Fundy Geological Museum: Shark Teeth!

The Fundy Geological Museum's primary field site (Wasson Bluff, NS) is known for being the location of Canada's oldest dinosaur, but there is so much more there! Did you know that 200 million years ago there were sharks in Nova Scotia too? Shark body fossils are not often found, but shark teeth are common in the fossil record. Shark skeletons are made of cartilage (same as your ears and the tip of your nose) which does not easily fossilize. Shark teeth are made of dentin (like our teeth), which is a hard substance the fossilizes well. Follow the activity below to learn how we can use fossil shark teeth to learn more about ancient sharks.

Introduction (for teachers/educators/adults)

Megalodon was the largest shark that ever lived! Estimated to be approximately 18m in length, this formidable top predator occupied the world's ancient oceans 17 to 2 million years ago. Megalodon—or *Carcharodon megalodon*—consumed vast quantities of marine animals and likely contributed to the stability of ecosystems, the same as top predators do today. Understanding megalodon's life history is critical to improving our knowledge of evolution and living shark conservation.

Students will actively inquire and evaluate hypotheses while answering the following questions about megalodons:

- **How big was megalodon**
- **How long did megalodon live?**
- **What did megalodon eat?**
- **When did megalodon live?**
- **Where did megalodon live?**
- **Who was megalodon related to?**
- **Why is megalodon important?**

Lesson Summary:

This lesson will allow students the opportunity to estimate the body length of a megalodon based on modern shark models. Students will be 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 a megalodon, using the same methods as professional scientists. Younger students will instead construct a Megalodon to scale.
STEM Subjects: anatomy, geology, life sciences, mathematics, physics
STEM Concepts & Skills: allometry, morphology, graphing, obtaining measurements
Vocabulary: allometry, cartilage, cartilaginous, centrum (centra), fossilization, morphology, ossification (ossified)

Background Information:

Based on the size of megalodon teeth, we know that this shark was larger than all modern and extinct sharks. However, it is difficult to know the exact size of a megalodon as entire skeletons are not

preserved. This is because all sharks have cartilaginous skeletons (i.e. composed of cartilage), which does not 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, we must use modern sharks to estimate the size of megalodons. 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.

Materials:

- **Copies of the activity sheet**
- **Pencils**

Procedure for teacher/educator/adult:

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. This discussion can cover all vocabulary words and explain why modern sharks are needed to help us determine the body size of megalodon. 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 (provided on activity sheet)—graphing 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 see that an allometric relationship exists between shark tooth width and body size. Lastly, they are asked to extend their graph to meet the appropriate tooth width of a megalodon; this task will allow students to estimate the body size of megalodon. A megalodon tooth that is 14 cm wide should yield a body length estimate of approximately 18m!

Discussion Questions:

- **How big were megalodons?**
- **Why are complete megalodon skeletons not preserved?**
- **Can we use modern sharks to help us estimate a megalodon's body size? Why or why not?**

Extension Activities:

Once a size estimate for megalodon has been determined, a roll of tape (or string) can be cut to represent megalodon's body length to scale. Additionally, younger students can figure our 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 within increasing body length and is instead exponential?). How would juvenile teeth line up on this graph? Since sharks are constantly replacing their teeth, how would a geriatric shark tooth look? Would it be larger because the shark is older, or would it be smaller due to having less resources to contribute to growing new teeth?

The following are the pages meant for students:

Megalodon was the largest shark to have ever lived! Bust just how big was Megalodon?
Today, you will determine a megalodon's size using the exact methods of professional scientists.

Background
Complete shark skeletons are not found in the fossil record. Do you know why that is (hint: wiggle your nose and ears for the answer)? Because we don't have complete fossilized skeletons of megalodons, we must instead look at living sharks as model.

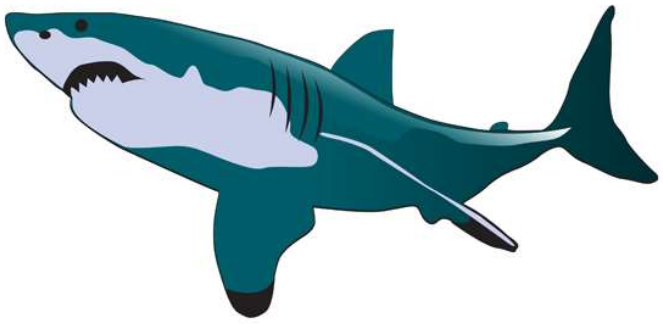
Key Question
Is there a predictable relationship between tooth width and body length in modern sharks?

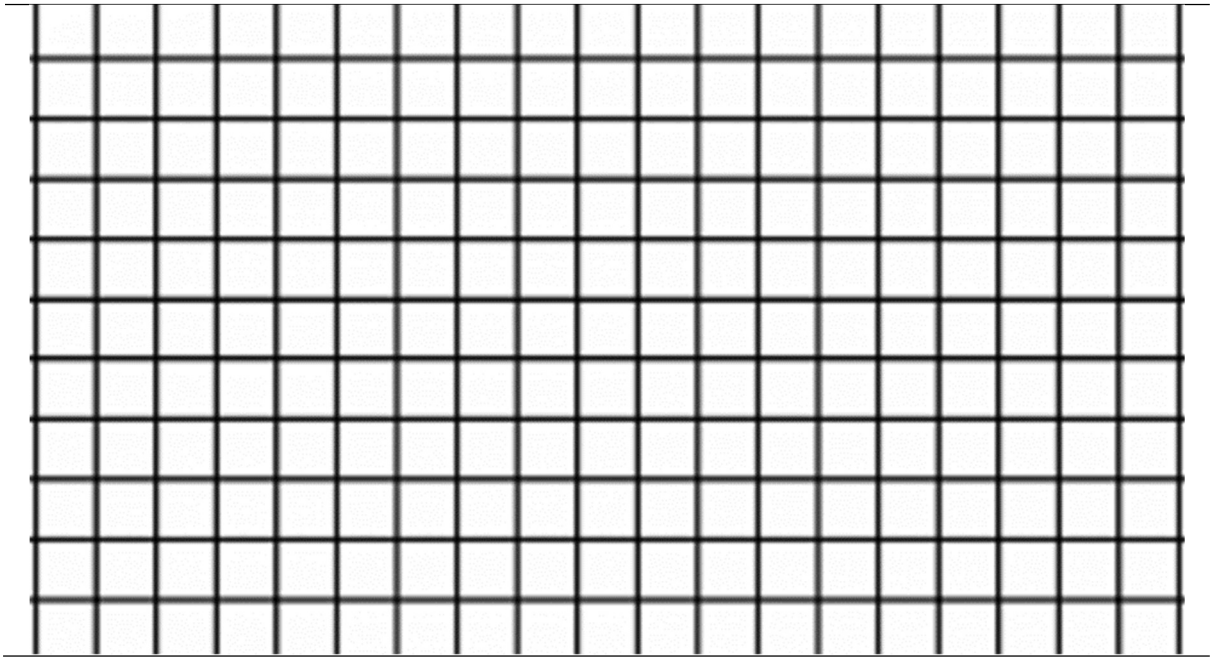
Directions
Develop a hypothesis to help answer the key question. Use the following data to test your hypothesis. This can be done by graphing tooth width (your independent variable) on the x-axis and body length (your dependent variable) on the y-axis. Be sure to label your graph!
After you have graphed all of the data in the data table, answer questions 1 & 2. Next, extend your graph to intersect with the megalodon tooth width of 14cm and determine this megalodon's body length.

Use the data in the table below to plot the relationship between shark tooth width and body length.

DATA TABLE

Tooth Width (cm)	**Body Length** (cm)
0.5	66
1.3	163
2	254
2.5	323
3	381
3.6	457
3.8	483
5.1	635
12	1500





Questions

1. What is your null hypothesis? Is it testable and falsifiable? Why or why not?

2. After graphing your data, is your null hypothesis supported or falsified? Explain.

3. After extending the graph to meet the tooth width of Megalodon, what is your estimate for Megalodon's body length?

Extra Credit:
Do you have any concerns about this estimate? Why or why not?

Shark Teeth at the Fundy Geological Museum

Here are some images of shark teeth in the Fundy Geological Museum Collection.

Fossil Megalodon shark tooth, 11.2cm wide. From unknown location.

Hybodont shark (extinct group) tooth from Wasson Bluff, near Parrsboro, Nova Scotia. The tooth is approximately 200 million years old and is 0.3cm wide.

Juvenile great white shark tooth that was collected in Advocate Harbour, Nova Scotia in 2015. Tooth is 2.5cm wide.

Question: What do you estimate the body lengths are of the megalodon, hybodont shark, and the Great White Shark based on there tooth widths? Hint: use the graphing plot you created.

Part of activity modified from *MEGALODON: Largest Shark that Ever Lived, Educator's Guide* by the Florida Museum of Natural History.