



Everblue Education

Why Whales are Big, but Not Bigger

Ever wondered why whales are so big? But also... why aren't they bigger? What limits their growth? And, how do scientists learn so much about the biggest animals on the planet? In this week's lesson, students will answer these questions and more by exploring research by scientist Jeremy A. Goldbogen! This paper was published in the journal *Science* in December 2019, and explores the limits and drivers of whale size.

Everblue is a 501(c)(3) nonprofit dedicated to encouraging ocean-conscious living by increasing scientific literacy. Our online education resources connect current science to daily life, allowing you to learn about the ocean at your fingertips! Stay in touch by following @oceaneverblue on your preferred social media platform or by visiting our website at www.oceaneverblue.org.

To help us keep the ocean ever blue, please share this program with the teachers and parents you know so we can spread ocean science far and wide. Partnering with marine scientists from around the world who study all parts of the ocean, we've created simple and engaging activities based on recently published papers! These activities connect you and your students to current research while fulfilling education standards for reading, math, science, and writing. Even though the activities are created for grade school, they're fun and informative for parents and siblings, as well! Keep an eye on our website oceaneverblue.org/education for regularly published lessons.

Research Paper:

Why whales are big but not bigger: Physiological drivers and ecological limits in the age of ocean giants. *J. A. Goldbogen et al. 2019.*

Grade Level:

Elementary School, Grades 1-3

Timing:

1 hour and 30 minutes

Materials:

Writing utensils, paper, scissors, stuffed animals or other objects for marking distance, timing device, Legos or other small objects, and a printer (optional)

Next Generation Science Standards

Science & Engineering Practices: Developing & Using Models	Crosscutting Concepts: Scale, Proportion, & Quantity Structure & Function Systems & System Models	Disciplinary Core Ideas: Biodiversity Energy Flow in Ecosystems
--	---	--

Activity Overview

Title of Activity	Learning Cycle Stage	Time
How Big is a Whale?	Invitation, Exploration	20 minutes
A Whale of an Appetite	Concept Invention	30 minutes
Sampling Scientists	Application	30 minutes
Reflection	Reflection	10 minutes

Appendix Contents

Appendix I Instructor Support	Appendix II Attached Lesson Materials
Ocean Vocabulary Common Questions	Whale Fact Cards (Blue, Minke, Sperm, Grey, and Orca) Sampling Tools Cards



Activities

How Big is a Whale?

In this activity, students will use their own bodies to see just how big different species of whales are! You will need several objects, such as stuffed animals, cones, or pieces of paper, to mark the length of each whale.

1. Gather students in an open area, whether this is a large room, a long hallway, or an open field outside. You're going to need a lot of space! Have students stand at one end of the space. If you are outside, you may want to set out markers at your "start" line so that students can more clearly see how far they move during the activity.
2. From the starting point, have students take one large step forward. This will represent 3 feet (1 meter) of distance, roughly half the height of a human. Whatever size step they take this first time, they should try to make all their steps in this activity the same distance.
 - a. Note: This step is just for practicing - don't set down a marker yet. Go back to the starting line to begin! Each time the students mark a whale, read its fun fact!
3. First, let's mark the height of a human. Have students take two measuring steps forward and set down a marker.
4. Now let's start with the smallest whale, the critically endangered vaquita. This dolphin grows to about 4 feet (1.4 meters) in length, so have students take 1.5 steps forward and set down a marker.
 - a. *Fun fact:* The vaquita is the world's smallest whale, and lives in the Gulf of California!
5. Repeat this process for the following whale species:
 - a. Bottlenose dolphin - 10 feet (3 meters) = 3 steps
 - i. The bottlenose dolphin is the most well-known dolphin, and they're also one of the smartest animals on the planet!
 - b. Minke whale - 18 feet (6 meters) = 6 steps
 - i. The minke whale is the smallest baleen whale! Baleen whales feed by taking big gulps of water and krill, and filtering the water out through their baleen (a wall of coarse hair-like material.)
 - c. Orca - 20 feet (6.7 meters) = 7 steps
 - i. The orca is the largest whale in the "dolphin" family.
 - d. Grey whale / Sperm whale - 40 feet (13.3 meters) = 13 steps
 - i. Grey whales migrate up and down the West Coast of the United States each year to feed and breed!

- ii. Sperm whales are known to take naps while floating vertically in the water column, sleeping for 10-15 minutes at a time.
- e. Humpback whale - 50 feet (15.2 meters) = 16 steps
 - i. Humpback whales have complex communication “songs” that are unique to each individual - just like recognizing your friends or family by their voices!
- f. Blue whale - 100 feet (33.3 meters) = 33 steps
 - i. Blue whales are the largest animals known to have ever lived on earth! (That includes any dinosaurs!)

A Whale of an Appetite

For this activity, you will need an open space for students to run in, a timer or stopwatch, and many small objects, like Legos or similarly sized items, to represent baleen whale’s primary food source, krill. If you have multiple students, assign each student a different size class of whale; small = minke whale, medium = humpback whale, large = blue whale. If you have a single student, have them run through this activity multiple times so that they can experience each size class. Notes to you, the instructor, are in *italicized text*.

Read the following to your student(s):

When you think of whales, what’s the first thing that comes to mind? (*Students will hopefully say “big” or similar.*) Whales are some of the biggest animals that have ever lived, including the dinosaurs! The largest whales all have a common trait; they are baleen whales. This means that they feed with specialized structures in their mouths called **baleen**, instead of teeth! This allows them to eat lots of their favorite food, krill! Krill are small crustaceans that look like shrimp. Baleen whales eat them by taking in huge mouthfuls of water and then using their baleen to sieve out the water and keep the yummy, nutritious krill in their mouths. Krill may be small, but there are lots of them, which makes them a great source of food for big whales with big appetites. In fact, a blue whale, the LARGEST animal to EVER LIVE, can eat as much as 1,100 pounds of krill in a single mouthful, which equals about 457,000 calories!

It makes sense that a big animal like a whale needs to eat a lot. Actually, being big helps them eat more! In this activity, we’ll see how being bigger helps whales to get the food they need in the most efficient way possible.

1. *Begin by scattering your Legos (or other small objects) in your designated area on the floor.* These represent the krill you whales will be eating!
2. Baleen whales are big animals, but there is a lot of variation in size among different species of baleen whales. Do you know how large a blue whale is? (*100 feet/33.3 meters*) The minke whale is one of the smallest species of baleen whale at just 18 feet (6 meters). And humpback whales are in the middle at about 50 feet.

- a. Assign or have students choose their size class of whale.*
3. In order to survive, every whale (indeed every animal) must eat a certain amount in a day. However, different sized whales will need different amounts of food.
 - a. Inform students of the food needs of their type of whale:*
 - i. Minke = 12 pieces*
 - ii. Humpback = 25 pieces*
 - iii. Blue = 25 pieces*
4. Size not only determines how much total food a whale needs in a day, but also how much food they can gather at one time.
 - a. Tell students the maximum number of “krill” they can hold at once:*
 - i. Minke = 2 pieces*
 - ii. Humpback = 6 pieces*
 - iii. Blue = 25 pieces*
5. Have each student start at a “home base” space. Instruct students to grab the bottom of their shirt and hold it out in front of them, creating a basket with their shirt. This basket will be their “baleen.”
6. When you have your maximum number of pieces in your baleen shirt basket, you must come back and drop them at this “home base” before you can go and pick up more. Do this until you have your required number of “krill.” You’ll have 30 seconds to gather all the food your species needs to survive. *Adjust this time limit as necessary for your particular group of students to make it a fun challenge.*
7. *Repeat this activity two more times so that your student(s) can experience all of the different size classes of whales.*
8. Now that you’ve seen what it’s like to survive as the largest and smallest of the baleen whales, did you think it was easiest to gather all your food as a large whale, a small whale, or a medium-sized whale? How many trips did it take to gather your food at each different size? Did you run more as a big whale or a small whale?
9. Although a blue whale needs much more food than a minke whale, a blue whale is able to get much more of the food they need at once, so they don’t have to spend as much time and energy swimming around looking for food. This makes them more **energetically efficient** than smaller whales, which is part of why whales get so big!

Read the following to your student(s) to reflect:

So, the amount of food that each whale can eat every day *limits* their size! Blue whales can grow to be so big because they can capture a lot more food at once than other whale species, making them more energetically efficient. This means they can conserve their energy to eat more food and grow bigger! Now, let’s play a game in the next activity to learn how scientists like you study whales!

Sampling Scientists

Have you ever wondered how scientists have learned so much about whales? In this activity, you'll get to be a research scientist and learn about the tools scientists use to study whales! For this activity, you'll need either A) a printer and scissors, or B) paper, a writing utensil, and scissors. Print out the game cards in Appendix II and cut them in strips horizontally so each piece of paper has two boxes on it. Fold the paper pieces halfway in between the boxes so one box is on the front side and one box is on the back. The side with the blue text should face up and the side with the black text should face the ground. If you'd like, you can glue or tape the two sides together.

Option: if a printer is not available to you, feel free to copy the information on the cards onto pieces of blank paper with a writing utensil, then cut them out. If you do not have scissors available to you, simply tearing the paper will work.

Make one pile of the "Sampling Tools" cards in front of your student(s) with the blue text facing up. Then, make five other piles on the table or ground near your student(s) with one pile for each whale species. Notes to you, the instructor, are in *italicized text*.

Read the following to your student(s):

1. Welcome to your laboratory! You are a world-renowned whale research scientist, and you just received lots of grant money for a new project researching five different whale species: the orca whale, sperm whale, minke whale, grey whale, and blue whale.
2. To research the whales, you'll need some technologies and tools. Flip over the "Sampling Tools" cards one at a time to learn about each one!
 - a. Each of your sampling tools will only allow you to learn one or two facts about your whales. This is why it's important to use *all* of your tools! However, that also takes time, as you'll soon find out. Let's dive in!
3. *Pick up one card from each species pile and shuffle them, then hold them out in a fan for the student to pick one.* To decide which whale you'll research first, close your eyes and pick a card from your educator! Whichever species card you draw will be the whale you research first.
4. *Pick up the pile of "Sampling Tools" cards and shuffle them, then hold them out in a fan.* To figure out which tool you'll use first, close your eyes and pick a card! Each Sampling Tool only allows you to learn a few facts. Once you decide which tool you'll use, refer to this list to see what facts you can learn about your whale:
 - a. Marine acoustics: This tool allows you to learn about whale behavior and range.
 - b. Drone footage: This tool allows you to learn about whale range, behavior, and size.
 - c. Whale tagging: This tool allows you to learn about whale feeding, range, and age.

- d. Feces and tissue sampling: This tool allows you to learn about whale feeding.
 - e. Necropsies: This tool allows you to learn about whale size and age.
5. Based on the sampling tool you selected, pick up one whale fact to learn about your whale! The five facts are listed below.
 - a. Feeding, behavior, range, age, and size.
6. Repeat steps 4-5 until you have read all the facts about your whale. This will take multiple rounds, since you have to use many tools to learn all five whale facts! If you pick a tool card that you've already chosen, either use it to learn another fact from the list above, or redraw.
7. *Repeat step 3 if your student would like to learn about any of the other five whales.*
8. Great job learning about your whales! Using your scientific tools, you were able to discover more about the feeding habits, behavior, range and habitat, age, and size of the blue, minke, sperm, orca, and grey whales. Incredible!
9. *Ask your student the following reflection questions:*
 - a. What tool allowed you to learn the most facts?
 - b. How many times did you have to draw tools to learn all of your facts?
 - c. Did you ever get any repeated cards drawn, or did you draw tools that covered facts you'd already learned?
 - d. How do you think scientists might use all different kinds of tools?
 - e. Why do you think it's important to use many different tools in research?

Reflection

As you and your student are cleaning up, talk to your student about what you just did together. Here are some guiding questions to help shape your conversation.

- What was your favorite part of our activity today?
- What is something that you learned about {lesson subject here}?
- Did you notice any patterns during our activity today?
- What is something you wonder about {lesson subject here}?
- What surprised you the most during our activity today?



Appendix I - Instructor Support

Ocean Vocabulary

- Baleen - Bristly sheets made of keratin (the same substance found in human fingernails, skin and hair) that hang from the top of a baleen whale's mouth
- Cetaceans - a group of aquatic mammals that includes whales, dolphins, and porpoises
- Energetic efficiency - using less energy to perform the same task; that is, eliminating energy waste
- Mysticetes - a group of cetaceans that includes blue whales, minke whales, and grey whales (commonly known as baleen whales)
- Odontocetes - a group of cetaceans that includes dolphins, sperm whales, orca whales, and porpoises (commonly known as toothed whales)

Common Questions

How do whales feed?

There are two main types of whales: **odontocetes** (oh-DON-toe-seets) and **mysticetes** (MIS-ti-seets). Odontocetes are more commonly known as “toothed whales,” while mysticetes are more commonly known as “baleen whales.” Toothed whales use their teeth to grab, tear, and chew food. Baleen whales use their baleen (see *Ocean Vocabulary* above to learn more about baleen) to filter food out of the water. If you want to learn more about blue whale feeding, check out this article from Nat Geo: <https://www.nationalgeographic.com/science/phenomena/2010/12/09/blue-whales-can-eat-half-a-million-calories-in-a-single-mouthful/>

Whales and dolphins and porpoises, oh my! What's the difference?

The terms “whale,” “dolphin,” and “porpoise” are used to describe marine mammals in the grouping called **cetaceans**. The grouping is split into two categories: (1) odontocetes, or toothed whales, and (2) mysticetes, or baleen whales. Dolphins and porpoises are categorized as odontocetes, since they have teeth! But, the whales that we think of can be either odontocetes or mysticetes, depending on whether they have teeth or baleen. So, all dolphins and porpoises are whales, but not all whales are dolphins and porpoises.

Appendix II - Attached Lesson Materials

Blue Whale Facts

<p>blue whale feeding</p>	<p>blue whales eat krill using their baleen - some can eat up to 6 tons in one day</p>
<p>blue whale range</p>	<p>blue whales are found in every major ocean except the Arctic, and often make long migrations</p>
<p>blue whale behavior</p>	<p>blue whales usually swim alone or in pairs, and it's common to see mothers with their babies</p>
<p>blue whale size</p>	<p>blue whales can grow up to 80 feet long</p>
<p>blue whale age</p>	<p>the average lifespan of a blue whale is 80 to 90 years old</p>

Minke Whale Facts

<p>minke whale feeding</p>	<p>minke whales use baleen to filter krill and small fish from the water</p>
<p>minke whale range</p>	<p>northern minke whales are usually only found north of the equator, while antarctic minke whales have been found near the south pole</p>
<p>minke whale behavior</p>	<p>minke whales are very active at the surface, curiously approaching boats or breaching often</p>
<p>minke whale size</p>	<p>minke whales only grow to about 18 feet in size - the smallest baleen whale</p>
<p>minke whale age</p>	<p>minke whales usually live for 30-50 years</p>

Grey Whale Facts

<p>grey whale feeding</p>	<p>grey whales pick up mouthfuls of sediment and filter it through their baleen to eat small animals on the seafloor</p>
<p>grey whale range</p>	<p>grey whales are only found in the Pacific and stick close to the shorelines to feed and migrate up and down coastlines</p>
<p>grey whale behavior</p>	<p>grey whales are very friendly and often approach boats during their breeding season in Baja California</p>
<p>grey whale size</p>	<p>grey whales grow to about 40 feet long</p>
<p>grey whale age</p>	<p>grey whales live between 55 and 70 years</p>

Sperm Whale Facts

sperm whale feeding

sperm whales dive deep for food like squid, sharks, and fish that they eat with their teeth

sperm whale range

sperm whales live in every ocean in the world, but stay away from very cold waters

sperm whale behavior

sperm whales are very social and can be seen in pods of up to 50 whales

sperm whale size

sperm whales usually grow to 40 feet long

sperm whale age

sperm whales can live as long as 60 years

Orca Whale Facts

<p>orca whale feeding</p>	<p>orcas are at the top of their food chain and use their 4-inch long teeth to eat seals, fish, penguins, and even other whales</p>
<p>orca whale range</p>	<p>orcas are found in all oceans, but are most abundant in colder waters</p>
<p>orca whale behavior</p>	<p>orcas are very intelligent and often hunt and live in pods, or social groups</p>
<p>orca whale size</p>	<p>orca whales grow from 15 to 25 feet in length</p>
<p>orca whale age</p>	<p>orca whales live for about 50 years on average</p>

Sampling Tools

marine acoustics	hydrophones - just like microphones, but for underwater - record whale songs for scientists to hear and study!
drone footage	scientists can fly drones over the ocean to follow whales and collect video footage of their movement and behavior
whale tagging	a whale can be tagged and tracked using a tag attached to the whale that sends data on the whale's movements and information to scientists on land
feces and tissue samples	scientists can collect feces (poo and pee) that whales leave behind in the water as they swim
necropsies	if a whale is ever found washed up on the shore, scientists can perform necropsies (dissecting the whale) to learn about it and how it passed