# Cabrillo Marine Aquarium
# Lesson Plan

**Grade Level:** Fifth and Eighth Grades

**Title: JAW-normous: A Lesson on the Biggest Shark that Ever Lived!**

**Objective:** Megalodon is believed to be the largest shark to have ever lived! But just how big was Megalodon? In this lesson, students will determine Megalodon's size using the same methods as research & field scientists. This lesson will allow students the opportunity to estimate the body length of Megalodon based on modern shark models. Students are provided with actual data from which they will construct a graph demonstrating the relationship between living shark tooth width and body length. The resulting graph will then be used to estimate the body length of Megalodon.

**California Science Standards:** **5th:** 2a, 6a-i **8th:** 9a-g

**Time to Complete:** 45 to 60 minutes

**Materials Provided by CMA:** ***Reading Handout: How Megalodon Worked; Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas, Worksheet: Megalodon Crossword Puzzle***

**Materials Provided by Teacher**: Photocopies, drawing paper & pencils.

**Vocabulary:** Allometric, cartilage, cartilaginous, centrum, fossilization, morphology, ossification, null hypothesis, independent variable, dependent variable

**Background Information:** Complete shark skeletons are not found in the fossil record. This is because sharks have cartilaginous skeletons (i.e., composed of cartilage), which will rarely fossilize. Instead, scientists often only find fossilized shark teeth and/or ossified (i.e., boney) shark centra (i.e., vertebrae). Because of the lack of skeletal preservation of ancient sharks, we must use modern sharks to estimate the size of Megalodon. In order to do this, scientists first determined that an **allometric relationship** (i.e., a relationship of anatomical variables that fits an equation) exists between the **morphology** of a preserved element (i.e., tooth width) and body length in living sharks. Because tooth width and body length are correlated in modern sharks, one can use this allometric relationship to estimate Megalodon's body length by instead measuring the width of Megalodon teeth.

**Lesson Outline:**

- **Activity 1:** ***Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas***
- **Activity 2:** ***Reading Handout: How Megalodon Worked***
- **Activity 3:** ***Worksheet: Megalodon Crossword Puzzle***



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**Activity 1: Megalodon - Biggest Shark that Ever Roamed the Seas**

- **Use the *Worksheet: Megalodon - Biggest Shark that Ever Roamed the Seas***

**Procedures:**

- This activity begins by getting students of all ages excited about their task of determining the body size of the largest shark that has ever lived.
- An opening inquiry-based discussion should include why complete shark skeletons, including Megalodon, are not found.
- Ask students if they know why this is. (Hint: wiggle your nose and ears for the answer.) Because we don't have complete fossilized skeletons of Megalodon, we must instead look at living sharks as a model.
- Let students know that the Megalodon is the largest shark to have ever lived! Based on the size of Megalodon teeth, we know that this shark was larger than all modern and known, extinct sharks. However, it is difficult to know the exact size of Megalodon, as entire skeletons are not preserved. Estimated to be approximately 60 feet in length, this formidable top predator occupied the world's ancient oceans 2-17 million years ago. Megalodon consumed vast quantities of marine animals and likely contributed to the stability of ecosystems – as top predators do today.
- This discussion can cover all vocabulary words and explain why modern sharks are needed to help us determine the body size of the Megalodon (see ***Background Information***).
- Next, students can either work in groups or individually to formulate their **null hypothesis** that "**Modern shark tooth width - does not correlate with body size."**
- Subsequently, students will begin to graph their data.
- Have students graph tooth width on the x-axis (**independent variable**) and body size on the y-axis (**dependent variable**).
- Once students have completed this task they should be able to conclude that an **allometric relationship - does exist between shark tooth width and body size**.
- Lastly, they are asked to extend their graph to meet the appropriate tooth width of the Megalodon.
- This task will allow the students to estimate the body size of the Megalodon.

**Key Question:**

- **Is there a predictable relationship between tooth width and body length in modern sharks? Yes, there is a relationship between tooth width and shark body length.**

**Student Directions:**

- Develop a hypothesis to help answer the key question. Use the following data to test your hypothesis. This can be done by graphing tooth width (your independent variable) on the x-axis and body length (your dependant variable) on the y-axis. The first data point has been plotted on the graph. After you have graphed all of the data

in the data table, answer questions 1 & 2. Next, extend your graph to intersect with the Megalodon tooth width of 5.5 inches and determine Megalodon's body length.

**Worksheet Questions**

- **What is your null hypothesis? Modern shark tooth width does not correlate with body size.**
- **Is it testable and falsifiable? Why or why not? Yes, it is a testable & falsifiable hypothesis because scientists have already determined an allometric relationship (i.e., a relationship of anatomical variables that fits an equation) exists between the morphology of a preserved element (i.e., tooth width) and body length in living sharks. Because tooth width and body length are correlated in modern sharks, one can use this allometric relationship to estimate the Megalodon's body length, by measuring the width of Megalodon teeth.**
- **After graphing your data, is your null hypothesis supported or falsified? Explain. The null hypothesis is falsified because modern shark tooth width DOES correlate with body size.**
- **After extending the graph to meet the tooth width of Megalodon, what is your estimate for Megalodon's body length? A Megalodon tooth that is 5.5 inches wide should yield a body length estimate of approximately 700 inches (~60 feet long).**

**Activity 2: How Megalodon Worked**

- **Use the *Reading Handout: How Megalodon Worked***

**Suggested Discussion Questions:**

- **How big was Megalodon? 45-60 feet**
- **How long ago did Megalodon live? over 2 million years ago**
- **What did Megalodon eat? other sharks, sea turtles & whales**
- **Where did Megalodon live? in all the seas**
- **Who was Megalodon related to? possibly the great white or mako shark**
- **Why is Megalodon important? it can give us clues to the evolution of sharks**

**Activity 3: Megalodon Crossword: World's Largest Predator**

- Use the ***Worksheet: Megalodon Crossword Puzzle***

**Lesson Wrap-up: Discussion Questions:**

- **How big was Megalodon? Scientists estimate - 60 feet in length**
- **Why are complete Megalodon skeletons not preserved? A shark skeleton is composed of cartilage, which rarely fossilizes.**
- **Can we use modern sharks to help us estimate Megalodon's body size? Why or why not? Yes, there is an allometric relationship between the width of modern-day shark teeth & size- that can be applied to ancient shark morphology & tooth width.**

**Lesson Extensions:**

- Once a size estimate for Megalodon has been determined, a roll of tape (or string) can be cut to represent Megalodon's body length and placed around the classroom. Younger students can instead forgo the graphing activity and construct Megalodon's body length to scale. Additionally, younger students can figure out how many of them (in height) equal one Megalodon (in body length). For more advanced classes, such as high school science or mathematics, a discussion can ensue that touches on the potential uncertainties regarding the Megalodon body length estimate (e.g., what if the graph is not linear with increasing body length and is instead exponential?).

**Further Student Exploration:**

- **Carcharodon versus Carcharocles: What's in a Name?**
  A controversy exists because some scientists believe that this species should be classified as a member of the genus *Carcharocles* instead of *Carcharodon*. See:
  http://www.elasmoresearch.org/education/evolution/carcharodonvscarcharocles.htm

- **Book Recommendations**
  - Caroline & Caple / ***Giant Shark: Megalodon, Prehistoric Super Predator***
  - Benton, Michael J. / ***Vertebrate Paleontology, Third Edition***
  - Cocke, Joe / ***Fossil Shark Teeth of the World: A Collector's Guide***
  - Hulbert, Richard C. / ***The Fossil Vertebrates of Florida***
  - Renz, Mark / ***Megalodon: Hunting the Hunter***

- **Recommended Websites**
  - American Museum of Natural History
    http://www.amnh.org/exhibitions/permanent-exhibitions/fossil-halls/hall-of-vertebrate-origins/carcharadon
  - Discovery Education's Prehistoric Sharks
    http://school.discoveryeducation.com/schooladventures/prehistoricsharks/
  - Florida Museum of Natural History Website on the Megalodon Exhibit
    http://www.flmnh.ufl.edu/fish/sharks/fossils/megalodon.html

**References:**


- Modified Lesson from the Florida Museum of Natural History
  An Educators Guide for Megalodon: The Largest Shark that Ever Lived!
  http://www.flmnh.ufl.edu/files/2513/4664/7890/Megalodon-guide.pdf
- How Stuff Works: Article - How Megalodon Worked
  http://science.howstuffworks.com/zoology/marine-life/megalodon.htm/printable
- San Diego Natural History Museum
  http://www.sdnhm.org/archive/exhibits/mystery/fg_megalodon.html
- Fossils Rock! - Crossword Puzzle
  http://www.fossils-facts-and-finds.com/support-files/megalodon-crossword.pdf

# Cabrillo Marine Aquarium
# Lesson Plan

**Grade Level:** Fifth and Sixth Grades

**Title: Swimming with Sharks: A Lesson on Shark Migration**

**Objective:** Students will learn about the blue shark's migratory nature and how scientists study shark movements with electronic tags.

**California Science Standards:** **5th:** 6a-i **6th:** 5a-e, 7a-f

**Time to Complete:** 30 to 45 minutes

**Materials Provided by CMA:** ***Reading Handout: All about the Blue Shark, Worksheet: Tracking a Shark, Worksheet: Shark Word Search***

**Materials Provided by Teacher:** Photocopies, pencils, rulers (optional)

**Vocabulary:** Endangered, threatened, vulnerable, extinction, conservationist, ecosystem, migration, coordinate, vertical, horizontal, seamount, species, buoyancy, gill rakers, viviparous, pelagic

**Background Information:**
Presently, it is estimated that 55-100 million sharks and rays are killed worldwide each year. Some shark populations have declined by as much as 80% due to human activities such as fishing. At this time, many species of sharks and rays are considered **endangered, threatened** or **vulnerable**. For instance, currently, Great White sharks are vulnerable to extinction and sharks once as common as the Blue, Mako and Hammerhead are now threatened. In order to protect shark populations, information about where sharks go and what routes they take is needed. Identifying the movement patterns of sharks can help scientists and **conservationists** safeguard sharks by advocating for the protection of those areas most favored by sharks.

**Lesson Outline:**
- **Activity 1: Brainstorming with Students -** Discussion
- **Activity 2: Shark Tracking -** Class Activity
- **Activity 3: All About Blues -** Reading Handout
- **Activity 4: Shark Word Search -** Student Activity

**Activity 1: Brainstorming with Students**
- Many animals migrate. Birds migrate many thousands of miles to avoid extreme temperatures and to find food. Large African mammals such as gazelles and


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elephants migrate to find water. Large marine mammals, like the gray whale, migrate to birth their young in the warm, protective waters of the Gulf of California

- **Why do sharks migrate?**

- Students will brainstorm all the reasons they know for why sharks migrate.
  - **Why do animals migrate?**
- Write student responses, for animal migration, on the board & discuss as a class.

  **Possible answers may include:** to seek better living conditions, travel to feeding, nesting and nursing grounds, migrate to breed, to find food & shelter, migrate due to changing environments—including factors such as temperature & climate, population growth & decline, habitat destruction & natural disasters, etc.

**Activity 2: Shark Tracking**

**Procedures**

- The following activity is an exercise that involves mapping the coordinates of a tagged shark onto a map to identify its movements.
- Each student will be given the handout with a map of Baja California and instructions on how to construct the tracking map of the Blue shark, Jeff.
- Learners should follow the instructions, placing a mark on the map and connecting the marks to follow the migration of the shark.
- In the Gulf of California, many species of shark migrate to the open ocean in search of food including small fish like sardines and herring; but they also like to eat squid and octopus. In search of food, blue sharks can migrate over 3000 miles!
- Print the map (see ***Worksheet: Tracking a Shark***) and the directions for the shark tracking activity.
- Each student should receive a copy of the directions and the map.
- Map Directions: The map has **horizontal** lines indicated by numbers (1-21) and **vertical** lines indicated by a letter of the alphabet (a-u).
- Each **coordinate** is made up of a letter and number. Use the coordinate to mark the position of the shark on the map.
- Connect the coordinates by drawing a line from one coordinate position to the next to track the movements of Jeff the Shark.

**Discussion with Students**

- Following the tracking exercise, discuss with the students Jeff's movements. Have the students think about his movements and why he may have preferred certain areas. Also, have the students discuss his shark senses and how he might have navigated to all of the areas.
- Some discussion prompts:
  - What was the farthest location (coordinate) Jeff moved from the point he was tagged? (Have the students use a ruler to measure from his starting place to find the farthest location he moved to.)
  - Jeff had returned to the Gulf of California when the tag came off at the end of his journey. Discuss some reasons why Jeff may have returned to this inland

sea. (Some possibilities would be to find food or to find a mate). Jeff was often found to visit **seamounts** in the ocean. What is a seamount?

- Discuss some reasons why Jeff may visit seamounts? (Some possibilities would be to find food, find a mate, or for preferred ocean temperatures.)

**Activity 3: All about the Blue Shark - see reading handout**

- Read & discuss as a class

**Activity 4: Shark Word Search**

- Make copies for students

**Lesson Extensions: Shark Tagging Video Gallery!**

- National Aquarium's Shark Tagging Trip
  http://www.aqua.org/care/conservation-initiatives/shark-tagging
- Discovery Channel: Shark Up! Shark Up! - off the coast of California, researchers tag a massive great white shark. The tag will help reveal where this apex predator is going and why - 02:27 minutes
  http://dsc.discovery.com/tv-shows/shark-week/videos/great-white-shark-videos.htm
- Discovery Channel: Tagging a Ruthless Shark - a research team tags an enormous great white shark just off the coast of Cape Cod - 02:13 minutes
  http://dsc.discovery.com/tv-shows/shark-week/videos/great-white-shark-videos.htm

**Further Student Exploration:**

- Book recommendations
  - **Shark (DK EYEWITNESS BOOKS)** by Miranda MacQuitty
  - **Uncover a Shark** by David George Gordon
  - **What Do Sharks Eat For Dinner?** by Melvin Berger, Gilda Berger
  - **The Best Book of Sharks** by Claire Llewellyn
  - **Sharks : 3-D Book** by Discovery Kids
  - **Shark!: A Sticker Safari** by Discovery

**References:**


- Iemanya Oceanica
  http://www.adoptashark.com/
- The-Shark-Side-Of-Life
  http://www.the-shark-side-of-life.com/
- Discovery Channel
  http://dsc.discovery.com
- The Shark Side of Life
  http://www.the-shark-side-of-life.com
- Shark World
  http://www.sharks-world.com

# Cabrillo Marine Aquarium
# Lesson Plan

**Grade Level:** Kindergarten through Third Grades

**Title: Shark Biology, Shark Bingo & other JAW-some Shark Activities!**

**Objective:** This collection of classroom lessons, activities and games will introduce young students to the biology and behaviors of sharks, skates and rays. While also having FUN!

**California Science Standards: K:** 2a-c, 4a-e **1st:** 2a-d **2nd:** 2a-d, 4a-g **3rd:** 3a-e, 5a-e

**Time to Complete**: approximately 30 minutes for each lesson

**Materials provided by CMA:** ***Worksheet: Shark Coloring Sheet, Worksheet: Parts of a Shark, Graphic: Parts of a Shark Answer Key, Graphic: Cut and Paste Words for Parts of a Shark***

**Materials provided by Teacher:** Xerox copies of the Shark Bingo Card Print-outs, paper plates, Bingo game pieces (ex. bottle caps, dried pasta shells), classroom art supplies - markers, paper, scissors, glue, etc.

**Vocabulary:** Chondrichthyes, cartilage, dermal denticles, cold-blooded, camouflage, countershading, fusiform, caudal fin, pectoral fin, dorsal fin, pelvic fin, gills, lateral line, electro-receptors, ampullae of Lorenzini, gill rakers, carnivores, plankton, prey, ecosystem, conservation, apex, keystone species

**Teacher Preparation**: Go through the lessons that you plan to do for the week and prep any materials you may need to complete the project or activity.

**Background Information:** Sharks are mysterious and misunderstood creatures that have fascinated people for generations. There are over 400 species of sharks worldwide. Sharks belong to a large group of fishes known as **Chondrichthyes**, which in Greek means "cartilage fish." This group also includes skates and rays, all of which have skeletons made of cartilage, not bone.

**Lesson Outline:**

- **#1 - Shark Anatomy**
- **#2 - Shark Senses**
- **#3 - Shark Feeding Behaviors**
- **#4 - Shark Bingo!**
- **#5 - JAW-some Shark Activities & Games**

**Lesson Procedures:**



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**Lesson #1 Shark Anatomy: Show & Tell**

- There are lots of misinformation and fallacies about sharks. Ask your students these questions. Give them the facts and try and dispel the myths.
  - Do sharks have a skeleton? Yes, sharks have skeletons made of **cartilage**, the same material that our ears and noses are made of. **(have students investigate the shark vertebrae)**
  - Do sharks have scales like most fish? Sharks are covered with tiny, tooth-like **scales**, called **dermal denticles**. These scales grow on the shark's skin usually point towards the tail. They make the shark's skin feel like sandpaper. **(have students touch the shark skin)**
  - Are sharks warm-blooded like people? No, sharks are **cold-blooded**. This means that their blood changes temperature as the water temperature changes. (Quick Fact: Some sharks like the great white, threshers, and porbeagles have special heating systems that keep their blood slightly warmer than that of other sharks.)
- What color are sharks? Sharks are generally a light color underneath and darker above. This is a type of **camouflage** that helps them blend in with their surroundings. When viewed from above, sharks blend in with the dark ocean depths. When viewed from underneath, they blend in with the lighter sea surface. This is known as **countershading**. **(show the great white shark picture and counter shading)**
- How do sharks swim? Sharks' bodies are **fusiform** (streamlined and torpedo shaped). They have five different kinds of fins that they use to lift, stabilize, and propel themselves. The **caudal fin**, or tail fin, can be used for turning as well as for propulsion. Unlike most fish, the shark's backbone extends well into the tail, making it very powerful. The erect **dorsal fin** on a shark's back is used for balance. The second dorsal fin controls rolling. The front fins, or **pectoral fins**, are much stiffer than in other fish. The shark can change the angle of these fins to swim either up or down; they can not swim backwards. Stability is provided by the **pelvic fins**. (Quick Fact: Great White sharks can swim from 20 to 30 miles per hour and unlike most bony fish, sharks have no swim bladders to keep them afloat. They can use oil in their liver, which can be more than 15% of their total body weight, for buoyancy.) **(show the fins of sharks)**
- How do sharks breathe? Sharks breathe underwater the same way fish do, through **gills.** As the sharks take water into their mouths, their gills can absorb oxygen from the water, enabling them to breathe. Most sharks have five slits on each side, although some may have up to seven. **(show gill specimen)**
- How do sharks eat? The jaws of a shark are generally positioned on the underside of the snout. When biting, the snout protrudes upward as the jaws thrust forward. This gives the shark a rather fearsome appearance. The jaws of a shark are extremely powerful. Some sharks can bite hard enough to cut through a piece of steel.
- Do sharks lay eggs? Baby sharks or pups, are born in a couple of ways. Some shark species lay eggs. Laying them in underwater weeds and grasses. Some mothers carry their pups in a sac inside their body for about 10-12 months. Some are even carried

for two years. Female sharks can give birth to fully developed baby sharks, usually tail first. Shark pups are miniature versions of their parents. Once born they must fend for themselves. **(investigate shark egg specimens)**

- Do sharks like to eat people? No, sharks do not normally eat humans, although there are some situations where people are mistaken for food and attacked. Less than about 25 people are killed by sharks each year worldwide. Many more people die from lightning or bee stings than shark attacks. **(show shark jaws and teeth specimens)**

**Activity 1: Shark Color Pages & Parts of a Shark - see Worksheets**

- Tell students that there are about 400 different types of sharks in the world or make this a guessing game and hint - if the number guess is higher or lower, until they guess 400.
- Show students pictures of the different types of sharks **(refer to photos section)**
- Talk about the physical differences between each shark/ray species (color, size, feeding behaviors, habitat, conservation issues; refer to background information)
- Pass out the ***Worksheet: Shark Coloring Sheet*** and ***Worksheet: Parts of a Shark*** - go over the answers using ***Graphics: Parts of a Shark Answer Key***
- Use ***Graphic: Cut and Paste Words for Parts of a Shark*** if necessary
- For more shark color pages and printables go to: http://www.education.com/slideshow/shark-week1/hammerhead-shark-coloring/

**Lesson #2: Making Sense of Shark Senses!**

- Sharks have larger brains than most **cold-blooded** animals. With this larger brain comes a vast amount of sensory information. In addition to the five senses used by humans, sharks possess a sixth, very unique sensory adaptation, **electro-reception**.
    - How do sharks **see**? Although sharks' eyes are small, they can see rather well, even in dim light. Color vision is believed to be somewhat limited. Sharks' eyes are very sensitive to light. They are designed for seeing in the dim light underwater. While most fish do not have eyelids, some sharks have 3 of them. Like humans, sharks have upper and lower eyelids. In addition, they also possess third eyelids that cover the entire eye. Deep water sharks generally have bigger eyes than shallow water sharks.
    - How well can sharks **smell**? Sharks have an extremely acute sense of smell. Nearly two thirds of a shark's brain is devoted to the sense of smell. They can detect minute quantities of certain substances, especially blood, in the water. Fish give off a certain odor when they are in distress, which is easily detected by sharks. They can detect odors up to one mile away.
    - How well can sharks **hear/feel**? Sound is often times the first sense a shark uses to locate food. They have excellent hearing. Some can hear prey in the water from 3,000 feet away. Their internal ear can detect sound as well as feel vibrations in the water, such as the thrashings of sick fish. The shark also uses its **lateral line system** to sense vibrations. The lateral line system is a series of

fluid-filled canals just below the head and along the sides of the shark. The canals are open to the surrounding water through tiny pores. Tiny hairs attached to sensory cells project into the canal. These hairs can detect turbulence or vibrations in the water. Sharks can locate injured or distressed fish by detecting their erratic movement.

- Can sharks **detect electricity**? Yes. They can detect electrical charges that are emitted by all living things. This is called **electroreception**. Some sharks can actually use electricity to locate prey. All living creatures emit small electrical impulses as they breathe or move. A shark uses a system of small holes and canals located in the snout and head called the **ampullae of Lorenzini** to detect these impulses. This works best at close range, and can be used to locate animals that the shark may not be able to see.
- Sharks rely on all of these senses to locate food and to make sharks extremely effective at hunting down prey.

**Activity 2: Sniff-o-Rama**

- Sharks have odor-detecting cells inside their nostrils. They can smell odors in very low concentrations - explain it this way: a great white shark can smell one drop of blood in 100 gallons of water.
- This activity will allow children to use their sense of smell just like a shark.
  - Gather several different opaque jars or vials & label them by number; you should not be able to see the contents through the jar.
  - Fill each one with different fragrant items. One jar could be filled with cinnamon, another one with rose petals, one with orange slices or vinegar.
  - Select familiar scents that the students will recognize.
  - One- at-a-time, have students take turns sniffing the jars.
  - Have students write down their answers.
  - After every student has had a turn sniffing all the jars, go over the contents.

**Lesson #3 Shark Feeding Behaviors: A Feeding Frenzy**

- Sharks do not chew their food. They swallow food whole or in big chunks and rely on enzymes and hydrochloric stomach acids to break the food down.
- Different species of sharks have different shaped teeth. The shape of sharks' teeth depends on the type of food they eat.
- They can have anywhere from 20 to several hundred teeth. Some sharks have one type of teeth in the upper jaw and another type in the lower jaw.
- There are three basic shapes for shark teeth:
  - **Triangular, blade-like teeth; often serrated; used for cutting large hunks of meat out of their prey (great whites, tiger sharks)**
  - **Long, pointed, needle-like teeth; used for impaling, gripping, holding, and tearing (mako sharks, lemon sharks)**
  - **Flattened, blunt teeth, used for crushing (nurse sharks, rays)**

- Sharks often loose their teeth. There are several rows of new teeth in a shark's jaw to replace lost teeth. A replacement tooth can move into place in less than 24 hours. Some species of sharks may loose as many as 30,000 teeth in a lifetime.
- A few species of shark, like basking sharks and whale sharks have small, nonfunctional teeth. These sharks filter plankton out of the water, much like whales. They filter water through their gills and catch plankton with tiny, bristle-like projections called **gill rakers** which are located on the inner margins of the gills.
- Sharks normally do not kill for sport. They kill only when they are hungry. After a large meal, a shark may go for many days without eating at all. A shark will usually eat about 2% of its body weight per day.
- Almost all sharks are **carnivores**, or meat eaters.
- Sharks have a varied diet, including **plankton**, fish, crustaceans, coral, sea urchins, horseshoe crabs, mollusks, sea turtles, sea birds, marine mammals, and other sharks. Most **prey** on weak, injured, or dying animals, since they are easier to catch. Some sharks have food preferences. Nurse sharks prefer crustaceans and mollusks; shortfin makos like bluefish; hammerheads prefer stingrays; bull sharks often eat other sharks; smooth dogfish eat crabs and lobsters; and tiger sharks prefer sea turtles. Sharks do not normally eat humans, although there are some situations where people are mistaken for food and attacked. Only about 25 people are killed by sharks each year worldwide. Fatal shark attacks are extremely rare, that is why it usually makes headline news. People are not a shark's prey of choice.

**Activity 3: Chomp!**

Project Materials:

- Paper plates
- Scissors
- Pencils & Markers

To Make:

1. Fold your paper plate in half "backwards" (with the bottom of the plate facing you, and the folded edges coming toward you).
2. Using small scissors trim away the outer edges of the plate in a sweeping arched "M" design on the top half and bottom half, which should leave it looking like the hinges on the jaw, and the "m" shaped bottom & top of the mouth.
3. **C**ut out a large oval from the middle, and then work from that center to cut out free-form teeth that follow the inside arc of the paper plate on the top and bottom. Shark teeth are often quite irregular and jagged and not always parallel. Be creative!

**Lesson #4 Shark Bingo!**

Game Materials:

- Shark Bingo Cards & Print-outs (make 3-5 copies of each)

- For Shark Bingo Printables - Go to: http://deceptivelyeducational.blogspot.com/2013/01/shark-bingo-game-free-printable.html
- Set of 25 game pieces for each student (ex. dried pasta shells or beans, gummy bears or fish crackers)

How to Play:

- Five squares covered - across, up, down or diagonal - wins!
- Alternatively, play Shark Bingo Blackout.
- In a game of blackout, all of the squares on the bingo card must be marked with a game piece to win.
- Teacher or a designated student can pick and call out the colored game cards. **ex.** Letter S, Bull Shark, color Green or Letter H, Nurse Shark, color Blue
- You can also give facts about each shark as you call the cards

SHARK FACTS:

- **Thresher Shark:**
  - Known for their 10 foot tails; which can be half the size of their body
  - Feed primarily on squid & schooling fish
  - Often get caught in tuna fishery longlines
  - Scientists think they use their long tails to herd or even stun fish

- **Six-gilled Shark:**
  - Also known as a cow shark or mud shark
  - Have 6 gill slits unlike the more common 5 gill slits of most sharks
  - A deep water shark
  - Only has one dorsal fin at the back of its body, near the tail
  - Can grow to lengths of 18 feet

- **Shortfin Mako Shark:**
  - Fastest of all the sharks; can swim at speeds of over 30 mph
  - Prey on sharks, swordfish and tuna
  - Can leap high in the air to try and shake out a hook if caught on a fishing line
  - Have knife-long, serrated teeth
  - Are bluish gray on top and white underneath

- **Hammerhead Shark:**
  - Their eyes are at either end of their rectangular-shaped head
  - Have a heightened sense of electro-reception
  - Make meals out of crustaceans, octopus, rays and small sharks
  - Common around tropical reefs
  - Can give birth to over 40 pups in one litter

- **Bull Shark:**
  - Can grow to a length of 11 feet
  - Can weigh over 200 pounds
  - Have been known to attack swimmers in rivers, estuaries & saltwater creeks that flow directly to the ocean
  - Gray to brown in color
- **Nurse Shark:**
  - Sluggish and generally docile sharks that usually lie on the ocean floor
  - Nocturnal animals, resting in large groups during the day
  - Have long, fleshy appendages, called barbells that hang below their snouts
  - Usually found near rocky reefs, mudflats & sandbars
  - Feed on crab, lobster, urchins & fish

- **Great White Shark:**
  - Strong & powerful swimmers
  - Prey on seals, sea lions, sea turtles and other sharks
  - Are known to attack humans, in a case of mistaken identity
  - Found in all the oceans
  - Can reach lengths of over 20 feet and weigh over 2,000 pounds

**Lesson #5 Jaws-some Shark Activities & Games!**

➢ **Who Am I?**

1. Play a fun game of charades with your students
2. Have students take turns picking an animal from the sea, then act out how it eats.
3. Have the others try to guess what ocean animal they are.
4. Some leading descriptive statements that you can HINT to your students:
   - Can you think of an animal that chases its food? (crab, seabird)
   - What is an animal that waits for its meal to come close? (a ray)
   - What animals strain tiny plants and animals from the sea? (whale shark)
   - An ambush predator? (a great white)

➢ **Science Songs**

- Kids love learning science songs to help them remember science lessons and science vocabulary in a fun & educational setting. Just remembering a simple rhyme can help students recall simple facts about even the most complicated subjects. Elementary schools and middle schools are incorporating fun online games, songs and videos into their regular curricula and best of all, kids have fun while learning!

- Check out these catchy tunes from the band - **They Might be Giants**
  - **I am a Paleontologist**
    http://www.learninggamesforkids.com/science-games/science-songs/paleontologist_song.html

- **Science is Real**
  http://www.learninggamesforkids.com/science-games/science-songs/science_is_real_song.html
- **The Sun Song**
  http://www.learninggamesforkids.com/science-games/science-songs/sun_song2.html
- **Meet the Elements**
  http://www.learninggamesforkids.com/science-games/science-songs/elements_song.html

- Check out these cool **VIDEO** links on Sharks and Rays:
  - Great White Shark : National Geographic Video
    http://www.learninggamesforkids.com/animal_and_nature_games/ocean-animal-games/shark-games/video-great-white-shark.html
  - Whale Shark : National Geographic Video
    http://www.learninggamesforkids.com/animal_and_nature_games/ocean-animal-games/shark-games/video-whale-sharks.html
  - Sting Ray City: National Geographic Video
    http://video.nationalgeographic.com/video/animals/fish-animals/sharks-and-rays/stingray/

➢ **Do-it, Do-it!**

- Why should WE care about sharks? And what can YOU do to protect sharks?
- **Fact: Sharks keep our oceans healthy and productive. Share with your students:**
  - Sharks have evolved in a tight inter-dependency with their **ecosystem**. They tend to eat very efficiently going after the old, sick, or slower fish in a population, keeping that population healthy. Sharks groom many populations of marine life to the right size so that those prey species do not cause harm to the ecosystem by becoming too populous. The ocean ecosystem is made up of very intricate food webs. For the most part, sharks are at the top of these webs and are considered **keystone species**, meaning that removing them may cause the whole structure to collapse. For this reason, the prospect of a food chain minus its **apex** predators may mean the end of the line for many more species.

➢ **Weave a Food Web**

- Students will discover the food/energy relationships within a food web.
- Materials: animal index cards (so that you have one organism/ animal for each student), yarn or string, large playing area
- Game Procedures:
  - Draw or write the names of organisms/ members of the reef ecosystem and use yarn to create signs students can wear around their necks with yarn. (ex.

sea turtle, phytoplankton, zooplankton, fish, sea anemone, octopus, jellyfish, coral, crab, lobster, sea star, sea bird, shark, etc.)

- Be sure you only have one sun, roll the rest of the yarn into a ball.
- Define a food web for your students: write the words sun, phytoplankton, jellyfish, and sea turtle on the board and draw pictures to symbolize each one. Share with students the idea that phytoplankton gets its energy from the sun, the jellyfish gets energy by eating the phytoplankton, and then the sea turtle gets its energy by eating the jellyfish. Explain that most animals eat more than one thing. Tell them that the transfer of energy through food between life-forms in an ecosystem is called a **food web.**
- Take students out to a safe playing area, and have them form a large circle. Give everyone an animal index card to wear.
- Have the person who is wearing the sun card hold one end of the string. Ask students which member of the food web gets its energy from the sun (phytoplankton). As they volunteer answers, unroll the yarn and have students wearing those signs hold onto the yarn. Next, ask students which members of the food web get their energy directly from phytoplankton (coral polyps and zooplankton). Have those students hold onto the yarn, too.
- Continue until the food web is complete.
- Carefully lay the yarn on the ground so that the web stays intact. Step back and notice the pattern created by the interaction of organisms.
- Explain that many factors can disrupt a food web: pollution, overfishing, and habitat destruction. As you name each factor, use your foot to discreetly disturb part of the yarn web.
- Have the students pick up the yarn again and ask them if the web looks the same. Explain that many factors including pollution, habitat destruction, and overharvesting resources destroy ecosystems.
- Instruct students to set the web down again. Ask all corals to take a step back. Have students pick up the web again. Ask students what happens to the food web when an animal becomes extinct.
- Play the game a few times; describing natural & man-made disasters that might disturb the food web.

- **Making Waves** - This activity is to encourage students to be more creative in their writing assignments. Have students write descriptive sentences about the ocean in up and down patterns, depicting the waves of the sea. Then students can add color and ocean animals creating a colorful, language-arts experience!

- **Saltwater Paintings** – Have students paint ocean pictures with a saltwater mixture on white construction paper. In a small container, mix 1/4 cup of warm water with 6 teaspoons of salt and 3 drops of food coloring. Mix well. Have students brush on a beach or ocean scene. Let pictures dry. When the water evaporates the colored salt will remain, creating a colorful & textured ocean scene.

- **Guess Who?** - On index cards write the names of different ocean animals. Have students pick a card and research the animal on it. On the back of the card they can write unique facts about their animals: where it lives, what it eats, color, size, shape, how it behaves and protects itself. When they are finished, your students can swap with multiple partners to guess what ocean animal the description matches.

- **Aqua Animal Acrostics** – This is a great way for students to recall facts about sea animals. Write an ocean word down on the board. Brainstorm related words that begin with each letter and list them on the board. As a class, use the words to create an acrostic about the animal. In no time at all, students will be creating their own!

- **Creature Discovery** - Pretend you have just discovered a new animal in the ocean. Name your animal; tell where you found it, what it looks like, size and color, what it eats, and how it behaves. Make an illustration of your ocean animal in its habitat and share your discovery with the class. The stories and illustrations can be separated and your students can guess which creature illustration matches its description.

- **Sand Art –** Give each student a sandwich-sized plastic baggie filled with sand, add a few drops of desired food coloring, seal bags and shake for about 1 minute. Have students design a beach scene on white construction paper using white Elmer's glue. Then pour the colored sand over the entire picture and after about 10 minutes have students shake off the excess sand into a container. Students can also share their colored sand with classmates to make a colorful beach scene.

**References:**


- Shark Traveling Trunk Curriculum: Cape Lookout National Seashore www.nps.gov/calo/forteachers/classrooms/travelingtrunks.htm
- The-Shark-Side-Of-Life http://www.the-shark-side-of-life.com/
- Learning Games for Kids http://www.learninggamesforkids.com/
- The Great White Shark: Dare to Explore http://library.thinkquest.org/
- How to Smile.org/ All the Best Science & Math Activities: Sharks Sense of Smell http://howtosmile.org/
- The Original Paper Plate Shark Jaws http://paperplatesharkjaws.com/
- Shark Bingo http://deceptivelyeducational.blogspot.com/
- Sea World: Corals and Coral Reefs: 4 - 8 Teacher's Guide www.usm.edu/marineeducation/old/coralreef/13.pdf

# Reading Handout: How Megalodon Worked

***Carcharodon megalodon***, the megatooth shark, isn't just a favorite topic among science fiction fans and cryptozoologists (who study evidence of the existence of unverified species) -- it was a real, living shark that roamed the oceans around 1.5 to 20 million years ago. ***Carcharodon megalodon*** was discovered in the 1600s when naturalist Nicolaus Steno identified large fossils -- previously thought to be tongues of dragons or snakes -- as giant shark teeth. Since then, biologists and scientists have unearthed hundreds of fossilized megalodon teeth and **centra** (boney, vertebrae-like spinal segments), allowing us to learn more about this mysterious creature of the ancient seas.

**Mega Anatomy**

Since the skeleton of a shark is primarily made up of cartilage, which decomposes over time, the only megalodon remains we've discovered are serrated teeth and vertebrae-like centra. This has left experts with the arduous task of reconstructing megalodon's anatomy based on limited knowledge. But, just as human dental records can be examined postmortem to identify remains, shark teeth can also tell experts enough to identify the species and its size, possible prey, and prey size. Hundreds of megalodon tooth fossils have been found, and they average 6 inches in length -- about the size of a human hand. By comparison, great white sharks' teeth average around 2 inches long.

Using fossilized teeth, scientists have reconstructed the jaws of the megalodon and discovered that this shark's mouth was a staggering 7 feet in diameter. Based on this reconstruction and additional research, experts believe that this ancient shark had a broad, domed head with a short snout and massive jaws. If the latest reconstruction is accurate, paleontologists believe megalodon was wider than the great white with larger pectoral fins, and could have grown up to 45 to 60 feet in length -- about the size of a Greyhound bus.

In addition to the knowledge gained from megalodon teeth, the centra tell their own story. Because sharks are cold-blooded, each year they get growth rings on their vertebrae with the changing of the seasons, just as a living tree does. Experts can easily determine a megalodon's age at death by examining the centra and counting how many rings appear. The color and width of the rings also help determine growth rate; wide, light rings indicate a faster growth than narrow, dark rings. By studying megalodon's tendencies in growth rate and age at death, scientists are able to understand more about sharks' evolution and how to conserve today's shark populations, too.



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PHONE 310-548-7562 • FAX 310-548-2649 • www.cabrillomarineaquarium.org
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**Life of a Megalodon**

What could life have been like for such a monolith of the sea? Many theories float around about the megalodon's habitat and prey. Megalodon fossils have been discovered far and wide, from Japan to the United States, so researchers conclude that megalodon was an intercontinental species, living all over the world's ancient oceans. Due to the coastal locations where the most fossils have been discovered, experts believe the megatooth shark had similar habitats as the great white of today -- living offshore in more temperate climates and setting up nurseries in warm, shallow water closer to coastlines [source: Renz].

In 2009, a group of paleontologists from the University of Florida in Gainesville discovered the fossilized remains of a megalodon nursery in Panama that was made up almost entirely of juvenile megalodon tooth fossils. Between this new discovery and a breeding ground found in South Carolina, scientists believe that an infant megalodon could have been an average 20 feet long, the same size as an adult great white.

Life at the top of the food chain meant the megalodon could eat whatever it wanted and, with its supersized, serrated teeth and a wide mouth, it could disable whales and seals easily before gulping them down. A team of researchers in Australia determined the megalodon's bite force was so strong, it could crush the skull of a whale as easily as a human can eat a grape. So what happened to the megatooth shark that knocked it from the top of the food chain to complete extinction?

**Extinct Legend or Living Myth?**

Most scientists, paleontologists and other experts believe from the fossil evidence that megalodon became extinct over 2 million years ago during the Plio-Pleistocene period. One theory puts changes in climate and shifts in the continents as the cause. Another suggests that large predators like orcas and great whites could have preyed on juvenile megalodons, decreasing their chance for survival to adulthood. Megalodon expert Gordon Hubbell theorizes that the megalodon's diminishing food sources could have also been responsible for its demise -- as whale populations disappeared from tropical waters, the megalodon began to disappear, too.

**The Modern Megalodon**

Despite the fact that scientists believe megalodon has been extinct for 1.5 to 2 million years, this mysterious megabeast continues to fascinate and educate people today. It is important to understand megalodon's history, because it provides clues about the evolution of sharks and can help with today's shark conservation efforts. Since several shark species are showing signs of population decline, scientists look to megalodon to help them understand how a top marine predator can become extinct. Sharks may have a reputation for being killers, but they provide a vital service for the future of healthy ocean ecosystems.

Reference:
http://science.howstuffworks.com

# Reading Handout: All about the Blue Shark

Beautiful and elegant are not words often associated with sharks, but they seen appropriate for the sleek blue shark. Its streamlined, indigo-blue body seems to move effortlessly from the surface to the deep sea that it favors.

**Description**

Its large pectoral fins help with swimming, but its secret to **buoyancy** is a giant, oil-filled liver. This makes it easier for the shark to travel incredibly long distances. One tagged blue shark traveled from New York to Brazil, a distance of over 3,740 miles.

**Feeding Habitats**

Blue sharks eat until they almost burst. Researchers have observed groups of the shark approach schools of anchovies. They will feed enthusiastically and then will later **regurgitate,** before starting to feed once again. In addition to anchovies, they also consume mackerel, sardines, birds, seals, turtles and squid. **Gill rakers** help to prevent the slippery squid from escaping. The shark's quest for food sometimes compels it to dive to depths of 1,500 feet or more.

**Growth & Reproduction**

The blue shark is a **viviparous** species, nourishing the young in the uterus and giving birth to live pups. Once the eggs have been fertilized there is a gestation period of between 9 and 12 months. The new-born pups measure 16 to 20 inches in length and litters usually consist of between 25 to 50 individuals. Litters of up to 135 pups have been reported. Females reach maturity at a size of 7 to 11 feet, while for males it is achieved at lengths of 6 to 9 feet.

**Habitat and Range**

In temperate waters the blue shark is a wide ranging **pelagic** species occurring near the surface. In tropical waters the blue shark is more commonly found in deeper waters as it prefers cooler temperatures between 7 and 16 degrees Celsius. The blue shark occurs in the Atlantic, Pacific and Indian Oceans in both inshore and offshore waters.

**Conservation Concerns**

This is the considered most "fished" shark of all shark species. They are caught for their fins, shark skin, tails and flesh. Sadly, over 10 million of these sharks are killed due to human capture every year. Conservation efforts are being taken, globally to save these majestic animals.

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