9-12 Diets and Dangers Activity

South Carolina Aquarium

Overview

Focus Question
What do marine mammals eat and why is it important to understand their diets?

Activity Synopsis
Students will learn about marine food webs, how fragile the ocean ecosystem is and why it is important to study the diets of apex consumers like bottlenose dolphins. Once students understand food webs, they will play a game that will introduce the concepts of bioaccumulation and biomagnification.

Time Frame
60 minutes

Objectives
The learner will be able to:

- Describe different feeding methods of marine mammals
- Draw a marine food web with a dolphin as the apex consumer
- Explain why it is important to study food webs
- Explain the trophic levels of a food chain
- Define the difference between bioaccumulation and biomagnification
- Provide 3 dangers or threats to marine mammals
- Understand how scientists study marine mammal feeding methods

Student Key Terms

- Apex consumer
- Baleen
- Begging
- Bioaccumulation
- Biomagnification
- Carnivore
- Echolocation
- Ecosystem
- Filter feeding
- Food chain
- Food web
- Foraging
- Herbivore
- Keystone species
- Marine debris
- Marine mammal
- Melon
- Otolith
- Primary consumer
- Producer
- Secondary consumer
- Tertiary consumer
- Trophic level

Teacher Key Terms

- Mysticeti

- Necropsy
- Odontoceti

Standards

South Carolina College- and Career-Ready Science Standards 2021

Biology: B-LS2-1, B-LS2-3, **B-LS2-4,** B-LS2-6**, B-LS2-7,** B-LS2-8, **B-LS4-5**, B-LS4-6
Earth and Space Science: E-ESS3-4, E-ESS3-6

*** Bold standards are the main standards addressed in this activity**

Biology Performance Expectations
B-LS2-1 Use mathematical and/or computational representations to support explanations of biotic and abiotic factors that affect carrying capacity of ecosystems at different scales.
B-LS2-3 Construct and revise an explanation based on evidence for the cycling of matter and flow of energy in aerobic and anaerobic conditions.
B-LS2-4 Use mathematical representations to support claims for the cycling of matter and flow of energy among organisms in an ecosystem.
B-LS2-6 Evaluate claims, evidence, and reasoning that the complex interactions in ecosystems maintain relatively consistent numbers and types of organisms in stable conditions but changing conditions may result in a new ecosystem.
B-LS2-7 Design, evaluate, and refine a solution for reducing the impacts of human activities on biodiversity and ecosystem health.
B-LS2-8 Evaluate evidence for the role of group behavior on individual and species' chances to survive and reproduce.
B-LS4-5 Evaluate the evidence supporting claims that changes in environmental conditions may result in (1) increases in the number of individuals of some species, (2) the emergence of new species over time, and (3) the extinction of other species.
B-LS4-6 Create or revise a simulation to test a solution to mitigate adverse impacts of human activity on biodiversity.

Earth and Space Science Performance Expectations
E-ESS3-4 Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.
E-ESS3-6 Use a computational representation to illustrate the relationships among Earth systems and how those relationships are being modified due to human activity.

Background

Key Points
Key Points will give you the main information you should know to teach the activity.

- There are over 100 species of **marine mammals** found throughout the world.
- The majority of marine mammals are **carnivores** with the exception of the Order Sirenia, which are **herbivores**.
- A **trophic level** is an organism's position in its food chain in relation to acquiring energy. The trophic levels are **producer**, **primary consumer**, **secondary consumer** and **tertiary consumer**.
- Most marine mammals are **apex consumers** in a marine **food chain** and they help control population growth of their prey items. A low number of prey items is also a danger to marine mammal **food webs**.
- **Bioaccumulation** is when an individual animal's pollutant concentration increases over time.
- **Biomagnification** is when pollutant concentrations increase as they are passed up the food chain.
- Scientists study marine mammal diets through field observation and stomach contents during **necropsies**.
- Marine mammals are an integral part of the ocean's food webs and they need to be protected around the world in order to maintain a healthy ocean.
- Marine mammals face many dangers including marine debris, entanglement, chemical pollutants and human harassment.

- Bottlenose dolphins are the most common marine mammal off the east coast of the US and feed primarily on fish. There are 2 species of bottlenose dolphins in SC. The larger Common bottlenose dolphin (*Tursiops truncatus*) is found offshore whereas the smaller Tamanend's bottlenose dolphin (*Tursiops erebennus*) is found inshore.
- Dolphins are largely affected by chemical toxins in the water due to runoff.

Detailed Information
Detailed Information gives more in-depth background to increase your knowledge, in case you want to expand the activity or you are asked detailed questions by students.

Marine mammals are mammals that live in or need to be close to the ocean to survive. These mammals have specific adaptations that make efficient hunters in the water. Some marine mammals like the bottlenose dolphins use **echolocation** to find prey using sound waves like sonar to show where food is located. Others, like seals and sea lions, are very agile swimmers using their streamline bodies and flippers to chase down their food. Some other marine mammals have modified teeth, called a **baleen**, that are similar to bristles to strain out water and trap krill and plankton. A humpback whale is a great example of a baleen whale.

Like all mammals, marine mammals are warm-blooded, breath air, give live birth, nurse young with milk and have hair. For some marine mammals this hair is different than most mammals and will fall out a few days after birth.

There are over 100 species of marine mammals and they live in salt, fresh and brackish water and inhabit every ocean on the planet. Marine mammals are divided into three orders: Cetacea (89 species), including dolphins and whales; Carnivora (35 species), including seals, sea lions, sea otters, and polar bears with and Sirenia (4 species), including dugongs and manatees.

Foraging/Hunting Adaptations

With over 100 species, not all marine mammals eat the same thing. Some are **herbivores** while most are **carnivores,** even eating other marine mammals. The body design of the marine mammal gives a clue as to how the animal hunts.

Order Cetacea:
Cetaceans hunt in two main ways, depending on if the animal is a toothed or a baleen whale. Suborder **Odontoceti**, or toothed whales, communicate and locate their prey in a unique way. They use echolocation to speak to each other and also to hunt. In echolocation, these marine mammals send out sound waves which hit their prey and come back to the marine mammal. This echo of the original sound wave is how they know how far away a prey item may be. Marine mammals use their **melon**, a part of their forehead, to focus the outgoing sound waves towards a specific area while their lower jaw acts as the receiving dish for returning sound waves.

Mysticeti, or baleen whales, hunt in a different method. Since their prey are much smaller organisms like shrimp and plankton, they usually swim up underneath their food and take a huge gulp of water. They then strain out all the water through the baleen plates keeping the plankton, but getting rid of the water. This process is called **filter feeding**. Humpback whales work in a group to hunt strategically with a method called bubble netting. Some whales in the group with blow bubbles either in a continuous stream to create a curtain around the fish or in separate bursts to create columns. The bubbles scares the fish into a tight ball and when they are close together the whales will lunge forward gulping up as many fish as possible.

Order Carnivora:
The Order Carnivora includes the Pinnipeds (flipper-footed) and Fissipeds (paw-footed) marine mammals. Pinnipeds, such as seals, sea lions and walruses, use their very sensitive whiskers for exploring and hunting. The whiskers pick up on small vibrations in the water that helps the pinniped find its food.

Fissipeds, like polar bears are very adapt hunters and hunt seals for their blubber. They watch nearby breathing holes and wait for a seals to come up for a breath in the arctic ice and capture their prey by surprise. Polar bears also use their nose to

smell for prey by either smelling out a new breathing hole or actually smelling a close seal through compacted snow. Other fissipeds, like sea otters, primarily eat sea urchins and many times can be seen floating of their backs with sea urchins in their paws.

Order Sirenia:
Sirenians, such as Dugongs and Manatees, are herbivores and graze on sea vegetation. They spend much of their day grazing, eating over 1,000 pounds of sea grass in day. Sometimes referred to as a sea cow, these animals are very large as adults and slow moving in shallow waters where their food source is abundant. Dugongs and Manatees are related to the true Stellar sea cow, a massive herbivorous extinct Sirenia. The true Steller sea cow was hunted to extinction in 1768, after only 27 years of hunting.

Researching Marine Mammal Diets

There are a few techniques to research a marine mammal's diet. The main two techniques are observing their feeding behaviors in the wild and examining their feces and or stomach contents. The first technique deals with observing live animals while the latter technique can be used with living (feces) and deceased (stomach contents) marine mammals.

Observing marine mammal feeding behaviors provides only a small picture into the feeding strategies of these aquatic animals. With over 100 species of marine mammals their feeding behaviors significantly vary; therefore, the observation techniques will also be varied. A common factor between the observation techniques is technology, which allows a researcher to record and analyze the feeding behavior. As technology improves so does the ability to capture never before seen feeding strategies of different species. With the advanced technology available to researchers they can even attach a small video camera, in a non-invasive way, to an animal to record the underwater behaviors and strategies. The video camera is temporarily housed on the animal and after a certain amount of time, the housing comes off the animal and floats to the surface of the water where the researcher can pick it up and analyze the rare footage.

Examining animal feces or stomach contents is another way scientists learn about marine mammal diets. When a marine mammal strands and can be taken to a rehabilitation facility, the feces or stomach contents hold valuable information that tell scientists what the animal ate before it stranded. If a deceased marine mammal strands, scientists can perform a **necropsy** to determine the cause of death. During this procedure scientists examine the stomach contents in search of clues. In otherwise healthy animals scientists find left over parts of the prey. Typically these are ear bones or, **otoliths**, and cephalopod jaw bones or, beaks. The otoliths and beaks are great clues for scientists because both are unique to a species and both provide a good length and weight estimate for the animal it came from. With these clues scientists can build an aquatic **food web**.

Marine Mammals in Marine Food Webs

All species of marine mammals play an important role in their marine **ecosystem.** The majority of marine mammal species are **keystone species**, which means they are needed to keep other populations at sustainable numbers. Without these top predators a food web becomes unbalanced with an overabundance of prey items. Take for instance the sea otters' important role in the kelp forest ecosystem. Sea otters eat urchins which eat kelp. If the sea otters' population decreases or disappears the urchin population will increase with no predators. As a result the urchins will eat the kelp at an accelerated rate, eventually destroying the kelp forest which is a rich habitat for hundreds of animals, not to mention its important role in converting CO_2 into oxygen. These types of relationships are mirrored throughout all **food chains**, but sometimes the direct consequences are not as obvious.

A trophic level is the position an organism occupies with its food chain. Every organism needs energy to survive. The food chain looks at how energy moves from one organism to another. The **producers**, plants, are the first trophic level, getting their energy from the sun. Next are the **primary consumers** that consume the producer for energy. Next the **secondary consumers**, who eat the primary consumers sometimes followed by the **tertiary consumer**. Most food chains have 3-5 levels of passing energy. The animals at the top of a food chain is called the apex consumer.

Marine Debris/Dangers

Food chains/webs are also in danger from unwanted additions like **marine debris** and contamination. Marine debris is huge threat to the ocean. It is estimated that by 2050 there will be more plastic in the ocean than fish! Marine mammals, as well as other marine wildlife, often mistake marine debris for their typical food items and ingest the trash. This is a serious issue as the ingested trash could cause the animal to become sick and lead to death. There are news articles every year that report on deceased marine mammal that washed ashore with a stomach full of trash. Even if a marine mammal does not ingest the marine debris, they can still be negatively affected by it. Animals often become entangled in marine debris such as discarded fish line, rope and netting. Sometimes the animals can survive with the entanglement for a while but as it grows the entanglement becomes tighter, which could cut the animal leading to injury and infection. Unfortunately, when the entanglement becomes too severe it can lead to death.

Sometimes there are additions to the food chain that are microscopic. These toxic additions are found within the food items themselves. Chemical pollutants from runoff and chemical spills get into the waterway and make their way to the ocean where the pollutants are absorbed and consumed by small organisms. Once the pollutants enter the body, they are stored within fat or muscle tissues, which means they do not leave the individual. These contaminated organisms have a negative impact on the marine food chain and lead to **bioaccumulation** and **biomagnification**. Bioaccumulation refers to an individual animal whose pollutant concentration increases over time. An example would be a fish's toxin concentration increases over time as it continues to eat contaminated krill. Biomagnification refers to the food chain as a whole. The pollutant magnifies in strength as it climbs the food chain. Therefore, the apex or top, consumer of the food chain would carry the heaviest toxin load because all of the toxins from its prey and its prey's prey are combined within the **apex consumer**. The toxin concentration has a positive relationship with the **trophic** (food chain) **level**; as one increases so does the other.

Another danger that marine mammals face is human interaction in regards to feeding and harassment. It is illegal to feed or harass wild marine mammals. Harassment as defined by the Marine Mammal Protection Act is "any act of pursuit, torment, or annoyance that has the potential to injure a marine mammal or marine mammal stock in the wild… or … acts that have the potential to disturb (but not injure) a marine mammal or marine mammal stock in the wild by disrupting behavioral patterns, including, but not limited to, migration, breathing, nursing, breeding, feeding, or sheltering". Understanding how to safely interact with wild marine mammals is vital to maintaining a healthy population. Feeding wild animals interrupts their food web and causes harmful consequences such as inappropriate food introduced to animals as well as **begging** behavior from wild marine mammals, such as bottlenose dolphins. This behavior is so dangerous to dolphins because it teaches individuals to approach boats rather than to avoid them, which can result in boat strike injuries. Additionally, these dolphins spend their time begging rather than catching food on their own, a behavior that has been documented as a behavior that is passed on to their offspring. This teachable behavior is cause for concern as whole populations may adapt to this new way of acquiring food.

<u>Marine Mammal Conservation</u>

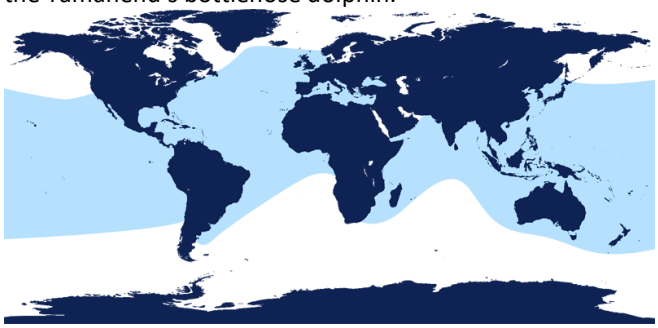
Marine mammals, just like all living things, have their place in the ocean ecosystem. Without a balance of animal populations through food chains, communities and ecosystems could become unbalanced. People around the world rely on the ocean for food, oxygen, the earth's climate and medicines.

About 16% of the world's food comes from the ocean. This might not seem like a large percentage, but it equals about 200 billion pounds each year. It is thought that about 90% of the world's oxygen is produced by the phytoplankton of the ocean. This is important because all living things need oxygen to breath. The ocean also plays a huge role in the climate of the earth. The ocean collects and mixes carbon dioxide, heat and water which in turn will control the climate patterns around the world. Researchers are always discovering more about the living things in the ocean. New marine discoveries could lead to medical breakthroughs in cures for diseases and medicines.

Many efforts are being done to protect marine mammals around the world. Protecting marine mammals must include the protection of the waterways as well as the ocean. Marine mammals are federally protected by the Marine Mammal Protection Act that was passed in 1972 and protects all species of marine mammals.

Bottlenose Dolphins (*Tursiops truncatus & Tursiops erebennus*)

The bottlenose dolphin is the most common dolphin species found off the east coast of the USA. The Common bottlenose dolphin (*Tursiops truncates*) is found in tropical to temperate waters offshore around the world in the Pacific, Atlantic, and Indian Oceans. Since they have a global habitat and live off the coast, this species has been extensively studied. In 2023, the Tamanend's bottlenose dolphin (*Tursiops erebennus*) was recognized as a new species specific to the inshore waters of the east Atlantic ocean to the Gulf of Mexico. The Common bottlenose dolphin is large in size and darker in color compared to the Tamanend's bottlenose dolphin.



Common bottlenose dolphin range (light blue) from Voices in the Sea

Bottlenose dolphins use echolocation to locate their prey and use their sharp cone-shaped teeth to feed primarily on fish. They have been known to strand feed in South Carolina, which is a feeding method where they case fish onto the beach and then carefully come onshore to grab the fish before sliding back into the water. This feeding method can be dangerous because of the possibility of getting stuck on land.

Procedure

Materials

- Activity Presentation
- 7 Food Web Trophic Level Guides
- Diets and Dangers Case Cards
- Diets and Dangers Worksheet (1 per student)
- Diets and Dangers Worksheet Answer Key (Teacher only)
- Writing utensils
- 3 Pitchers filled with water (1 per group)
- (10) 250 mL clear beakers (3 per group, 1 for teacher)
- (3) 500 mL clear beakers (1 per group)
- 3 Calculators (1 per group)
- Large white board (or large piece of paper)
- Dry erase markers (or markers) – 4 different colors

Procedure

1. Go through Slides 1-18 of the Activity Presentation to serve as an introduction to marine mammals and bottlenose dolphin food chains and food webs.
   - Review the characteristics of marine mammals.
   - Go over marine mammal taxonomy.
   - Review the difference between a food chain and food web.
   - Talk about the trophic levels of a food chains (producer, primary consumer, secondary consumer and tertiary consumer).
   - Discuss the difference between bioaccumulation and biomagnification.

- Review the different marine mammal feeding types (carnivores, herbivores, omnivores).
- Make sure all students understand that marine mammals feed in different ways. Go over the feeding techniques of highlighted marine mammal species and how they differ from one another.
- Talk about the different dangers marine mammals face (marine debris, entanglement, chemical pollutants and humans).
- Discuss the bottlenose dolphin as the animal focus for the next activity. Be sure they understand that dolphins are apex consumers in the ocean at the top of their food chain, only sometimes eaten by large sharks and orcas.
- Touch on the dangers bottlenose dolphins face with toxic runoff.
- Talk about how scientists study what dolphins eat.

2. Give each student a Diets and Dangers Worksheet and have them respond to the prompt: “Why is it important to understand what marine mammals eat?” (slide 19, Worksheet #1)

3. Divide class into 3 groups. Pass out 1 Diets and Dangers Case Card to each group as well as the Trophic Level Guides.

- Case 1 = 2 Trophic Level Guides
- Case 2 = 3 Trophic Level Guides
- Case 3 = 2 Trophic Level Guides

4. Have the group look at the otolith photos from their dolphin’s last meal. Students will need to identify the otoliths in order to confirm which species of fishes their dolphin ate. The Activity Presentation will contain an identification table of common fish otoliths (slide 21). Students should record information on their case card and worksheet (#2).

5. Now, have students use their Case Card and Tropic Level Guides to create a food web by circling their answers on the guide. For each fish otolith, they should use a new Trophic Level Guide so they can easily connect the food web.

6. Next, students should calculate the total amount of toxins for each trophic level and record their answers on each Tropic Level Guide. Toxin level is the number located below each organism on the Trophic Level Guide. It is measured in milliliters (mL).

7. Then have them calculate the total the toxin level of each trophic level by adding up the toxin levels from each Trophic Level Guide and record it on their worksheet (#3).

8. They can then calculate the total toxin level of their dolphin by adding up all the trophic levels (#3)

9. Next pass out the beakers and water jugs to each group. Each group will get 1 pitcher of water, three 250mL beakers (one per trophic level) and one 500ml beaker. Follow these steps to set up food web demonstration:

- The pitcher filled with water represents the toxins
- Have students label each 250 mL beaker (producers, primary consumers, secondary consumers)
- Have students label the 500 mL beaker “our dolphin”.
- Measure out the appropriate amount of water (water represents the toxins) for each tropic level found in step 6.

10. The students will now enact the food web by pouring the amount of water from one trophic level to the next when it is consumed in the food web.

- Students should first pour the producer beaker into the primary consumer beaker.
- Next, pour from primary consumer beaker to secondary consumer beaker.
- Finally, the secondary consumer beaker into the “our dolphin” (tertiary consumer/last meal beaker).
- This represents how much toxin was ingested by the dolphin in its last meal.

11. Ask students to finish their worksheet by answering questions 4-7 focusing on bioaccumulation and biomagnification (slide 23).

12. On the board, draw a graph with a space for each case on the x-axis (case 1, case 2 and case 3) and the toxin level on the y-axis (0-500 mL in 50 mL increments).

13. Have one student from each group come up to graph the total toxin amount their dolphin consumed on a graph in the front of class so all can compare the different dolphin cases.

- Could have them denote the toxin amount from each trophic level by using different colors if you want.
- Slide 25 shows an example graph.

14. Have students turn in their Diets and Dangers Worksheet for a grade.

15. Discuss the findings with the class. Use slide 26 to go over each case. What do they notice?

16. Once students have an understanding of the different cases, take it one step further. Pick out case 2: the pregnant female.

- Ask students what will happen to her toxins when she gives birth?
- Remind them that the toxins are stored in the fat of an individual and therefore during the birthing and lactation processes many of the toxins are offloaded to the newborn.
- Demonstrate this by pouring out a third of the liquid from the pregnant female beaker into a new beaker to represent the baby dolphin. What does this mean for the baby?

Follow-up Questions

- How do pollutants and trash enter the ocean?
- What can we do to help keep our waterways clean?

At-home Learning and Virtual Modifications

At-home or Virtual Learning: Use the following nearpod information to choose how to teach this activity. Activity will cover how scientists study marine mammal diets, where bottlenose dolphins fall in their food web, the dangers marine mammals face and the concepts of bioaccumulation and biomagnification. This lesson is narrated throughout.

Teacher led lesson without student interaction

If you would like to see the results of their nearpod activities, you can set it up as a Student-Paced activity or do it live with your class following these directions.

1. Create a free nearpod account (https://nearpod.com/)
2. Ask Aquarium to send you Diets and Dangers nearpod link (email education@scaquarium.org)
3. After you receive Aquarium link, add lesson to your nearpod activities by clicking “Add to My Library”
4. Send to students using Live Participation or student paced
5. You’ll be able to see their answers and interactions

Assessment

The assessment will be the student’s completed Diets and Dangers Worksheet submitted at the end of the activity. Use the Diets and Dangers Answer Key to grade.

Scoring rubric out of 100 points

Explains importance of knowing what marine mammals eat:	**10 points**
Correctly copies case number and lists fish:	**20 points**
Correctly completes toxin table:	**20 points (5 per row)**
Correctly defines bioaccumulation:	**10 points**

Correctly defines biomagnification:	**10 points**
Correctly explains difference between bioaccumulation and biomagnification:	**10 points**
Explains dangers of animals in relation to food web:	**20 points**

Cross-Curricular Extensions

Social Science Extension
Read about the Federal Water Pollution Control Act of 1948 and discuss how this law affects marine food webs.

- https://www.epa.gov/laws-regulations/history-clean-water-act

STEAM Extension
Have students create a map that connects them to the ocean. They will need to understand and review watersheds so that they can draw or list out the bodies of water that create the path to the ocean.

Some good watershed resources:

- http://watersheds.fernleafinteractive.com/
- https://water.usgs.gov/wsc/map_index.html

Resources

Teacher and Student Reference Websites

Audubon
https://www.audubon.org/news/killer-bubbles-humpback-whales-use-bubble-nets-capture-prey
Great information on bubbling net feeding by humpback whales.

Oceana: Protecting the World's Oceans
https://oceana.org/blog/what-you-didn%E2%80%99t-know-about-manatees-honor-manatee-awareness-month
Manatee information.

What-When-How: In Depth Tutorials and Information
http://what-when-how.com/marine-mammals/diet-marine-mammals/
Details on marine mammal diets.

Florida Fish and Wildlife Conservation Commission
https://myfwc.com/research/saltwater/fish/age-growth-lab/otolith-sectioning-process/
Information on fish otoliths.

Infinite Spider: Blog for Teachers and Naturalists
https://infinitespider.com/otoliths-fish-hear/
More information on fish otoliths.

Virtual Learning Opportunities

Pacific Marine Mammal Center
https://www.pacificmmc.org/distance-learning/

Alaska SeaLife Center
https://www.alaskasealife.org/distance_learning