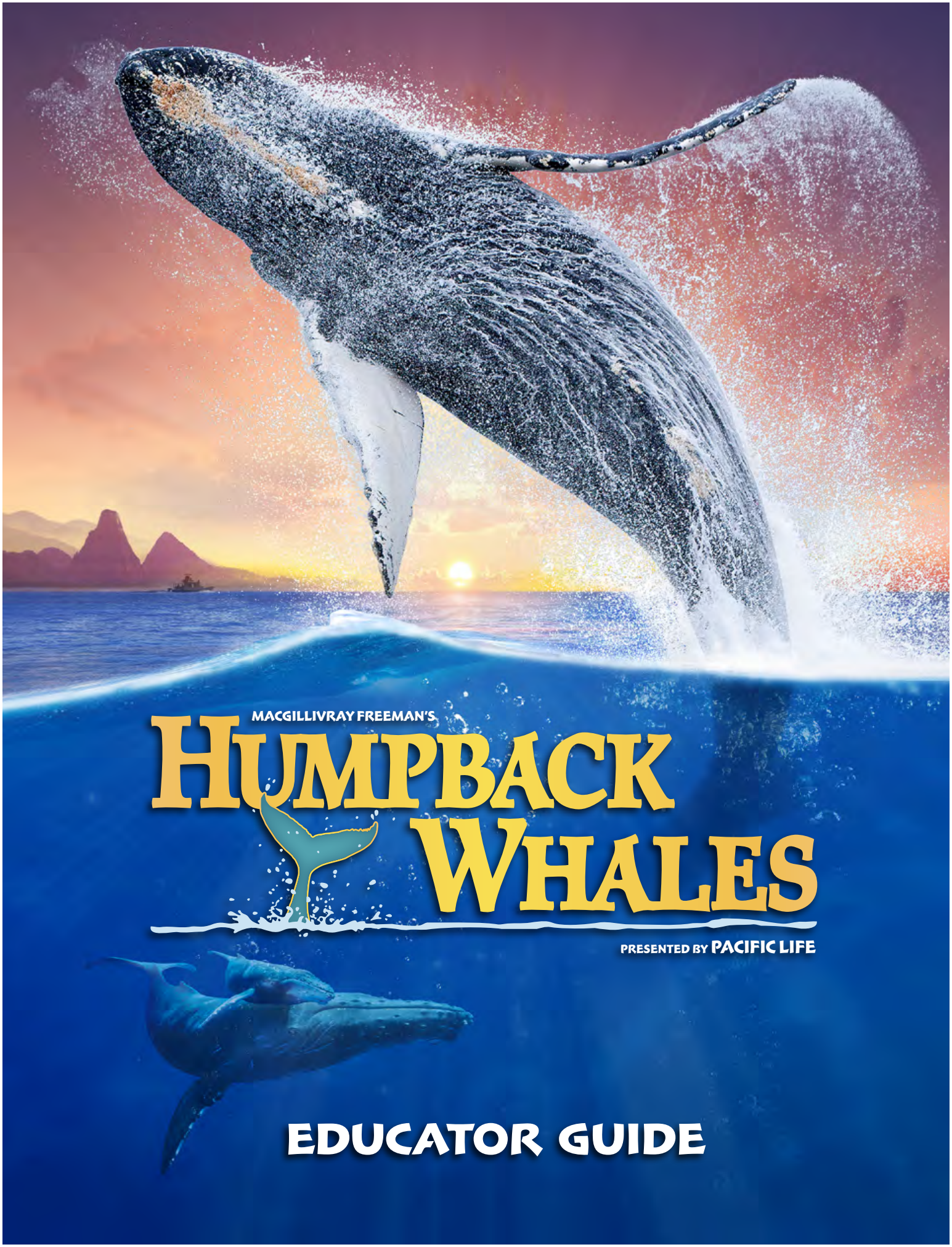
MACGILLIVRAY FREEMAN'S
HUMPBACK WHALES
PRESENTED BY PACIFIC LIFE
EDUCATOR GUIDE

HUMPBACK FUN FACTS

WEIGHT

At birth: 1 ton
Adult: 25 - 50 tons

LENGTH

Up to 55 feet, with females larger than males; newborns are about 15 feet long

DIET

Krill, small fish

APPEARANCE

Gray or black, with white markings on their undersides

LIFESPAN

50 to 90 years

THREATS

Entanglement in fishing gear, ship strikes, habitat impacts

MACGILLIVRAY FREEMAN'S

HUMPBACK WHALES

PRESENTED BY PACIFIC LIFE

EDUCATOR GUIDE

The Humpback Whales Educator Guide, created by MacGillivray Freeman Films Educational Foundation in partnership with MacGillivray Freeman Films and Orange County Community Foundation, is appropriate for all intermediate grades (3 to 8) and most useful when used as a companion to the film, but also valuable as a resource on its own. Teachers are strongly encouraged to adapt activities included in this guide to meet the specific needs of the grades they teach and their students. Activities developed for this guide support Next Generation Science Standards (NGSS), Ocean Literacy Principles, National Geography Standards and Common Core Language Arts (see page 27 for a standards alignment chart).

An extraordinary journey into the mysterious world of one of nature's most awe-inspiring marine mammals, *Humpback Whales* takes audiences to Alaska, Hawaii and the remote islands of Tonga for an immersive look at how these whales communicate, sing, feed, play and take care of their young. Captured for the first time with IMAX® 3D cameras, and found in every ocean on earth, humpbacks were nearly driven to extinction 50 years ago, but today are making a steady recovery. Join a team of researchers as they unlock the secrets of the humpback and find out what makes humpbacks the most acrobatic of all whales, why they sing their haunting songs, and why these 55-foot, 50-ton animals migrate up to 10,000 miles round-trip every year.

Humpback Whales is produced and distributed by MacGillivray Freeman Films and presented by Pacific Life. A One World One Ocean production, *Humpback Whales* is directed by two-time Academy Award®-nominated filmmaker Greg MacGillivray (*The Living Sea*, *Dolphins*). Run time 40 min. To learn more, visit www.humpbackwhalesfilm.com.

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INTRODUCTION

Their haunting songs intrigue listeners. Their ocean acrobatics delight whale watchers. Their behavior engrosses researchers. Once hunted, now protected, they are: humpback whales. And they are now also the "stars" of a new film for IMAX® and giant-screen theatres, Humpback Whales*, where your students will be able to see them life-size on the giant screen.*

Humpback whales are found in all of the world's oceans. They have a vocal range that is among the broadest in the animal kingdom. Although they're larger than a school bus, humpbacks are among the most acrobatic of all whales, launching themselves out of the water and slapping the surface with their flukes. These water wayfarers journey thousands of miles during annual migrations—but how do they know where in the world's oceans to go?

All of these facts make humpback whales a fascinating subject, but, despite their huge size, they're difficult creatures to study. After all, they spend most of their time underwater and out of sight. We are just beginning to understand these ocean giants, but there's still much to discover. Thankfully, they've been brought back from the edge of extinction, giving us the opportunity to learn more.

Humpbacks were hunted for whalebone, meat and oil during the 1800s and 1900s. Because they frequent coastal waters and migrate to the same regions every year, humpbacks were highly vulnerable to commercial whalers. Intensive hunting between the 1920s and 1950s decimated humpback populations, killing hundreds of thousands of the whales, until their numbers were down to only 5 to 10% of their original populations.

But then something changed. Whale biologist Roger Payne and his colleagues dropped a microphone into the sea and captured the remarkable sounds of the humpback and other whales. The recordings of these whale songs were released on vinyl by Columbia Records in 1970, and sold an astonishing 100,000 copies over the next 10 years. The songs helped break down the barrier between humans and whales and laid the foundation for an environmental movement to save the whales. Meanwhile, the International

Whaling Commission protected humpback whales in 1966 and later instituted a wholesale moratorium on commercial whaling in late 1985.

In response to these measures, most humpback populations have begun to recover. In the summer, humpbacks can be found in cold coastal waters, such as the Gulf of Maine in the Atlantic, the Gulf of Alaska in the Pacific and off Antarctica where they feed and build up their blubber reserves. Most migrate great distances in the winter to calving grounds in tropical or subtropical waters. In fact, humpback whales have one of the longest migrations of any marine mammal. In just 36 days, a humpback can travel from Alaska to Hawaii—a 3,000-mile journey.

But humpbacks' long migrations now put them at risk. Whales are being hurt or killed by collisions with ships and by becoming entangled in heavy fishing gear. Because they spend much of their lives near shore, what we do onshore affects their well-being and survival. Ocean polution is impacting their habitat. They still need our protection.

Newborn humpback whales, called calves, weigh up to 2,000 pounds (900 kg) and grow quickly, thanks to their mothers' highly nutritious milk. When they reach adult size, they'll eat up to 4,000 pounds a day—and perform a critical role in stabilizing the aquatic food chain. Mothers keep a close eye—and flipper—on their calves, swimming close to them and frequently touching them with their pectoral fins.

The calving grounds are also where humpbacks mate, and their courtship is anything but subtle. Males compete for female attention, sometimes chasing females, making vocal or bubble displays, and thrashing their tails. Sometimes they clash physically, striking each other or surfacing on top of one another. Yet, no scientist has ever observed humpback whales mating or giving birth.

In the 1970s, scientists discovered that humpbacks can be identified through the patterns on the undersides of their tail flukes. This pattern is so distinct that it's akin to a human fingerprint. Individual whales can now be identified, tracked and studied for years.

Perhaps the most fascinating behavior humpbacks display is their singing. Head down and motionless in the warm winter waters, males sing for hours at a time, repeating the same song again and again. (Females vocalize, too, but only males sing.) A song can be 15 minutes long or more and be heard up to 20 miles away. Within a geographic area, all males sing the same song, but the complex song changes gradually from year to year. As the song changes, all of the whales in that area sing the same new song. Underwater worldwide, humpbacks are singing —but we don't know how they learn their songs, and are uncertain why they sing at all. We still have much to learn about humpback whales.

As we see in the film, *Humpback Whales*, researchers like Drs. Fred Sharpe, Jim Darling, and Meagan Jones continue to work to understand whale songs and behaviors. People like Ali Takau are committed to conservation, and Ed Lyman and his team risk their lives to save whales from deadly entanglements. Perhaps the film and the activities presented in this guide will inspire your students to love the ocean, treasure its inhabitants, and even inspire one or more to become a conservationist or scientist who will work to protect and better understand the singers of the sea: humpback whales.

A. TOMILIN/MOSCOW PROJECT

Fifty years ago, commercial whaling nearly drove humpback whales to extinction, decimating more than 90% of original populations. An international ban on hunting humpbacks was enacted in 1966, and ever since their populations have been steadily increasing. Now, researchers must have special permits to study humpback whales.

LESSON **1**

Seeing Songs in the Sea

OBJECTIVE

Students will learn the role and importance sound plays in the life of humpback whales. They will see spectrograms that display sound, learn that sound travels in waves, and observe the complex structure of humpback whale song. In conclusion, students will create their own song and be introduced to the concept of noise pollution and how it impacts animals that depend on sound to navigate, feed and communicate.

KEY WORDS

Spectrogram—An image that displays sound where time travels along the x-axis and frequency is the y-axis. Higher frequency sound is shown above the lower frequency and brighter color demonstrates sound strength.

Sound Wave—A pattern of disturbance created when energy is traveling through air, liquid or solids as it moves away from the sound source.

Frequency—The number of times a wave vibrates back and forth. Sound wave frequency is measured by hertz (Hz) and 1 Hz = 1 vibration per second. Some humans can hear sounds as low as 20 Hz, or 20 waves passing the ear per second, and as high as about 20,000 Hz.

LESSON LENGTH

45 minutes

IN THE FILM

In the film we observe hump–back whale behavior at the breeding grounds off Hawaii, where males often compete for the attention of females, and where sound plays a role in male-to-male communication and dominance displays. We also see humpback whales in Alaska practicing a unique group-hunting strategy called bubble net feeding, where they produce sounds and bubbles to herd fish.

MATERIALS

- ☐ On the *Voices in the Sea* website (www.voicesinthesea.org), open the *Humpback Whales* page (from the home page, select *Species*, then *Baleen Whales*, then *Humpback Whales*). The video to play during the lesson are *Why Do Humpback Whales Sing?* and *Songs of the Humpback Whale*.
- ☐ A variety of sizes of tuning forks (at least 2 different sizes per each group of five to six students)
- ☐ Two cups of water per student group (preferably in a clear container)
- ☐ Paper for groups to write their own unique song
- ☐ Pens or pencils
- ☐ A pre-recorded song ready to play (any song can be chosen by educator) via computer or other device

TEACHER PREP NOTES

This lesson will introduce students to the science of studying sound through the visualization tool called spectrograms, which allow scientists to see sound waves. They will have hands-on interaction with tuning forks to see sound wave oscillation patterns. Tuning forks can be purchased online on sites such as Amazon.com in sets that are less than $40.00. In order to learn more about humpback whale song, students will watch the *Voices in the Sea* short videos on theories about why humpback whales sing, humpback whale song structure and complexity, and how whales use sound on their breeding and feeding grounds. Working in groups, students will then compose their own song to share as a small group with the class. In conclusion, they will be exposed to the concept of "sound pollution" in the ocean and discuss its potential impact on ocean animals.

BACKGROUND

Marine mammals live in an aquatic environment that often has low visibility. They are often separated by distance. Marine mammals therefore cannot rely on their eyesight to locate food, mates, and for mother and calf to stay connected. Sound travels more than 4 times faster in water versus air, making it an effective tool for whales to communicate. There are a variety of sounds produced by all marine mammals but humpback whales are known for their beautiful, detailed and elaborate songs.

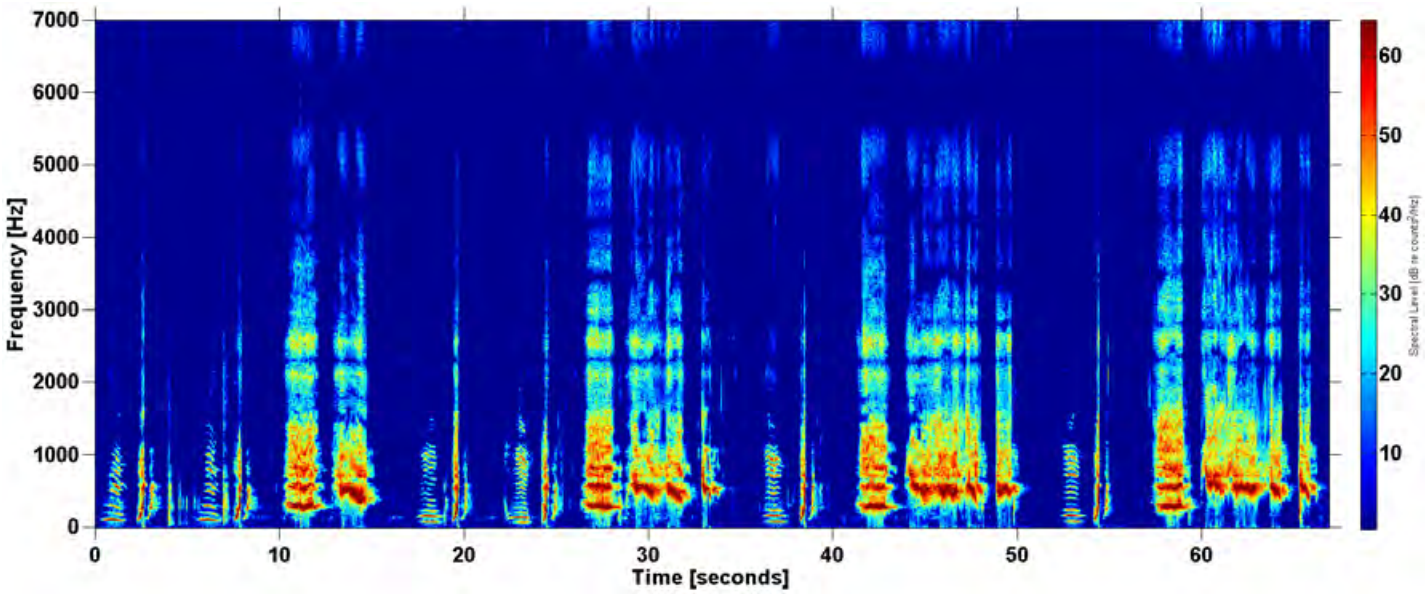
Scientists know that it is the male humpback whales that sing. For years, one theory has been that they sing to attract females. Further research has established another theory, that these songs are male-to-male communication, perhaps to show dominance or their fitness as a suitor for females over other males. The whales sing mainly during the breeding season. All share a similar song structure, although there are subtle changes that occur over the season. Cultural transmission of sound type has been heard among males, where they join each other for short periods and sing, then alter their future song slightly. Researchers have observed that east coast humpback males near Australia adopted the song of western Australian humpbacks, exactly matching their song in just a two-year period.

Sound in the ocean comes from a variety of sources including human use and industries such as geophysical research, oil and gas exploration, low-frequency naval sonar, large container ships, and other ships of all sizes

including personal watercraft. The impact to whales is still under study. We are increasing our use of the ocean, from extraction of its natural resources to the continued expansion of busy shipping traffic. The underwater noise from those activities contributes to the overall sound pollution heard in the ocean and potentially changes the ability of whales to thrive.

TO DO

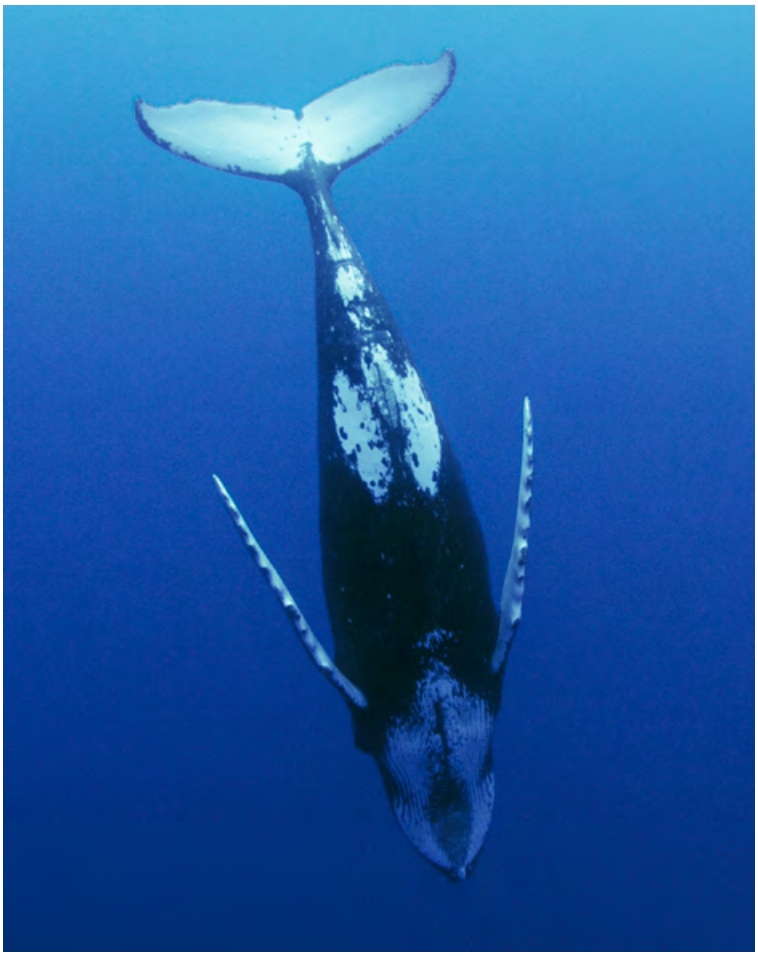
1. Display or have students enter the *Voices in the Sea* website (www.voicesinthesea.org) and locate the *Humpback Whale* page previously noted.
2. Explain that you will hear three distinct vocalizations made by humpback whales and observe these sounds in a spectrogram.
3. Play all three calls and ask students to pay attention to the bar that glides left to right as the sounds play through the spectrogram image. This allows students to "see" the sound since the lines are brighter with sound strength and the higher frequency sounds are above the lower frequency sounds.
4. From the *Voices in the Sea* website and *Humpback Whale* page noted above, play the video *Why Do Humpback Whales Sing?* narrated by Dr. Jim Darling who appears in the film.
5. Once students have heard theories about why whales sing, they will learn more about sound in the sea and what is represented in spectrograms. To better understand frequency and the movement of sound traveling in a wave pattern, students will use tuning forks.
6. Give each student group two tuning forks making sure there are two different pitches of tuning forks and two cups of water, preferably contained in clear plastic.
7. Instruct students to hold the tuning fork by the slender base and gently tap the prong portion on the side of the table and insert the prong in the cup of water.
8. Repeat for each tuning fork.
9. Ask students to make observations of the water movement. They will observe disturbance on the surface of the water through splashes, ripples and waves. This is one way to observe how sound travels. They will also see that tuning forks have different frequencies by observing the various levels of disturbance of water. These frequencies sound different, as either high or low sounds, and contribute to the complexity of humpback whale songs.
10. Instruct students that they will be creating their own original song in their small group based on the basics of humpback whale song structures and typical musical song structures.
11. Play the video *Songs of the Humpback Whale* from the *Voices in the Sea* website noted above for students.
12. Discuss as a class the typical music we hear on the radio: songs last only a couple of minutes, there is a repeating chorus, there are stories told in a song, and usually there are two to three verses.
13. In a humpback whale song we hear: songs that last 15 minutes or more sung continuously without interruption from breathing, with 2 to 9 themes in each song, and with each theme repeating 15 to 20 times! Often humpback whales will have song sessions that last for hours.



Researchers use spectrograms to analyze the sounds and songs of humpback whales. This spectrogram shows a 67-second segment of a humpback song recorded in Tonga. One can see that the repeated phrases evolve as the song progresses from one theme to another.

On the breeding grounds, as many as 30 to 40 males can often be seen chasing a single female for reasons that still remain unclear to scientists.

14 Instruct students to each have a piece of paper, to help them sketch their song they will "sing" as a group. They do not have to sing, but they can as a group repeat sentences. Each group of students will perform their song at the same time. This illustrates how all the whales are singing at the same time during the breeding season. Male humpback whales often sing the same songs while creating small, temporary groups.



Although all humpbacks make sounds to communicate, only males sing. Head down and motionless, males sing for hours at a time, emitting complex songs that can last up to 20 minutes.

15 Ask each group to create two verses (sentences) and one chorus (one sentence to repeat twice). When ready, have all the groups "sing" their songs at the same time.

16 Next, pick one student from each group and have them switch with someone in another group.

17 Have students repeat their songs again; the new student added to the group must now sing this new song version. This illustrates how male humpback whales move among each other, learning new songs to stay competitive. You could do another round and have that same group learn the new song from the new singer joining them.

17 Finally, ask students to sing in their separate groups and have each play another previously recorded "song" from a device. They can also try to sing their song while random noise (from car engines or loud fans or machinery) is played close to them.

18 Engage in a classroom discussion

- What is the advantage of males moving among other competitors? Disadvantage?
- Did the sound played in step 17 have an impact on your group and your ability to sing together? If so, how? What is sound pollution? What are sources of sound in the sea? Answers can be ships, sonar, oil and gas exploration air guns. Can this impact whales? How?
- To further discuss man-made sound in the ocean and impacts on marine mammals, go to *Voices in the Sea* website home page, select *Videos*; then *Conservation Efforts*, then *Beaked Whales* and watch this summary video narrated by Dr. John Hildebrand.

LESSON **2**

Migration Match

OBJECTIVE

Students will practice being scientists responsible for identifying individual whales by matching photos of whale flukes. They will track and map the migration patterns of whales while calculating distances covered and discuss threats whales face during migration.

LESSON LENGTH

45 minutes

IN THE FILM

In the film, we see footage of humpback whales in different geographic regions and learn there are 15 separate global populations. We witness humpback whales traveling far distances to breed in one region and feed in another, as seen in the North Pacific population of humpback whales that spend the winter in the Hawaiian Islands and summer in regions mostly off Alaska. All whales generally breed in warmer waters near the equator and feed in colder regions. We also see the large ships and numerous small private vessels that whales encounter during migration and in their seasonal habitats.

MATERIALS

- ☐ Copies of Migration Match Fluke Cards and the Migration Map worksheet
- ☐ Ruler for measuring during mapping activity
- ☐ Globe or world map (optional) for students to refer to during migration measuring exercise
- ☐ Paper for notes
- ☐ Pen or pencils

TEACHER PREP NOTES

For each group of five students, make one copy of the Migration Match Fluke Cards. Cut out each square to make a pack of "cards" and bind together for storing. Each student needs a copy of the Migration Map to complete the lesson.

BACKGROUND

Having a complete understanding of an animal's requirements for survival is critical to ensure the long-term survival of a species. Scientists want to know about individual whales in order to monitor their behavior and life cycle. Tracking individual animals in the ocean is difficult due to time spent underwater by the animals, their movement, ocean conditions, and not having consistent access to the areas where the animals might be. Technology has enabled researchers to attach satellite-monitored tags to whales to track their movements across oceans, and small DNA samples can be used to identify individual animals. However, the most long-standing methods for identifying (and tracking) humpback whales is through photo-identification.

Humpback whales have specific patterns of markings on their bodies and tail flukes. These distinguishing characteristics are coloration, variations of white, gray or black, nicks, notches, scars and sometimes barnacle patterns. These patterns are genetically determined, and populations in different regions can share similar body coloration. For example, humpback whales in the Southern Hemisphere have a large proportion of white on their bodies. By photo–graphing, cataloging, and tracking individuals we can learn about life span, population numbers, mating, birthing, and migration patterns. Humpbacks are found in populations around the world and spend summer months feeding in cold, nutrient-rich water and winter months in tropical, warm water to mate and give birth. These migration routes can be up to 5,000 miles one-way in distance with whales utilizing the same feeding and breeding grounds year after year.

The migratory routes of humpback whales have distinct overlap with global shipping lanes. Collecting exact data on the number of ship strikes on whales is difficult since deceased whales often sink to the ocean floor. There is growing observation of scars on whales from boat strikes and reports of deceased whales, floating or beached, with evidence of ship strikes. Humpback whales often inhabit coastal areas, making them especially susceptible to being struck by vessels.

KEY WORDS

Population—The number of individuals in a specific species in a single area.

Fluke—The end tip of a whale tail made up of two lobe structures. While the thick tail peduncle contains bones, the fluke does not.

Migration—The movement from one geographic location to another. Animal migrations are often seasonal.

Shipping Lanes—A route used by commercial ships on a regular basis.

TO DO

1. Have a classroom discussion about humpback whales, leading with questions: Do whales stay in one region of the ocean year round? Why or why not? Why would it be important to know why animals move between locations? Why do researchers want to keep track of individual whales? How do you think they do this? Do all humpback whales look alike? Why or why not?
2. Instruct students they will be working in a small group of five students. The first activity challenges them to match whale flukes, just like scientists. The whale fluke photos are from film scientist Fred Sharpe's archives. Two of the whales, Vulture and Melancholy, actually appear in the film.
3. Each student will receive a fluke card with the name of a whale on it. Names are: Captain Hook, Vulture, Melancholy, Arpeggio and Viking Petal. Give the group the remaining 12 cards from the set. Each student's fluke will match two other images in the set. (There are also two cards in the set that don't match anything.) The flukes on these cards were photographed from different angles and time periods, and some are in black and white, so identifying individual whales may not be as easy as it first seems. To aid students, explain the distinguishing characteristics of humpback whale flukes, highlighting shape, coloration and scratch pattern.
4. In each group, lay all twelve cards out, image side up. Students can take turns choosing which fluke image matches their named whale, one card per round. Students can help each other, if necessary. An answer key is found on the first card in the card deck.
5. For the second activity, ask students to locate Alaska and Hawaii on the Migration Map. A line is already drawn between these two locations, with "3,000 miles in 36 days" noted on the map. This is the time it took one whale to travel this distance—the fastest on record.
6. Ask students to calculate how many miles per day the whales in Alaska must travel to reach Hawaii in 36 days. (Answer: 83.3 miles per day)

ALISA SCHULMAN-JANIGER

As humpbacks migrate from their winter breeding grounds to their summer feeding grounds, they are at risk of being hit by commercial ships. This humpback bears the scars of an encounter with a ship propeller.

7. Note the other whale migrations on the map (around the globe), with lines already drawn.
8. Have students take a ruler and measure the distance between the two migration points on the map (Or use a globe to measure the distance for even greater accuracy.) Students will then take the ruler and lay it against the distance chart on the map to measure the miles between the various sites and record it on the Migration Map.
9. Students will then calculate the distance whale populations travel one way and then round-trip for each migration. Mark each figure on a piece of paper. Now knowing that a humpback whale can travel 83.3 miles per day (from step 6), ask students to calculate how long it takes other populations to reach their destination one-way?
10. Discuss as a class: what are the threats whales might face during migration?
11. Refer students back to the Migration Map and have them locate the shapes found on the maps (triangles, circles, etc). Have them draw a line between the same colored shapes. (For example, draw a line between the two triangles, between the two circles, etc.) These shapes represent the major ports around the globe where large container ships transport goods to support global trade. Ask students: What do they notice about the routes both the whales and the ships take? Are there any risks ships pose to the whales? Show students photos of humpback whales with scars from ship propellers.
12. Discuss how ship strikes are a continuing threat to many species of whales. Agencies across the U.S. are looking at changing the lanes of shipping vessels to avoid areas frequented by whales and introducing speed restrictions. In 2013, the ports of Los Angeles and San Francisco made changes to their shipping lanes in an effort to reduce ship strikes on whales.

TAKING IT FURTHER

1. For older students: Have students do group or independent research on the port regions across the globe addressing the issues of whales and ship strikes. Students can choose geographic locations for their research and report their findings to the class as ongoing updates and as events happen.
2. For younger students: Have students record the distances various humpback whale populations travel during their annual migration. Ask students to keep a log for one week of their own "migration." Using their family's car odometer, personal pedometer, or smart device app, they can track the distances they travel by car, foot, and public transportation. How does their migration compare to a humpback whale?

MIGRATION MATCH

Fluke Cards

Migration Match Key: Unmatched: F, J; Viking Petal: O, B; Vulture: K, N; Arpeggio: A, G; Captain Hook: M, P; Melancholy: I, D

Photos courtesy Fred Sharpe, Ph.D., Alaska Whale Foundation
NMFS Research Permit No. 14599

L
Arpeggio

A

G

C
Captain Hook

M

P

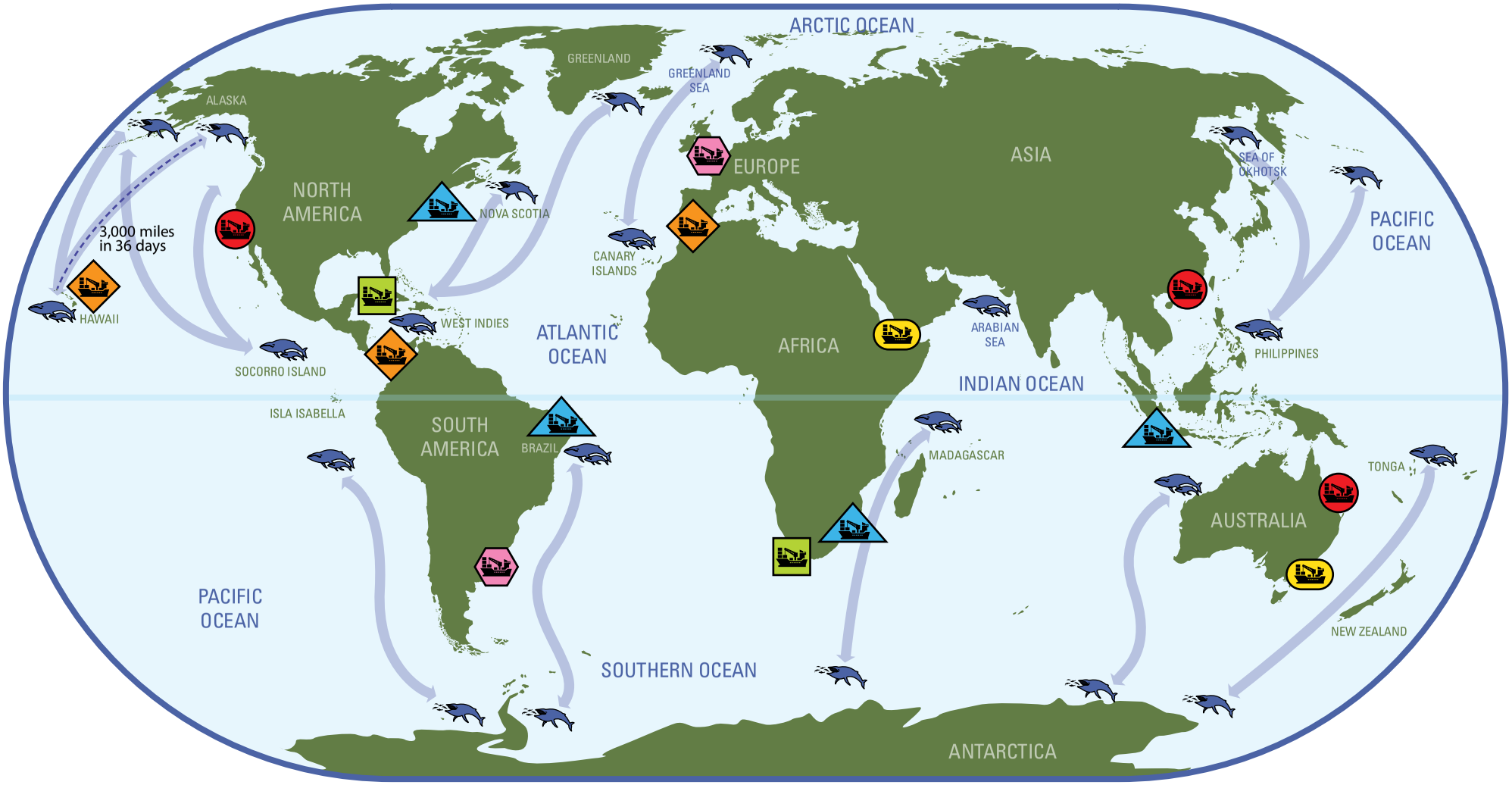
Q
Melancholy

I

D

MIGRATION MAP

WORKSHEET



MILES 1,000 2,000 3,000 4,000 5,000 6,000

HUMPBACK BREEDING SITE

HUMPBACK MIGRATION ROUTE

HUMPBACK FEEDING SITE

MAJOR SHIPPING PORT

LESSON **3**

Anatomy and Adaptation

OBJECTIVE

Students will observe anatomy form and function and how it relates to an animal surviving in their habitat. They will craft their own species of plankton to observe adaptations of marine organisms. Students will practice a variety of hands-on experiments to discover feeding strategies of various marine mammals, including the unique behavior seen in humpback whales called group bubble net feeding. In addition, they will observe adaptations humpback whales possess to thrive in the ocean in a variety of temperatures.

KEY WORDS

Adaptation—A mutation or genetic change that helps an organism, such as a plant or animal, survive in its environment. As it is passed down through generations it becomes a part of a species.

Blubber—A thick layer of fat just under the skin of marine mammals that provides insulation, stores energy, and provides buoyancy.

Buoyancy—The ability of an object to float in liquid or in air.

Baleen—Bristles made of keratin, which is the same material that makes human hair and fingernails, hang from the upper jaw of baleen whales. They use the baleen plates to filter small fish and plankton from large quantities of water taken into their mouths during feeding.

Plankton—Aquatic organisms living in both marine and freshwater environments whose movements are determined by the currents. Though most plankton species are microscopic, they also include such drifting organisms as krill (zooplankaton), a mainstay of the humpback diet, and jellyfish.

LESSON LENGTH

60 minutes (3 activities)

IN THE FILM

In the film we see the majestic humpback whales excelling in the ocean environment. We see groups of whales cooperatively feeding, creating elaborate nets of bubbles as a team to herd their prey. We see their ability to leap out of the air in acrobatic breaches, and observe how they can make a statement to other whales through "pec" slaps (pectoral flipper slaps) and tail slaps. In the film humpback whales are shown swimming across ocean basins to feed in one area near the poles and breed in another region closer to the equator.

MATERIALS

- ☐ Visit the *Humpback Whales* film website to watch the *Humpback Whales Bubble Net Feeding* video (www.humpbackwhalesfilm.com/education/bubblenetting). Project on screen or students can watch the video on individual devices.

Each student group will need:

Plankton Activity:

- ☐ Two graduated cylinders filled to top measurement with water
- ☐ Sculpey Clay (each student is given a nickel-size ball to act as plankton body)
- ☐ Toothpicks, pipe cleaners, and feathers to act as plankton appendages and cut into very small pieces in order to fit plankton into the graduated cylinder
- ☐ Stopwatch or timing device
- ☐ Video of plankton (see links below in activity "To Do")

Marine Mammal Warmth and Buoyancy Activity:

- ☐ One large bowl
- ☐ Two Ziploc bags
- ☐ 1 - 2 cups of Crisco or other cooking shortening
- ☐ One thick sock and one thin sock

Lunch With a Whale Activity:

- ☐ Dried parsley flakes (6 tablespoons)
- ☐ One large bowl
- ☐ Tablespoon measuring spoon
- ☐ Measuring cup
- ☐ Two paper towels
- ☐ One large hair comb
- ☐ Four straws

TEACHER PREP NOTES

This lesson has three activities that focus on exploring adaptations by marine organisms.

The **Plankton Activity** explores buoyancy and an ocean organism's use of appendages. Many species of plankton are in the upper water column since they either photosynthesize or feed upon photosynthetic organisms. Without large muscular bodies plankton rely on structures such as cilia and flagella to stay afloat.

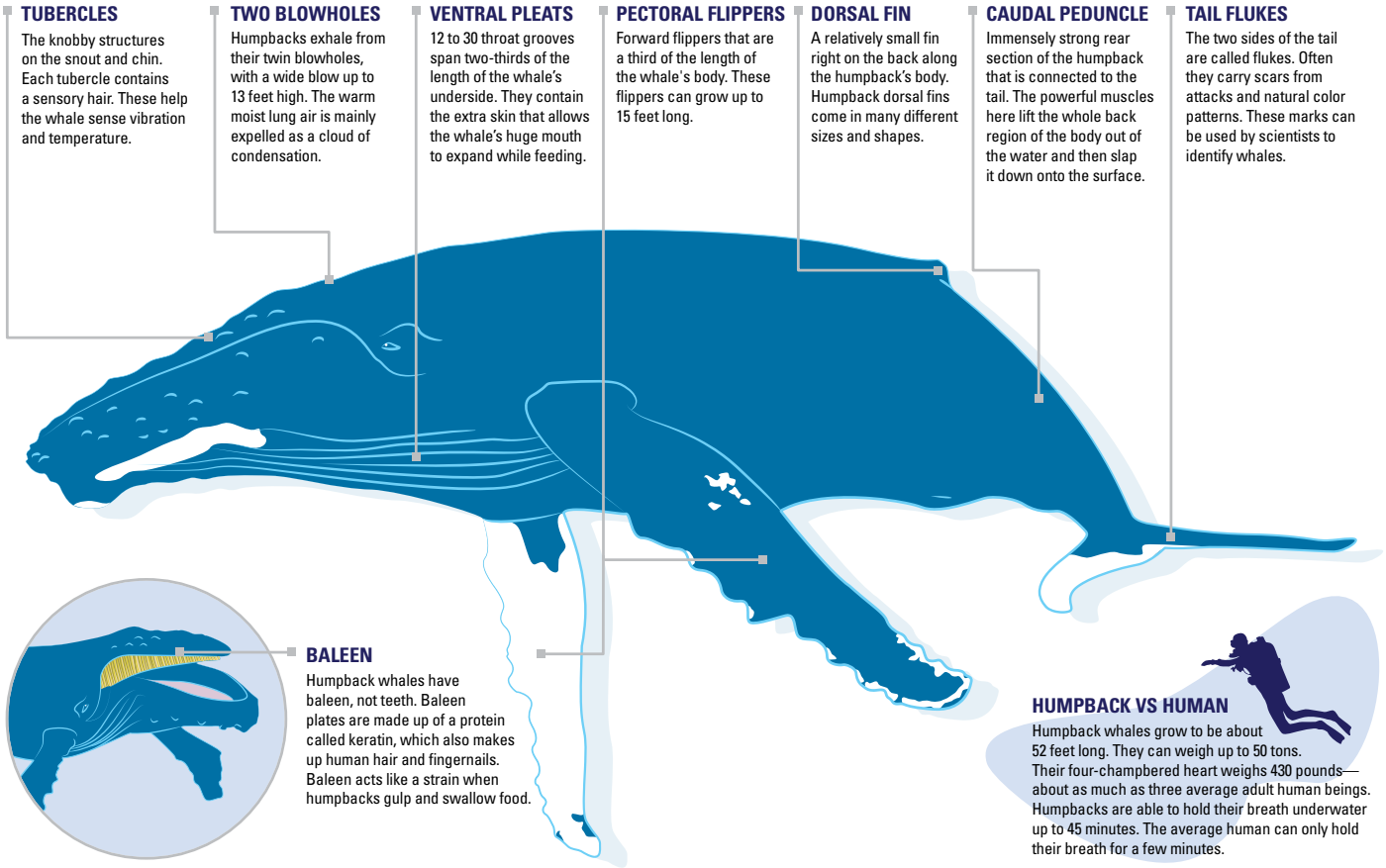
The **Marine Mammal Warmth and Buoyancy** activity looks at the function of blubber and fur in providing warmth for marine mammals.

The **Lunch With a Whale** activity explores humpback whale feeding strategies using their baleen, either lunge feeding as individuals or cooperatively herding fish as a group, called bubble net feeding.

BACKGROUND

Humpback whales are mammals, like humans. They possess the five characteristics shared by all mammals: warm-blooded, vertebrates, air breathing, hair or fur at

Humpback Whale Anatomy



some point in their life, and live birth (although the two exceptions to giving live birth are the platypus and echidna). Being a warm-blooded animal in cool ocean water requires special adaptations to maintain body heat. Marine mammals employ several types of features such as thick skin, a thick blubber layer and dense fur. In order to remain buoyant and able to breathe air regularly near the surface, whales have strong tails, large tail flukes, and in the case of humpback whales, long flippers, all of which make them agile swimmers. In addition, a layer of blubber aids in floatation and helps whales conserve energy and warmth. Humpback whales travel to cold, nutrient-rich water near the poles to feed on krill, herring, and other small schooling fish. Krill (small shrimp-like zooplankton) is a common food item for humpback whales in the Southern Hemisphere. The whales' baleen plates are large sieves capable of capturing thousands of pounds per day by filtering ocean water.

TO DO

Plankton Activity:

1. Ask students if they can define and describe plankton. Follow with video of plankton from the Ted-Ed lesson *The Secret Life of Plankton.* (www.ted.com/talks/the_secret_life_of_plankton#) The video is six minutes long and can also be found on the Ted-Ed You Tube page (www.youtube.com/watch?v=xFQ_fO2D7f0).
2. Have students construct plankton using a small ball of Sculpey Clay as the plankton's body. Pipe cleaners, feathers, and toothpicks will act as the appendages that help plankton move and stay buoyant.
3. When ready to test their plankton, have students drop their plankton in the graduated cylinder at the same time and observe. Which plankton floats closest to the surface and stays there for the longest time?
4. Have students discuss their observations and how they can modify their plankton to increase buoyancy.
5. Modify and repeat.
6. Discuss how marine mammals move and stay buoyant. (They have fins, flippers for swimming and blubber to help them stay afloat). Ask students to compare how whales move to the way plankton move. If whales were the size of most small plankton, would they look the same? What if plankton were the size of a whale?

In this animated recreation from the giant-screen film, humpbacks use bubbles and sounds to herd a school of herring, then lunge upwards to capture the trapped fish.

Marine Mammal Warmth and Buoyancy Activity:

1. To observe blubber, students will be making their own insulation glove. Have students place shortening in one Ziploc bag and spread it along the sides and bottom. To minimize mess in assembly students can use the second plastic bag as a glove. (Option: make several gloves ahead of time. Use duct tape to secure two Ziploc bags with Crisco in between. Students can share these gloves.)
2. Fill one of the large bowls with ice and water to mimic the ocean temperature in polar regions.
3. Students will take turns putting their hand in the clean and empty Ziploc bag, then in the blubber glove, and into the ice water.
4. Have them take turns placing their hand, now wearing the glove, in the cold water making sure they leave the top of the bag out of the water so no water leaks in.
5. When they have their gloved hand in the water, ask students to place the other hand in the water as well. Lead a discussion: What do you notice? Which hand is warmer? Not all marine mammals have skin and blubber like whales do. What other types of marine mammals are there? (Seals, sea lions, sea otters, the polar bear). What do they have to help stay warm? (fur)
6. To feel the difference between blubber and fur for warmth, have students take turns putting the sock on one hand and blubber glove on the other as well as alternating with a bare hand. Try different thicknesses of socks so they can see how fur thickness plays a role in marine mammals' ability to stay warm.

Lunch With a Whale Activity:

1. Take one large bowl and fill it with water. Sprinkle two tablespoons of parsley flakes on top. This represents krill in the ocean.
2. Ask students to scoop up parsley with the measuring cup and pour through the comb, so parsley gets stuck in the prongs of the comb. This is an example of gulping and filtering small prey such as krill and herring in the baleen bristles of humpback whales.
3. Wipe off parsley on to paper towel.
4. Students will now add more parsley to the bowl and use the straws.
5. Instruct students to work as a group, using straws, to gently blow into water to push parsley toward the center of the bowl.
6. Once most of the parsley is in the center of the bowl they can use the measuring cup to scoop up the parsley and filter it over the comb. Wipe the parsley on the other paper towel.
7. Ask students which method collected more parsley? Was there a difference? What did the two different strategies represent? Visit the *Humpback Whales* film website to watch the *Humpback Whales Bubble Net Feeding* video (www.humpbackwhalesfilm.com/education/bubblenetting) and discuss the behavior of the whales.

LESSON **4**

Bioaccumulation: It All Adds Up

OBJECTIVE

In this lesson students will create a representation of how energy flows and cycles through a food web containing a humpback whale. Using magnets of various sizes they will swim and feed through an ocean food chain and after each feeding session count the quantity of toxins attached to their predator (large magnet). By recording these numbers they will see the numeric accumulation of toxins, representing bioaccumulation.

LESSON LENGTH

60 minutes

IN THE FILM

In the film we hear how the future of humpback whales in the Southern Ocean depends on the health of the Antarctic ecosystem. We learn that having a healthy whale calf population now is what makes possible a healthy and abundant whale population in the future. One concern is how the abundance of toxins in the food chain can negatively impact the health of whales as well as humans who consume seafood.

MATERIALS

Each student group will need:

- ☐ One large bowl or baking pan with sides to hold a box of BBs
- ☐ One small bowl to hold large magnets
- ☐ Each student (or each pair of students) needs one large magnet
- ☐ Steel BBs that are coated with copper or brass to prevent rust. These will act as the lower trophic level organisms (such as bait fish) in the activity.
- ☐ Internet availability and projector to view websites, or individual student devices
- ☐ A copy of the Food Pyramid and Bioaccumulation worksheet and the Ocean Food Web worksheet (optional).

TEACHER PREP NOTES

Students will learn the concept of food chains and the linear relationship and order of who eats whom in the ocean. They will also learn the concept of bioaccumulation in that it takes thousands of plankton to create a small fish and then hundreds of thousands of small fish to create an adult humpback whale. Each student group needs one medium-to-large (2 to 3- inch) magnet to represent a consumer. The BBs represent the toxins in the ocean that are absorbed by producers or ingested by consumers. (Online retailers sell small cartons of BBs and various sizes of magnets.) It is recommended to complete *Lesson 3: Anatomy and Adaptation* before this lesson as there is an in-depth introduction to plankton as the base of the food web.

KEY WORDS

Food Chain—A group of organisms linked in order by the food they eat, from producers to consumers and decomposers.

Food Web—A food web consists of all the food chains in a single ecosystem.

Producer—Organisms that make their own food and do not depend on any other organism for nutrition. In the ocean these are single-celled plant-like plankton (phytoplankton) and algae.

Consumer—An organism that eats another organism, with the food choice being plant or animal.

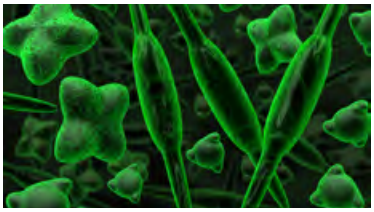
Decomposer—An organism that breaks down dead plant and animal material, releasing the minerals and nutrients from organic material and recycling them back into the food web.

Bioaccumulation—A process by which chemicals are taken up by an organism either directly from exposure to a contaminated medium or by consumption of food containing the chemical.

BACKGROUND

Bioaccumulation of toxic chemicals in ocean life comes from humans introducing chemicals through runoff pollution directly from land into the ocean or rivers. Once in the food chain, toxicity increases as energy moves up the food chain. If a medium size fish eats 10 small fish, then toxins in the medium fish can accumulate 10 times. Some of the most harmful toxins to humans and ocean animals such as whales include mercury, pesticides, and persistent organic pollutants (POPs). POPs stay in the environment for decades and in humans have been linked to impaired immune systems and developmental problems in young children. In the activity below students will write their data in an upside down triangle, which is the opposite of how we usually see food pyramids. Instead, this version shows the accumulation of toxins in the top predator. This activity also begins with a discussion of food chains and the roles organisms play in the food web. Consumers are organisms that eat primary producers and can be arranged in levels based on their prey choice. Primary consumers feed on producers, secondary consumers feed on the primary consumers, and tertiary consumers feed on secondary consumers. Examples include:

- **primary producer**—organisms, like plants, that produce food. Examples: phytoplankton, algae
- **primary consumer**—an animal that eats primary producers. Examples: krill, small fish, mussels



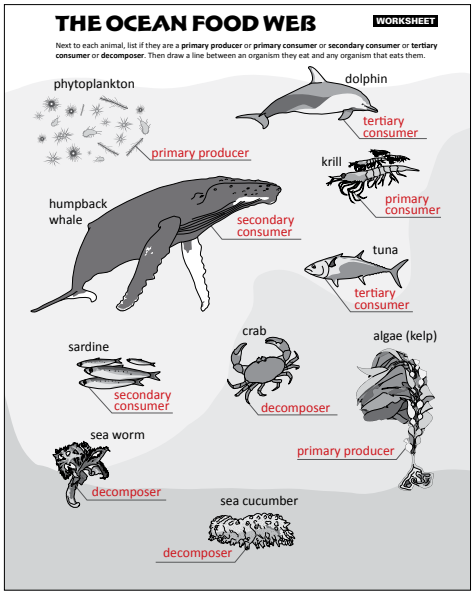
Microscopic organisms called phytoplankton (left) and zooplankton (right) form the base of several aquatic food webs. They provide food for many different sea creatures.

- **secondary consumer**—an animal that eats primary consumers. Examples: humpback whale, sardines
- **tertiary consumer**—an animal that eats secondary consumers. Examples: shark, dolphin, tuna
- **decomposer**—organisms that break down dead plant and animal material and wastes and release it again as energy and nutrients in the ecosystem. Examples: bacteria, sea cucumbers, worms, crabs

TO DO

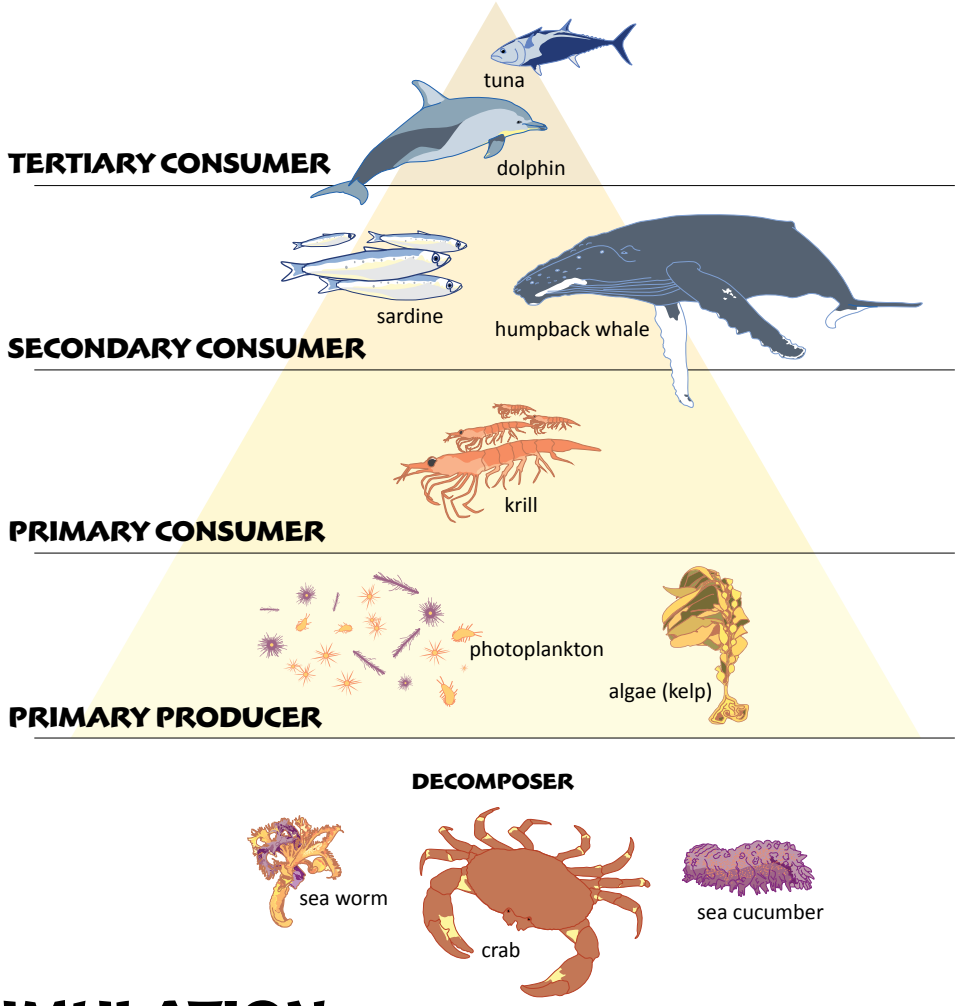
1. Lead discussion on food chains and write student examples on the board (it can be terrestrial if that is most familiar to students). Ask students to give examples of "who eats whom" starting with plants and moving up to the final consumer.
2. Ask students to give the same examples of food chains found in the ocean. Review the Food Pyramid and Bioaccumulation worksheet for examples of primary producers, primary consumers, etc.
3. (Optional) Hand out the Ocean Food Web worksheet and ask students to complete it.
4. Instruct students to take one large magnet (a krill) and swim through the water with the BBs (the ocean where they feed on plankton).
   - Count the number of BBs attached to the large magnet. These represent the number of plankton and the number of toxins ingested.Write the number on the bottom (point) section of the pyramid on the Food Pyramid and Bioaccumulation worksheet. (1 swim through ocean = 1 krill eating phytoplankton).
5. Repeat using the steps below:
   - Swim the magnet through the BBs 3 times and record the number of attached BBs in the middle section of the pyramid. (3 swims through the ocean = 1 small fish eating lots of krill)
   - Swim the magnet through the BBs 5 times and record the number of attached BBs in the top of the pyramid. (5 swims through the ocean = humpback whale eating thousands of small fish or krill)
6. Lead the discussion asking: How many fish do you think humpback whales eat a day during the feeding season? Several hundred? Several thousand? (Whales can eat up to 2,000 pounds of food a day). How about the fish eating plankton? How many a day?
7. Instruct students to take the numbers in the pyramid and multiple by 100 as an estimate of daily minimum feeding requirements.
8. Discuss: What are examples of toxins? Where do they come from? How do they get in the ocean? Which animals have the highest number? The pyramid shows the quantity of plankton it takes to feed the top predator and others on the food pyramid. It also shows the amount of toxins that are now in the body of each animal, showing the concept of bioaccumulation. Why did we draw an upside down pyramid? (to show the amount of toxins that accumulate in the top predator). What impact might this have on humpback whales' health? To the health of calves born to mother whales feeding on fish with higher toxins? Who else eats fish? Is there the potential for this to impact humans that eat seafood?
9. Go to the *One World One Ocean.com* website and locate the *Sustainable Seafood: Why It's Good for Your Health* infographic. (Go to *Media*, then *Infographics*) (www.oneworldoneocean.com/blog/entry/seafood_and_your_health_infographic)
10. Project the image on the board and discuss as a conclusion to the activity:
    - What toxins are harmful to humans?
    - In what seafood choices are those toxins found?
    - What are the better choices of seafood to make for your own health?
11. To view and discuss impacts of toxins and diseases on marine mammals, visit the website home page for *Voices in the Sea* and select the videos section *Issues in Focus* and watch the short video titled *Unusual Mortality Events* (cetus.ucsd.edu/voicesinthesea_org/index.html).

ANSWER KEY:



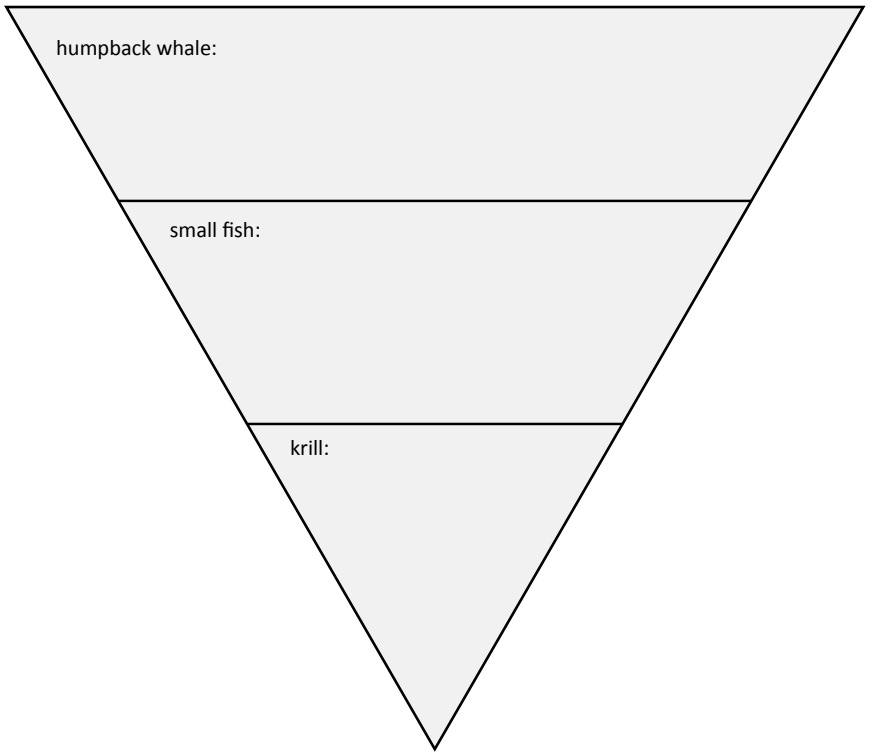
FOOD PYRAMID

WORKSHEET



DECOMPOSER

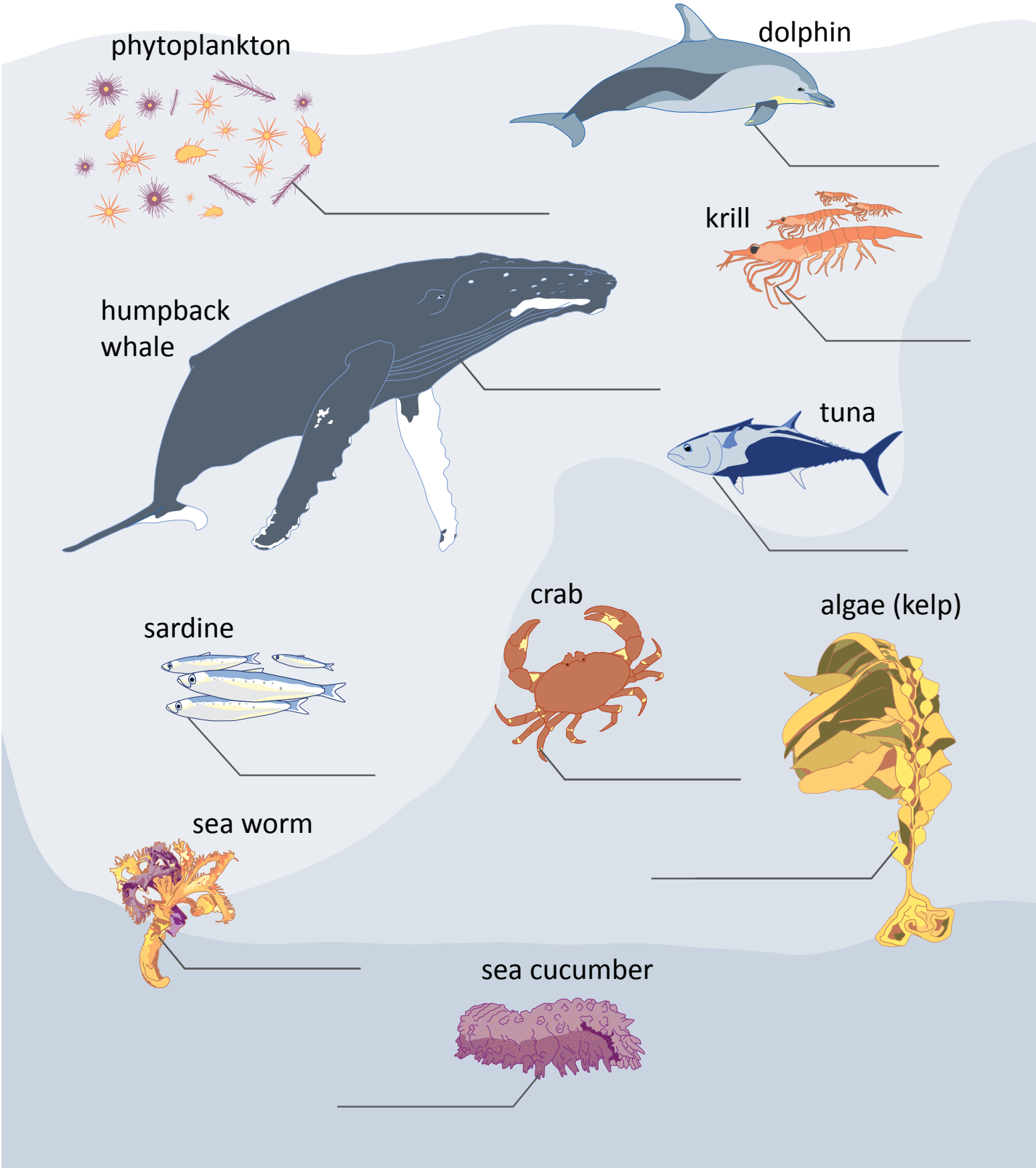
BIOACCUMULATION



THE OCEAN FOOD WEB

WORKSHEET

Next to each animal, list if they are a primary producer or primary consumer or secondary consumer or tertiary consumer or decomposer. Then draw a line between an organism they eat and any organism that eats them.



LESSON **5**

"Whale Safe" Engineering Challenge

OBJECTIVE

This lesson will present a design challenge to students to solve in teams in order to create ideas, strategies and equipment that can lessen the impact of fishing gear and the entanglement of whales.

LESSON LENGTH

45 minutes

IN THE FILM

The National Oceanic and Atmospheric Association (NOAA) along with their partners have created a program to respond to entangled and distressed whales. This network of highly trained individuals can be found in several U.S. states. In the film we join the response team in the Hawaiian Islands as they work to free an entangled humpback whale.

MATERIALS

- ☐ On the *Voices in the Sea* website (www.voicesinthesea.org), select *Videos* in the top menu bar, then *Issues in Focus,* then *Whale Entanglement.* View the *Entanglement* video, either projected for the entire group, or individual students can use internet capable devices.
- ☐ Another option to view is on the NOAA fisheries website, *How to Disentangle a Tangled Up Whale*, a 9-minute podcast showing a real whale rescue in Hawaii. (www.fisheries.noaa.gov/podcasts/2014/ 03/ disentanglement_whale.html#.U_O0Kyj_SI4)
- ☐ The International Smart Gear Competition page on the World Wildlife Fund website. (www.worldwildlife.org/initiatives/international-smart-gear-competition)
- ☐ Each student group needs a copy of the Whale Entanglement Threats handout.
- ☐ Photos of whales entangled in rope and nets and different kinds of commercial fishing gear and crab pots.
  - A resource for photos and videos is the *International Whaling Commission* website and the *Entanglement of Large Whales* gallery page. (www.iwc.int/entanglement-gallery) (Note: There are several images on this page that take time to load, however most of the images you will need are at the top of the page and load first.)
  - A resource for discussing marine debris and "ghost nets" is a website called *The Ghost Below*, an outreach partnership between artists and The Marine Mammal Center (www.theghostbelow.org and www.marinemammalcenter.org/)
- ☐ Paper
- ☐ Pens and pencils

TEACHER PREP NOTES

This lesson has multiple websites for students to access or view as a group, so preloading the websites and videos onto computers and/or devices would save time. Make a copy of the Whale Entanglement Threats handout for each student to refer to during the group design challenge.

BACKGROUND

Humpback whales are a global population. They swim throughout ocean basins as they migrate between feeding and breeding grounds. They also spend time near coastlines, giving birth in shallower waters or feeding in productive waters offshore. Due to the vast travel and time spent near shore, they have a high interaction with commercial fishing activities. For the humpbacks that live in the North Pacific, it's estimated that 50% of whales have been entangled at some point in their lives based on the observations of scar patterns on their bodies.

When humpback whales become entangled in large fishing nets or long ropes from crab fishing gear, it can lead to death. The weight of the gear can cause whales to struggle to stay at the surface to breath and can prevent them from diving to feed. If a calf becomes entangled, it may be unable to swim alongside or nurse from its mother. Entanglement is one of the main human-caused deaths to humpbacks. Every year hundreds of thousands of whales, dolphins, seals and sea lions die from entanglement. What entangles marine mammals is diverse, ranging from various plastics, discarded fishing gear such as monofilament line used by recreational and commercial fishermen and the large nets and ropes used in commercial fishing. Another cause of mortality is the infection from injuries caused by lines or nets cutting into the whale's flesh.

KEY WORDS

Bycatch—Animals and other organisms unintentionally caught in commercial fisheries and not kept for consumption or use. To include marine mammals in the definition, NOAA added "Discarded catch of any living marine resource, plus the unobserved mortality due to a direct encounter with fishing gear."

Derelict Fishing Gear (Ghost Nets)—Derelict fishing gear, sometimes referred to as "ghost gear" or "ghost nets," is any discarded, lost or abandoned fishing gear in the environment.

Humpbacks can become entangled in lost fishing gear and other marine debris, leading to serious injury and death.

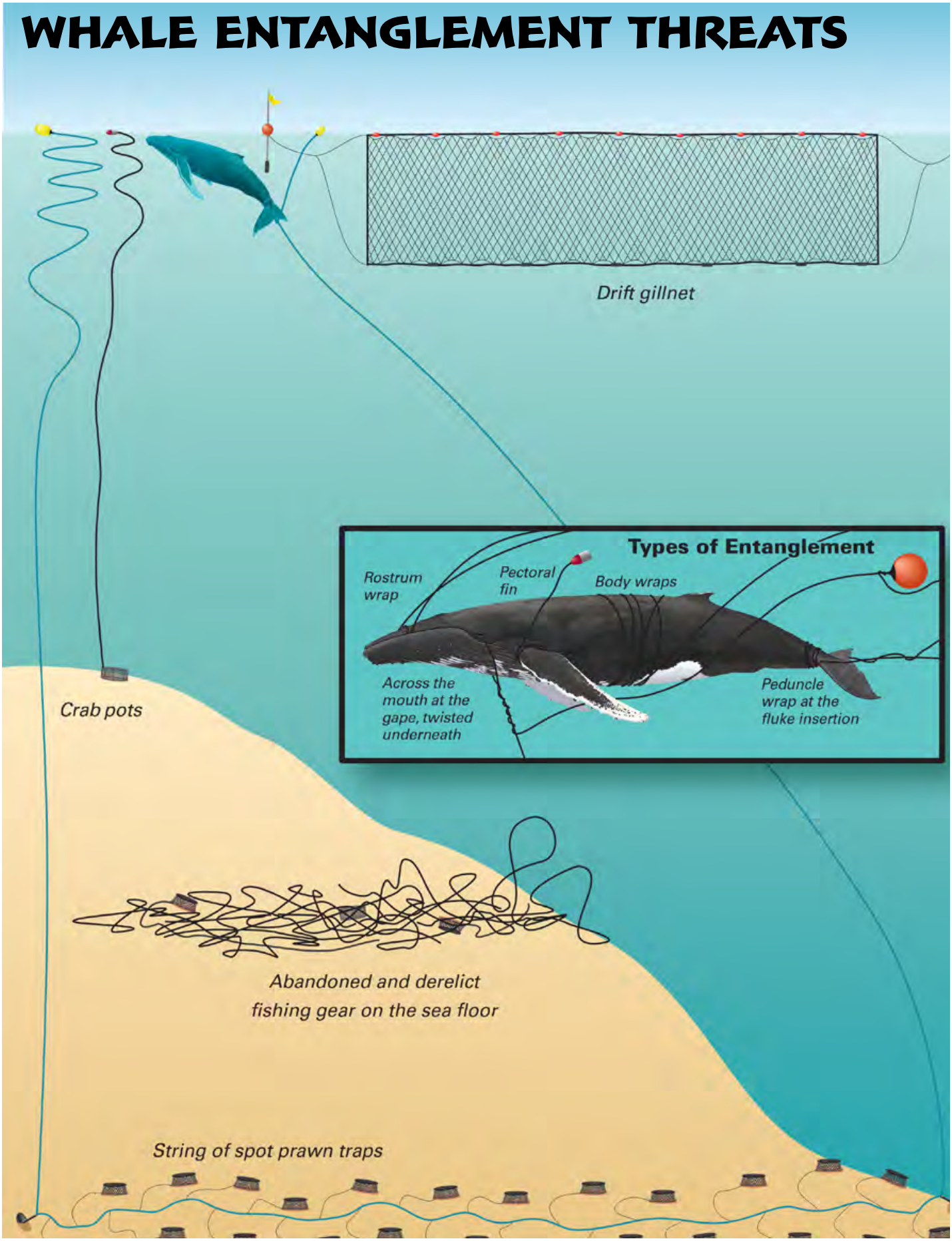
TO DO

1. Visit the website *Voices in the Sea (*www.voicesinthesea.org), and in the top menu bar select *Videos,* then *Issues in Focus* and select the *Whale Entanglement* video. Or you can view a 9-minute video on the NOAA Fisheries site, *How to Disentangle a Tangled Up Whale*, featuring Ed Lyman, a whale rescuer seen in the giant-screen film.
2. Lead a classroom discussion: What is entangling the whales? Where does it come from? Do you think the whales can free themselves? Why or why not? Why do you think it harms whales to be entangled? What can we do to help?
3. Visit the World Wildlife Fund website and the page *International Smart Gear Competition,* a worldwide incentive-based competition with the aim of reducing species bycatch by improving fishing gear. Project the website onto the board and read the *Overview*, watch and read the slideshow under *Why it Matters*. View several examples of past winners.
4. Discuss the modifications that have already been made to gear in order to reduce bycatch. Circle hooks are designed to cause less harm to the animal that swallows them (they can be pulled out versus a typical hook that is deep-hooked). Turtle Excluder Devices (TEDs) are part of trawl nets that drag along the bottom of the ocean floor to catch shrimp. When a sea turtle or other large animal hits the bars, they are sent out an opening in the net.
5. Show students photos of commercial fishing gear and of entangled humpback whales. A resource for photos and videos is the *International Whaling Commission* website under the *Entanglement of Large Whales* gallery (www.iwc.int/entanglement-gallery).
6. Pass out the Whale Entanglement Threats handout to each student group and instruct that they will be creating a paper and pen design of fishing gear that can lessen humpback whale entanglements and other bycatch.
7. Things for them to consider in regards to gear:
   - Rope and nets that have drifted off and are unable to be found by fishermen are known as "ghost nets." These nets and ropes float the world's oceans and get tangled in one another, creating even larger and heavier masses that ensnare wildlife.
   - Floating lines from gear such as crab pots come up from the seabed and can entangles whales at the surface.
   - Nets and ropes are strong and durable making it impossible for whales to break themselves free.
   - They are made of materials that are long-lived and do not decompose or break down, making them a threat for years.
8. Students will share their design and suggestions as a group to the rest of the class.

TAKING IT FURTHER:

1. Consider having students build a prototype of the device that they designed. Prototypes could be created using recycled materials.
2. Bycatch and fishing methods threaten the sustainability of numerous species of ocean wildlife. Students can do online research on sustainable seafood choices and print or download materials to share with their families on the following websites:
   - One World One Ocean campaign's *Go! Fish* initiative (www.oneworldoneocean.com/initiatives/gofish)
   - Monterey Bay Aquarium Seafood Watch (www.seafoodwatch.org/cr/seafoodwatch.aspx)

WHALE ENTANGLEMENT THREATS



LESSON **6**

Whaling to Whale Watching

OBJECTIVE

Students will watch videos on whaling, both commercial whaling and subsistence whaling. They will note the similarities and differences of these whaling practices. Students will research what has led to the extinction and current endangerment of different whale species and what steps have been taken to protect them. Students will examine and discuss their own role in species protection and how their daily lives impact the greater global conservation picture.

LESSON LENGTH

60 minutes

KEY WORDS

Commercial Whaling—The hunting of whales for consumer products (oil, meat, fat, and bone for monetary profit.

Subsistence Whaling—The hunting and collection of whales to support the nutritional and cultural life of native peoples and not-for-profit purposes.

Endangered Species—The classification provided to an animal or plant in danger of extinction within the foreseeable future throughout all or a significant portion of its range.

Extinct—A species no longer in existence.

IN THE FILM

Humans once hunted whales extensively for products. In the film we learn that due to these practices we brought humpback whales to the brink of extinction. Our evolving interactions with whales have moved toward appreciation, observation and awe. Ecotourism-based whale-watching programs and cultural traditions that respect animals, as we see in Tonga, have led to an increased understanding of whales.

MATERIALS

Several websites described below projected for the entire group. Individual students can also use internet-capable devices.

TEACHER PREP NOTES

This lesson will have several short videos to view (each around two minutes in length or less) and extensive classroom discussion. Loading the websites in advance will save time during instruction. The final portion of the lesson is a research activity where students will research a now-extinct species or a current endangered species (oceanic, aquatic or terrestrial) to find out more about the factors that lead to the population decline, what actions were taken to protect the species, and the status of closely related species. Students will share their results with the class. Through this lesson they learn the combined impacts that contribute to species decline as well as species conservation. Websites that will aid as student resources are:

- NOAA Fisheries—Species Information (www.nmfs.noaa.gov/pr/species/)
- U.S. Fish & Wildlife Service—Endangered Species (www.fws.gov/endangered/)
- World Wildlife Fund—Endangered Species Directory (www.worldwildlife.org/species/directory?direction=desc&sort=extinction_status)

BACKGROUND

In 1946, the International Whaling Commission (IWC) was created to manage whaling. Forty years later, the IWC enacted a moratorium that limited the number of whales being killed. Most countries have ceased whaling completely, while a few others have continued. Some subsistence whaling by native peoples continues as well. Because of these protections humpbacks are making a slow recovery. As of 2014, some humpback populations are being reviewed for possible removal from the endangered species list.

TO DO

1. Go to the *Voices in the Sea* website. (cetus.ucsd.edu/voicesinthesea_org/species/baleenWhales/humpback.html). (*Home Page*, then *Species*, then *Baleen Whales*, then choose *Humpbacks*).
2. Watch the short *Humpback Whale Conservation* video and have a class discussion: For what products were humpback whales being hunted? (primarily oil, and sometimes meat and bonemeal) Did whaling impact the total global numbers of humpback whales? What does it mean when a species is endangered?
3. On the *Voices in the Sea* website home page, project and watch the *Modern Whaling* and *Subsistence Hunting* videos. (*Home Page*, then *Videos*, then *Issues in Focus*, then two brief videos.)
4. Have students discuss: Does whaling still exist? Where? Why? What is the difference between scientific permit whaling (which Japan practices), commercial whaling, which Iceland and Norway still practice under the IWC's "objection" procedure, and

subsistence whaling, such as the Inupiaq practice in the United States Arctic? How are they similar? How are the whales caught in both examples of whaling (scientific permit whaling and subsistence whaling)? What needs are met by subsistence whaling? What is an endangered species?

5. Instruct students they will research a now-extinct species or a current endangered species to find out more about the factors that led to the population decline, what actions were taken to protect the species, and the status of closely related species.
6. Students will share their results with the class.
7. In conclusion, lead a discussion with students asking them to explain their role in conservation. What can we do to protect all species? Protect ecosystems?

N. DOROSHENKO/MOSCOW PROJECT

Although now protected by the International Whaling Commission's ban on commercial whaling, humpbacks, like the sperm whale above, were once hunted for their meat, blubber and bone.

Today, whale watching is a popular tourist activity in countries all over the world, with regulations varying from fairly strict to none, depending on the country. People remain fascinated by these enormous creatures whose lives are so hidden from our own.

Resources to Learn More

ALASKA WHALE FOUNDATION
alaskawhalefoundation.org

The Alaska Whale Foundation (AWF) was founded in 1996 by a team of passionate individuals who wanted to shed light on the amazing behaviors of the endangered humpback whales in Southeast Alaska. AWF continues to study humpbacks and their habitat, but with greater resources, established scientists, and ambitious graduate and undergraduate student participants.

AMERICAN CETACEAN SOCIETY
acsonline.org

The American Cetacean Society believes that the solution to threats facing cetaceans begins with education. Whales, dolphins, and porpoises (collectively known as 'cetaceans') have an exceptional ability to inspire people and serve as ambassadors for marine conservation. And yet they face more threats today than ever before—from entanglement in marine debris and fishing gear, ship strikes, noise pollution, climate change, ocean acidification, contaminants, loss of habitat and whaling.

DISCOVERY OF SOUND IN THE SEA (DOSITS)
dosits.org

The Discovery of Sound in the Sea website will introduce the science and uses of sound in the sea. There are several major sections on the site such as The Science of Sound in the Sea, People and Sound in the Sea, and Animals and Sound in the Sea. The Discovery of Sound in the Sea website has been developed by the University of Rhode Island's Graduate School of Oceanography in partnership with Marine Acoustics, Inc. of Middletown, RI.

HAWAIIAN ISLANDS HUMPBACK WHALE NATIONAL MARINE SANCTUARY
hawaiihumpbackwhale.noaa.gov/explore/humpback_whale.html

The Hawaiian Islands Humpback Whale National Marine Sanctuary was created by Congress in 1992 to protect humpback whales and their habitat in Hawaii. The sanctuary, which lies within the shallow (less than 600 feet), warm waters surrounding the main Hawaiian Islands, constitutes one of the world's most important humpback whale habitats. Through education, outreach, research and resource protection activities, the sanctuary strives to protect humpback whales and their habitat in Hawaii.

INTERNATIONAL WHALING COMMISSION
iwc.int/home

The International Whaling Commission (IWC) is the global intergovernmental body charged with the conservation of whales and the management of whaling. It was set up under the International Convention for the Regulation of Whaling signed in 1946. The Commission has a current membership of 88 governments from countries around the world. The pages on this website provide detailed information about the Commission, its meetings, decisions and its current work to conserve and manage whale populations throughout the world.

NATIONAL MARINE MAMMAL LABORATORY
afsc.noaa.gov/nmml/species/species_humpback.php

The National Marine Mammal Laboratory (NMML) conducts research on marine mammals important to the mission of the National Marine Fisheries Service (NMFS) and the National Oceanic & Atmospheric Administration (NOAA), with particular attention to issues related to marine mammals off the coasts of Alaska and the North Pacific. Research projects focus on ecology and behavior, population dynamics, life history, and status and trends.

NOAA FISHERIES
nmfs.noaa.gov/stories/2012/10/noaa_fisheries_education.html

NOAA Fisheries is responsible for the stewardship of the nation's ocean resources and their habitat. The resilience of our marine ecosystems and coastal communities depend on healthy marine species, including protected species such as whales, sea turtles, corals, and salmon. Under the Marine Mammal Protection Act and the Endangered Species Act, NOAA Fisheries works to recover protected marine species while allowing economic and recreational opportunities.

ONE WORLD ONE OCEAN CAMPAIGN
oneworldoneocean.com

MacGillivray Freeman Films, producer of the giant-screen film *Humpback Whales*, has created a multi-platform campaign that uses the power of film, television and new media to inspire, educate and connect millions of people worldwide in a common purpose: to protect and restore the health of the ocean. The goals of the campaign include: educate and inspire people to buy sustainable seafood; reduce plastic pollution in the ocean; and expand protected areas to 10% of the planet's ocean. MacGillivray Freeman Films and the One World Ocean Campaign are located in Laguna Beach, California.

THE HAWAIIAN ISLANDS DISENTANGLEMENT NETWORK
hawaiihumpbackwhale.noaa.gov/res/rescue_network.html

The network was formed in 2002 in an attempt to free endangered humpback whales and other marine animals from life-threatening entanglements and at the same time gather valuable information that will help mitigate the issue of marine debris and future entanglement. The network is part of the larger Pacific Islands Marine Mammal Response Network headed by NOAA's Pacific Islands Regional Office.

VOICES IN THE SEA
voicesinthesea.org

Voices in the Sea is an interactive multimedia exhibit and companion website created by the Pacific Life Foundation and the Whale Acoustics Lab at Scripps Institution of Oceanography that seeks to bring educational content about the natural history, acoustics, and conservation of whales to aquarium visitors, students, and the general public. The educational content is available online and includes 37 short videos featuring on-camera interviews with more than 20 leading whale scientists, resource managers and community leaders.

WHALE TRUST
whaletrust.org

Whale Trust Maui is a nonprofit organization dedicated to scientific research and public awareness of whales and their environment. Based on the Hawaiian Island of Maui, they conduct and support marine research and education programs around Maui and elsewhere throughout the Pacific Ocean.

National Academic Standards

Next Generation Science Standards

LS: Life Science
ESS: Earth and Space Science
PS: Physical Science
ETS: Engineering, Technology, and Applications of Science

Lesson 1: Seeing Songs in the Sea

Third Grade
- 3-LS1 From Molecules to Organisms: Structures and Processes (LS1.B)
- 3-LS2 Ecosystems: Interactions, Energy, and Dynamics (LS2.D)
- 3-LS3 Heredity: Inheritance and Variation of Traits (LS3.A and LS3.B)
- 3-LS4 Biological Evolution: Unity and Diversity (LS4.B and LS4.D)

Fourth Grade
- 4-LS1 From Molecules to Organisms: Structure and Processes (LS1.D)

Fifth Grade
- 5-ESS3 Earth and Human Activity (ESS3.C)

Middle School
- MS-PS4 Waves and Their Application in Technologies for Information Transfer (PS4.A)
- MS-LS1 From Molecules to Organisms: Structures and Processes (MS-LS1.B)
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS.A and MS-LS2.C)

Lesson 2: Migration Match

Third Grade
- 3-LS1 From Molecules to Organisms: Structures and Processes (LS1.B)
- 3-LS2 Ecosystems: Interactions, Energy, and Dynamics (LS2.D)
- 3-LS3 Heredity: Inheritance and Variation of Traits (LS3.A and LS3.B)
- 3-LS4 Biological Evolution: Unity and Diversity (LS2.C and LS4.B and LS4.D)

Fourth Grade
- 4-LS-1 From Molecules to Organisms: Structures and Processes (LS1.D)

Fifth Grade
- 5-PS3 Energy (LS1.C)
- 5-ESS3 Earth and Human Activity (ESS3.C)

Middle School
- MS-LS1 From Molecules to Organisms: Structures and Processes (MS-LS1.B)
- MS – LS1 Science and Engineering Practices (MS-LS1-8)
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS2.A and LS2.C)
- MS-LS3 Heredity: Inheritance and Variation of Traits (LS1.A and LS1.B)

Lesson 3: Anatomy and Adaptations

Third Grade
- 3-LS1 From Molecules to Organisms: Structures and Processes (LS1.B)
- 3-LS2 Ecosystems: Interactions, Energy, and Dynamics (LS2.D)
- 3-LS3 Heredity: Inheritance and Variation of Traits (LS3.A and LS3.B)
- 3-LS4 Biological Evolution: Unity and Diversity (LS2.C and LS4.B and LS4.C and LS4.D)

Fourth Grade
- 4-LS-1 From Molecules to Organisms: Structures and Processes (LS1.A and LS1.D)

Fifth Grade
- 5-PS3 Energy (LS1.C)

Middle School
- MS-LS1 From Molecules to Organisms: Structures and Processes (MS-LS1.B and MS-LS1.C)
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS2.A and LS2.C)
- MS-LS4- Biological Evolution: Unity and Diversity (LS4.B and LS4.C)

Lesson 4: Bioaccumulation: It All Adds Up

Third Grade
- 3-LS1 From Molecules to Organisms: Structures and Processes (LS1.B)
- 3-LS2 Ecosystems: Interactions, Energy, and Dynamics (LS2.D)
- 3-LS4 Biological Evolution: Unity and Diversity (LS2.C and LS4.C and LS4.D)

Fourth Grade
- 4-LS-1 From Molecules to Organisms: Structures and Processes (LS1.A)

Fifth Grade
- 5-PS3 Energy (LS1.C)
- 5-LS1 From Molecules to Organisms: Structures and Processes (LS1.C)
- 5-LS2 Ecosystems: Interactions, Energy, and Dynamics (LS2.A and LS2.B)
- 5-ESS3 Earth and Human Activity (ESS3.C)

Middle School
- MS-LS1 From Molecules to Organisms: Structures and Processes (MS-LS1.C)
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS2.A and LS2.B and LS2.C and LS4.D)
- MS-ESS3 Earth and Human Activity (ESS3.A and ESS3.C and ESS3.D)

Lesson 5: "Whale Safe" Engineering Challenge

Third Grade
- 3-LS4 Biological Evolution: Unity and Diversity (LS2.C and LS4.D)

Fifth Grade
- 5-ESS3 Earth and Human Activity (ESS3.C)
- 3rd – 5th Engineering Design (ETS1.A and ETS1.B and ETS1.C)

Middle School
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS2.A and LS2.B and LS2.C and LS4.D and ETS1.B)
- MS-ESS3 Earth and Human Activity (ESS3.C)
- Middle School Engineering Design (ETS1.A and ETS1.B and ETS1.C)

Lesson 6: Whaling to Whale Watching

Third Grade
- 3-LS4 Biological Evolution: Unity and Diversity (LS2.C and LS4.D)

Fourth Grade
- 4-ESS3 Earth and Human Activity (ESS3.A)

Fifth Grade
- 5-ESS3 Earth and Human Activity (ESS3.C)

Middle School
- MS-LS2 Ecosystems: Interactions, Energy and Dynamics (MS-LS2.A and LS2.C and LS4.D and ETS1.B)
- MS-ESS3 Earth and Human Activity (ESS3.C and ESS3.D)

Ocean Literacy Principles

Lesson 1: Principles 5 and 6
Lesson 2: Principles 1, 5 and 6
Lesson 3: Principles 1, 4 and 5 and 6
Lesson 4: Principles 1, 5 and 6
Lesson 5: Principles 5, 6 and 7
Lesson 6: Principles 5, 6 and 7

Ocean Literacy Principles
1. The Earth has one big ocean with many features.
2. The ocean and life in the ocean shape the features of Earth.
3. The ocean is a major influence on weather and climate.
4. The ocean made Earth habitable.
5. The ocean supports a great diversity of life and ecosystems
6. The ocean and humans are inextricably interconnected
7. The ocean is largely unexplored

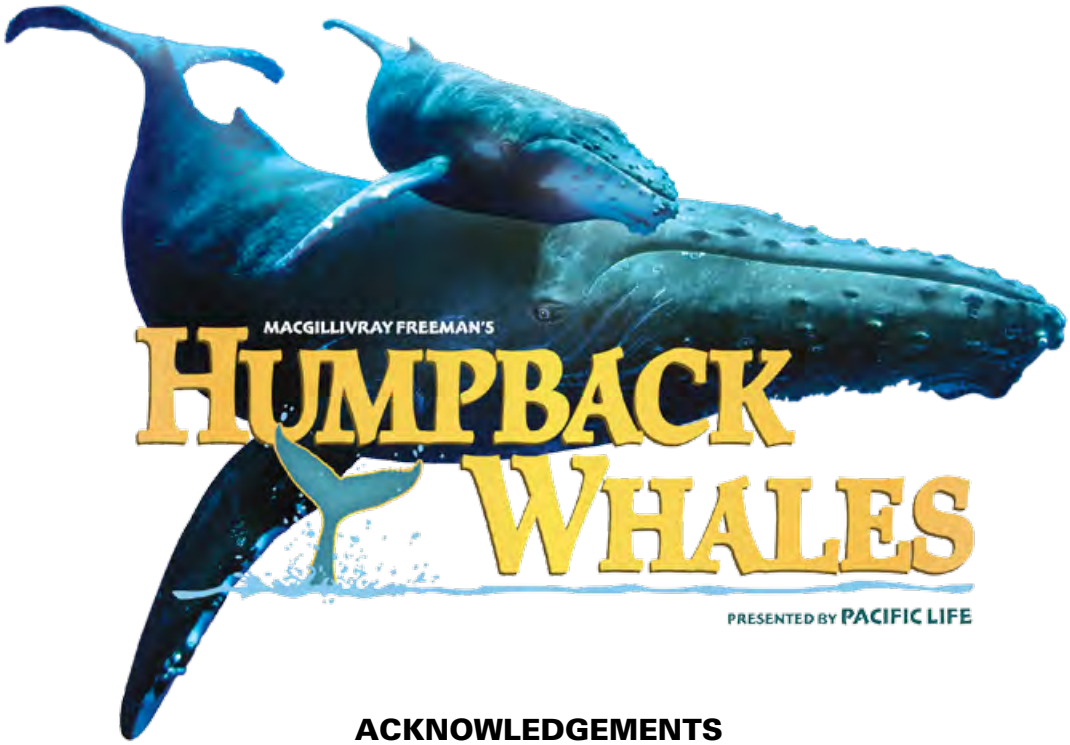
National Geography Standards

Lesson 1: Standards 4 and 5
Lesson 2: Standards 1, 3, 4, 5 and 6
Lesson 3: Standards 4
Lesson 4: Standards 4 and 5
Lesson 5: Standards 2, 4 and 5
Lesson 6: Standards 2, 4 and 5

National Geography Standards
1. The world in spatial terms
2. Places and regions
3. Physical systems
4. Human systems
5. Environment and society
6. The uses of geography

Common Core Language Arts

Reading Informational Text—Lesson 2, 4 and 6
Writing—Lesson 5 and 6
Speaking and Listening—All lessons



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www.humpbackwhalesfilm.com.