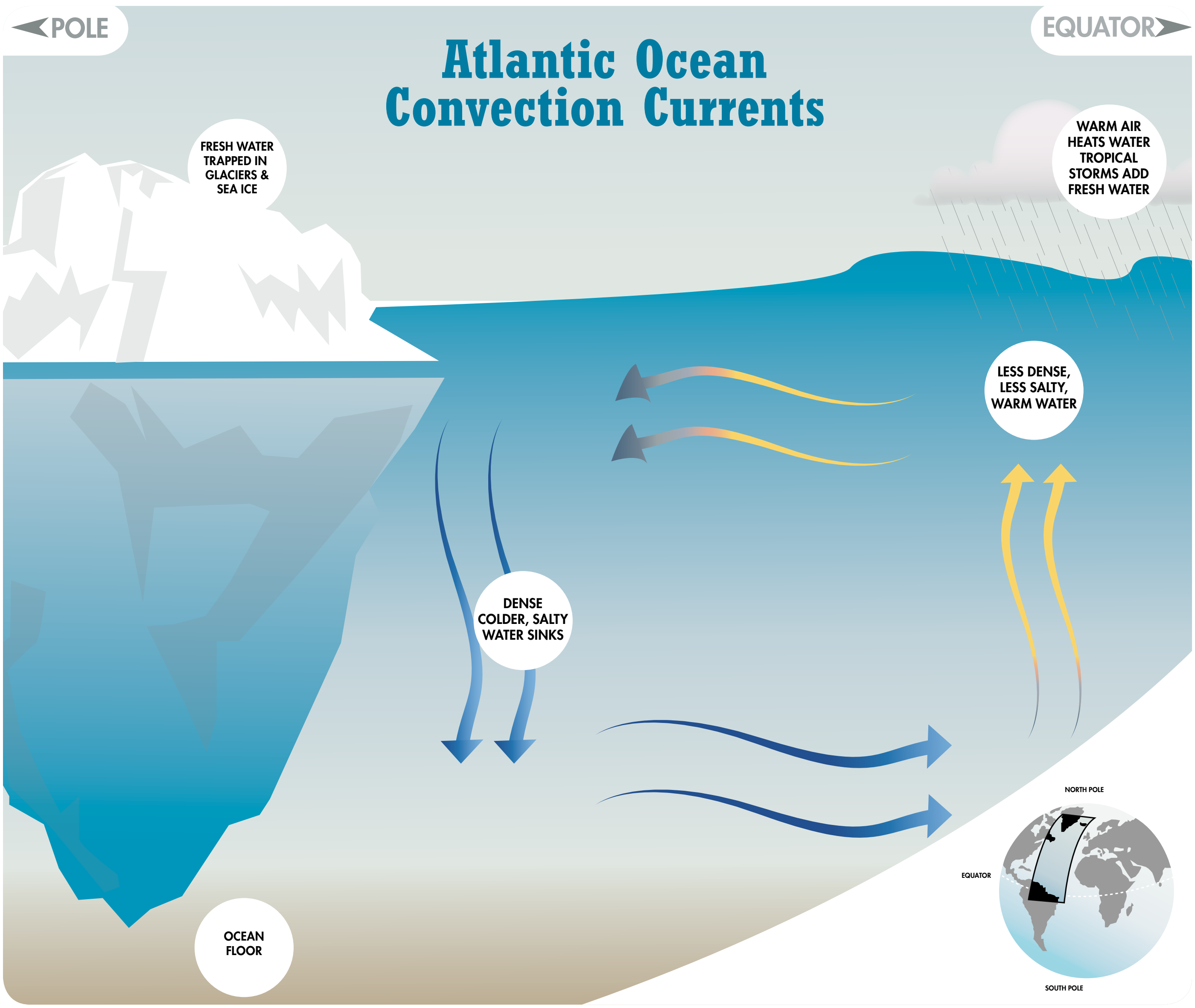
Definitions

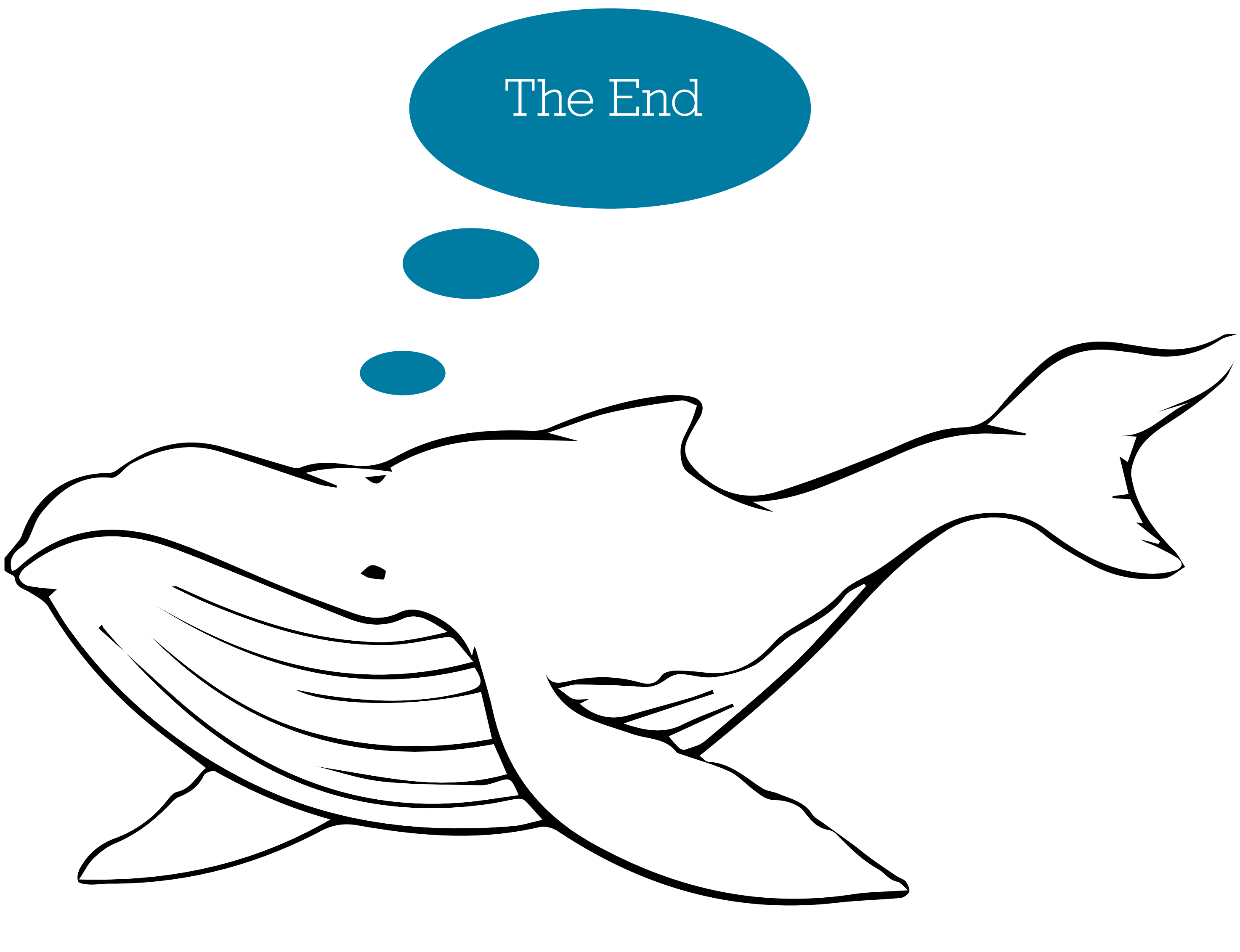
Current: a continuous, directed flow

Convection currents: in the ocean, dense cold salty water sinks at the poles, while warm, less salty, and less dense water rises near the equator.

Density: a measure of how much mass is contained in a given unit volume (density = mass/volume)

Salinity: the total amount of dissolved salt and minerals in grams in one kilogram of sea water




The End