



Anchoring Phenomenon

Numerous reports suggest an increase in white shark encounters* in the United States in recent years and the public is worried.



Lesson Concept

Analyze and interpret patterns in shark fossil data to document the existence and diversification of white sharks from their ancestors to estimate historical population size for use in revising an explanation of causes of recent increases in the white shark population.



Investigative Phenomenon

Fossil shark teeth can inform us about the past.

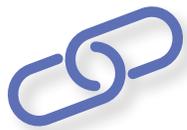


Standards

Refer to Appendix 8.2 for NGSS, CCSS (ELA), and California ELD standards.

*Encounters include sightings and census estimates, as well as physical interactions between humans and sharks.

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Storyline Link

Prior to this, students were introduced to the anchoring phenomenon of questioning the increased number of white shark encounters in the United States in recent years causing the public to worry.

Since this is positioned at the beginning of the last instructional segment for grade 8, it is expected that earlier in the school year, students learned about the fossil record, documenting the existence, diversity, extinction, and change in life forms throughout Earth's history. They also learned that the geologic time scale is interpreted from rock strata to organize Earth's history. This prior learning is recalled as students analyze evidence for white shark evolution and discuss ideas with peers. Students determine that sharks have been on earth a relatively long time and that species changed dramatically after every mass extinction. Species of sharks and the time periods they lived can be observed through fossils. Students mimic the investigation of this by using data to provide evidence for a phenomenon, using "random" sampling to look for patterns in rates of change and numerical relationships. Students come to the conclusion that, although fossil evidence is useful in many circumstances for establishing the existence, diversity, extinction, and change in life throughout time, it is insufficient when attempting to determine past population sizes of white sharks; the data is insufficient, as it relies on too many assumptions. This is the first time students consider assumptions to be a limitation of data, specifically fossil data. Although we can roughly estimate relative size, too many assumptions must be held to have a reliable measure (for example, only a portion of sharks fossilize—teeth, but teeth are constantly being replaced, sharks do not stay in one location, etc). This touches on an important nature of science themes, that the certainty and durability of science findings varies. This lesson is part of a series in the learning sequence that will culminate in students revising an explanation over time, leading to engaging in argument from evidence about the causes of recent increases in the white shark population with the goal of building public understanding and alleviating concerns.

In the next lesson, students analyze how historic fisher logs provide information on changes in white shark populations. They learn how humans have impacted the marine environment through legislation and how this affected the white shark population.

Throughout the lesson, a flag (▶) denotes formative assessment opportunities where instruction may change in response to students' level of understanding and making sense of phenomena.

8.2 Fossil Evidence



Time

90 Minutes

Part I	25 minutes	Engage
Part II	30 minutes	Explore
Part III	35 minutes	Explain



Materials

Whole Class

- 8.1.C1: Shark Encounter Claim Chart (from Lesson 8.1: Shark Encounters)
- Tips for Finding fossilized shark teeth! At the beach!* video, <https://www.youtube.com/watch?v=THmn-UVmRrE>

Per Group of 4

- 8.2.G1: Expert Group Cards
- 8.2.G2: Time Scale Cards
- Tub
- Sand to fill tub
- Small beads (or other small objects in two different colors)
- Newspaper (or tray)
- Small plastic cup

Individual

- Science Notebook
- 8.1.H2: Scientist Communication Survival Kit (from Lesson 8.1: Shark Encounters)
- 8.1.H3: My Shark Encounter Claim Chart (from Lesson 8.1: Shark Encounters)
- 8.1.H4: Crosscutting Concepts for Middle School Students (from Lesson 8.1: Shark Encounters)
- 8.2.H1: Geologic Time Scale

Teacher

- 8.2.R1: Geologic Time Scale Key

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Advance Preparation

1. Make sure that **8.1.C1: Shark Encounter Claim Chart** from Lesson 8.1: Shark Encounters, is posted in the room.
2. Prepare three charts to use during the lesson: Shark Population Questions Chart, Shark Fossil Assumptions Chart, and Shark Teeth Data Chart.
3. Review video *Tips for Finding fossilized shark teeth! At the beach!* (Step 2 of Procedure)
4. Duplicate (and possibly laminate) one set of **8.2.G1: Expert Group Cards** for each group of 4 students. (Step 3 of Procedure)
5. Duplicate (and possibly laminate) one set of **8.2.G2: Time Scale Cards** for each group of 4 students. (Step 3 of Procedure)
6. Duplicate **8.2.H1: Geologic Time Scale** for each student. (Step 3 of Procedure)
7. Plan for Expert Group meetings (i.e., one in each corner of the room).
 - a. Make a sign for each Expert Group (A, B, C, D) and hang one in each corner of the room.
 - b. The group now becomes the “home group.” Within each home group, assign Expert A, B, C, D. Expert Cards B and C have less reading than the other cards, for differentiation purposes.
8. Students should be seated in home groups of four to foster collaboration.
9. Review entire sequence for clarity before prepping fossil activity. (Step 4 of Procedure)
 - a. Prepare one tub for each group by filling with sand mixed with 2 different colored beads or other small objects (one color to represent fossil teeth and one color to represent modern teeth).
 - b. Place a piece of tape across the horizontal center-line of the tub and another one across the vertical center-line of the tub to create quadrants.
 - c. Decide what ratio you want your students to calculate in this location and place the appropriate number of beads in the tub that will represent modern shark teeth (x).
 - d. Place a second type of manipulative in the tub that will represent fossil shark teeth (y).
 - e. Cover with sand and stir (to simulate wave action).

All tubs in the classroom could be identical, but ideally, each tub should represent different locations for the same species, with slightly different ratios. (See Explore Step 4.f.iii below for clarification.)

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Procedure

Part I

Engage (25 minutes)

Ask questions about data supported by evidence to determine whether fossil remains from sharks have changed through time and if the fossil record can provide us with reliable information about shark populations in the past.

1. Review Lesson 8.1: Shark Encounters

- a. Remind students that in Lesson 8.1: Shark Encounters, they were exploring the idea that in recent years, shark encounters in the United States and around the world have been record breaking. White sharks were responsible for many of those encounters off the coast of California leading people to wonder about the potential causes for the increase. Remind students that they were left wondering how we can tell if the population has actually increased; to do that, we need a context for the normal or average population size. So, today they will try to determine that by digging into the deep past. Ask students to discuss the following in groups and then choose a few students to share with the class:
 - › How do scientists learn research information about the past?
 - › How would scientists know about shark history in the past?

2. Elicit Prior Knowledge

- a. Remind students of our purpose, to establish if we are seeing more sharks today than in the past, fewer, or the same number. In order to do this, how do we know what “the same” is or if that has changed? What do we need to compare to today’s information? Discuss with students how we might establish whether something has changed. (We need a reference.) When students start describing a reference, ask for ideas about what could provide a reference for change; students should eventually conclude that we need information from the past to be able to make the comparison. Ask students to reflect on what they have learned so far this year. When we consider the past, students should recall that many populations (such as foraminifera) fluctuate when there are changes taking place in the environment. For a complete context with sharks then, we need to look into the deep past for sharks, a history dating more than 400 million years.
- b. Present the following scenario to students: Imagine you are a larval paleoichthyologist (someone who studies ancient fish, but larval, someone new to doing this work) taking a walk on the beach and you stumble upon a shark tooth along the high tide line. You are pondering shark populations and what you currently understand, but there are gaps

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in your information. You have an appointment next week to give some information to a news reporter about whether or not the shark population has increased, decreased, or stayed the same and they want your professional opinion. Ask students the following questions:

- i. “What questions do you need to think about (and even ask your colleagues) in order to understand shark populations of the past to be able to give context on the current population?”
- ii. “What types of patterns or change in patterns related to shark populations (past and current) could identify cause and effect relationships that would help you make a determination about the past?”

Ask students to record their questions in their Science Notebook. During a class discussion of questions, chart student questions on the Shark Population Questions Chart for use in the Explore activity.

c. Some things students might ask:

- › *Do sharks leave behind fossils? If so, what kind?*
- › *Where would we find shark fossils?*
 - › *Would they always be underwater?*
 - › *Where else might we find shark fossils?*
- › *What similarities and differences would you look for to help you determine if you found a new tooth or a fossil?*
- › *What information was missing from your explanation? (Use **8.1.C1: Shark Encounter Claim Chart** as a reference.)*
 - › *Did you have multiple pieces of evidence supporting each claim?*
 - › *Was the evidence scientifically relevant?*
 - › *Was there enough information to establish patterns? Establish cause?*

d. After recording in their Science Notebook, give students a few minutes to share with their groups and the whole class. As students share out their questions, be sure the conversation leads to a discussion of the lack of reasoning in the explanation(s) (why was that empty on their **8.1.C1: Shark Encounter Claim Chart**?). How would information from their questions, and information we could possibly obtain from shark teeth, fill in this reasoning gap?

e. The goal is for students to consider looking at the fossil history of sharks to determine a pattern of species diversity, population size, etc. Guide students to refer to claims they made in the previous lesson on **8.1.C1: Shark Encounter Claim Chart** and “information needed to strengthen this explanation” section of the chart. Information from the past may help support one of the claims from the previous lesson—shark encounters today have increased, decreased, or stayed the same.

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TEACHER NOTE

Work with student ideas about where they think they will find shark fossil teeth. One of the easiest ways for people to access shark fossil teeth is to go to the beach where many wash up at the water's edge. To help students have a context for this, you can view the following video (show 0.17-2:20) [Tips for Finding fossilized shark teeth! At the beach!](#)



Procedure

Part II

Explore (30 minutes)

Obtain and communicate information to determine whether fossil remains from sharks have changed through time.

3. Create Expert Groups to Answer the Questions Generated Above

To help them prepare for their interview, let students know that you have reached out to various experts to help better understand shark fossils (specifically, teeth, as that is the part of the shark that fossilizes) and construct a more complete explanation by getting a context for shark populations over time (in this case, we are considering time to be geologic time/ evolutionary history). These experts have information based on their questions.

- a. Distribute one set of **8.2.G1: Expert Group Cards** to each group. Inform students that they will learn from experts on one of four topics, thereby becoming experts themselves.
 - › Assign each student to an Expert Group and direct them toward the appropriate group sign.
 - › As they read, invite students to record a big idea from the reading and any detail that would answer questions from the Shark Population Questions in their Science Notebook. (For classes that need extra support, consider having students meet in Expert Groups and read together; for example, all of the Expert As meet together, all of the Bs, etc., and then report back to their home group.)
 - › Give groups time to share the big idea from the reading and information they feel would contribute to class understanding of questions they asked.
 - › Remind students to use their **8.1.H2: Scientist Communication Survival Kit** (from Lesson 8.1: Shark Encounters) to help with group conversation and to make sure everyone has a chance to share.

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- b. Distribute a copy of **8.2.H1: Geologic Time Scale** to each student and ask them to insert it into their Science Notebook.
- › Ask students to recall understanding of patterns and their role in prediction. (Give students a moment to discuss.) Remind students that Geologic Timelines provide a context of revealing patterns to support prediction of events.
 - › Remind students that **8.2.H1: Geologic Time Scale** indicates the approximate times of the 5 major mass extinctions (highlighted.) Draw students' attention to these times and remind them that these mass extinctions are what separates the time periods. Geologists generally agree on the threshold of more than 50% of all species going extinct defines a mass extinction. This occurs when environmental factors (geologic and climate events) change so rapidly (within a relatively short period of geologic time) that the ability of most species to survive and reproduce is compromised or there isn't enough time for enough reproduction (enough generations) for populations to adapt.

TEACHER NOTE

8.2.H1: Geologic Time Scale is simply a tool for students to use in order to analyze the relative length of time different species lived and the sequence of events that occurred. You can find **8.2.R1: Geologic Time Scale Key** in the Toolbox.

This lesson sequence is designed to be taught at the end of the year after students have learned about the geologic time scale and mass extinctions.

▶ If students do not have this prior knowledge, additional instruction may be required. One suggestion when teaching geologic time scale is to construct a classroom-sized geologic time scale model in which adding machine tape is attached to the walls of the room. String with index cards attached is used for labeling. Key events and time intervals, in years, are marked. (A suggested scale is generally 1 cm = 1 million years). This provides students with a more accurate perception of the immensity of geologic time and patterns of climate and evolution. If this is already constructed in the room, students can attach special "shark cards" to the existing class geologic time scale as well as track on **8.2.H1: Geologic Time Scale**.

- › Distribute one set of **8.2.G2: Time Scale Cards** to each home group.
 - › Instruct students to record information they find on their timeline in order to establish information about past shark populations. This should help explain the evolution of white sharks and determine the population size of sharks through time. (Note that the **8.2.G2: Time Scale Card** about White Shark Evolution has two references to the timeline for students to record.)

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- › Groups shuffle the cards and turn them face down. One student draws a card and reads it, and then the group analyzes and interprets the data on the card in relation to their time scale.
- › When the group is in agreement as to where the information should be written, each member records the fossil information in the appropriate place on their timeline.
- › Direct students to use their Science Notebook to describe any patterns they see about the evolution of sharks and their relative position on the geologic time scale.
- › The person on the right draws the next card and the process continues until all of the cards have been drawn and read.
- › The readings should reveal patterns around diversification of sharks (an increase in different types of sharks over time), distribution of sharks (to worldwide), and fossils of shark teeth (the ones we find today are from “modern” sharks, not ancient).
 - › Facilitate student analysis and discussion by circulating and asking the following:
 - ❑ What patterns do you see? (Expected responses include, *Many different types of sharks appeared after each mass extinction. Sharks did not completely die out after every mass extinction. The appearance of sharks after mass extinctions changed greatly.*)
 - ❑ If you see patterns, what is the evidence for them?
 - ❑ What do you predict will happen in the future? How does a pattern showing change help you predict what will happen in the future?
 - ❑ Does the pattern you see support the conclusion that...

TEACHER NOTE

► For the questions above, students should be relying on evidence in the cards to establish patterns that lead to predictions. For students having difficulty, engage them in a discussion about what this means with all of the cards laid out to help with visually identifying the patterns, and together discuss appropriate predictions given the pattern under discussion.

This sequence uses different descriptors for *time*. “The Past” is still describing the geologic/evolutionary history of sharks. **Ancient** sharks precede the Permian (about 290 MYA), with modern sharks in more recent history (**origin** being “first” and **rise** as the expansion of diversity). **Earliest** is used in reference to early shark fossils (the first fossils to have some traits similar to sharks) and white shark fossils to indicate that the fossils are old, but not so old they are considered ancient (geologically speaking). It’s all semantic! If students are confused, have a conversation about the words and ask students to think of a way to clarify the language for their use. Help language learners with selecting appropriate affixes (such as early/earliest).

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- › The student recording of information on **8.2.H1: Geologic Time Scale** is intended to give a scientist’s perspective of a time scale that’s too large to mentally conceptualize.
- › How long does the history of sharks span? And how long does that compare to other species?
- › How could we study sharks at this scale and how could we study shark teeth at this scale?
- › If you do not have a class scale model, ask: What scale model will help you to gain further insight?
- › Relate a question on scale that students asked on the Shark Population Questions Chart.

TEACHER NOTE

One suggestion for teaching geologic time with students is to build a scale model of geologic time that can be hung on walls in the classroom. This is often done on adding machine tape (tickets, streamers, or toilet paper will also work); one million years of time can be represented by 1 cm. This could have been done previously in the year, and then used in this lesson. In addition to adding shark evolutionary history to **8.2.H1: Geologic Time Scale**, students can add “shark cards” to the classroom scale model.

- › Students may wonder why, when whole groups of other animals became extinct, some sharks were able to survive. Ask them what they recall about food webs and niches. Sharks have a diverse diet and can move rather quickly to a different area, so many were able to find food, even when most living things were dying off. Plus, they evolved to fill various niches as other animals became extinct.
- › Remind students that although the mass extinctions appear to have happened quickly in the fossil record, they actually took thousands, if not tens of thousands, of years to occur.

TEACHER NOTE

Use **8.2.R1: Geologic Time Scale Key** to guide the discussion.

Geologic time scales are often interpreted as having finite divisions between the time periods. This is not true. For example, mass extinctions are generally viewed as a distinct event occurring between two time periods. In fact, according to many geologists and paleontologists, the Permian Extinction occurred over the course of 15 million years during the late Permian period.

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4. Shark Teeth Sampling

- a. Remind students what they learned about shark fossils from their Expert Groups: how shark teeth are the only part of a shark that becomes fossilized, how shark teeth become fossilized, where they can be found, and how you can determine the difference between modern and fossilized shark teeth. Ask students to think about and share ideas of what shark teeth fossils could tell us. Chart the ideas that require us to make assumptions on the Shark Fossil Assumptions Chart.

Possible student responses:

- › *Open water shark behavior has not changed over time.*
 - › *The proportion of modern sharks would need to be the same as the proportion of ancient sharks.*
 - › *Each tooth represents one and only one shark.*
 - › *Not all shark teeth become fossilized.*
 - › *This window of time is the same of a modern shark.*
- b. The geologic time is based on evidence such as fossil evidence. Facilitate a brief discussion to solicit student ideas about the type of information scientists have come to understand from this fossil evidence. Continue discussion until a student mentions that we might get an idea of population size. Inform students that we are going to attempt to use fossil evidence to determine ancient population size of sharks. Ask students to record in their Science Notebook what they recall about features of evidence that make for a quality argument. (Students should recall from grades 3–5 that they must distinguish facts from judgment and speculation, and from grades 6–8 that empirical evidence and scientific reasoning is used to support or refute an explanation.) After a few moments, ask students to share, making sure they are demonstrating knowledge about empirical evidence and scientific reasoning supporting or refuting an explanation. (▶ Ask students who struggle to recall the discussion in Lesson 8.1: Shark Encounters on what was needed for strong/quality evidence and reasoning and how they think that applies here.)
 - c. Inform students that they will get a chance to see what it's like to be paleoichthyologists by sampling an area where fossilized and modern shark teeth are often found. Have students envision scientists surveying an area of the “water column” and counting how many sharks pass through that area over a period of time. Scientists can then survey the sediment and collect the number of teeth in that same area. By comparing the observed sharks (for example, observations from drones) against the shark teeth found (both modern and fossilized), scientists can set up a ratio to predict the numbers of sharks in an area when they find a certain number of shark teeth.

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- d. Provide a scenario; for example, in one area of Chesapeake Bay (where conditions are optimal for shark tooth fossilization), 75 sharks are observed and 3 modern shark teeth are found. In another area, 160 sharks are observed and 6 modern shark teeth are found.
- e. Use this data to determine the relationship, or ratio, of modern shark teeth to observed population. Based on the relationship, or ratio(s), suggested, ask students:
- How does this ratio help you see a possible pattern between the number of modern shark teeth found and the observed population?
 - Using this pattern, how many modern shark teeth might one find if 450 sharks are observed?
 - Using this pattern, how many sharks might be observed if 25 modern shark teeth are found?

Ask students to record this information in their Science Notebook.

TEACHER NOTE

► If students don't understand proportions and using patterns to solve math problems, these topics should be reviewed. Below is an example for students who need help specifically on problems in 4.e:

Sampling example: We sampled the water column in nine areas and counted the number of White Sharks over a 5 year period, then calculated the average number of sharks in that water column (n).

We then sampled the upper sediment and found x number of modern teeth. There is a proportional relationship between the number of teeth and the number of sharks.

$$\frac{\text{number of teeth found in the upper sediment } (x)}{\text{number of sharks in the water column } (n)}$$

We can use this same relationship to estimate the number of extinct sharks by sampling the lower sediment and finding the number of fossilized teeth (y) and setting up a proportion.

In both of the Chesapeake Bay scenarios stated above, the proportional relationship is 4% for number of teeth to number of sharks.

For example: 5 modern teeth are found in a sample and 100 sharks in the water column. In the deeper level, 15 fossil teeth are found. Estimate the number of extinct sharks in the water column.

$$\frac{\text{number of teeth found in the upper sediment } (x)}{\text{number of sharks in the water column } (n)} = \frac{\text{number of fossilized teeth } (y)}{\text{number of extinct sharks}}$$
$$\frac{5}{100} = \frac{15}{x}$$
$$x = 300$$

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TEACHER NOTE (CONTINUED)

As an extension for students at a higher math level or for those wanting to explore, ask them to scale this up even further to estimate the number of extinct sharks there were in any ocean region.

- f. Inform students that they will be collecting a sample of shark teeth in the sediment of a new location that scientists think has potential for finding shark teeth where x number of sharks have been sighted. They will be collecting random samples of two types of beads, or any other assortment of two different manipulatives (perhaps beads for modern teeth, marbles for fossilized teeth) in different quadrants of the sediment (sand) using a cup. Encourage students to randomize how deep they dig into the quadrants with their cups to model how scientists collect teeth samples in sediment.
 - i. First, tell students how many modern sharks have been sighted in this location (n).
 - ii. Students will be sampling their quadrant by sifting the sand for beads representing modern and ancient shark teeth (procedure described below in step h).
 - a. Count modern teeth found in the quadrant (x).
 - b. Calculate the ratio of modern sharks sighted to teeth found.
 - c. Count ancient teeth found in the quadrant (y).
 - d. Solve for ancient shark population.
 - iii. All tubs in the classroom could be identical, but ideally, each tub should represent different areas for the same species, with slightly different ratios. This sets the stage for student discussion around sample size and considerations of how they can make meaning from the different areas. (Students should eventually realize that an average ratio could do this.)

TEACHER NOTE

This sampling exercise allows students to see that the use of modern teeth is a way to estimate a modern population size as a proxy for predicting ancient population size. Since we cannot go back in time to count how many individual sharks there were in an ancient population, we can use the ratio of modern teeth to modern observed sharks to predict ancient population based on number of fossil shark teeth found. (A proxy is a preserved characteristic that can be a stand-in for direct measurement, and is important in science. For example, an ice core is a proxy for past temperature; the oxygen isotopes found in ice cores can give us a measure of temperature the year the snow fell even though we cannot directly measure the temperature that year.)

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TEACHER NOTE (CONTINUED)

When placing the manipulatives modeling modern and fossilized shark teeth in the tubs of sand, stir them around to randomize their placement in the sand. The amount of modern and fossilized teeth you put into each tub is determined by you, based on the scenario you provide (like the Chesapeake Bay scenario), being clear about the number of sharks sighted as this sets the ratio that is needed for predicting the estimated ancient shark population.

This is written for students to “discover” the ratio and use it to determine the ancient shark population. In order to do that, students will need to know the modern shark population and work with the data in their table to figure it out. If you prefer, you could instead provide the ratio (similar to the one given in the Chesapeake Bay scenario) and have students just use that to determine the populations for both modern and ancient shark populations.

- g. Instruct students to think about how they will organize their findings. Suggest that they prepare a data table in their Science Notebook titled Shark Teeth Sampling, and ask students to use this to track the data they collect.

► Students should generate their own data table, but a sample, such as the one below, can be provided for those that need guidance. (Consider simply making the table accessible to students who want/need to see it so they can build it in their Science Notebook, rather than printing the table.)

Shark Teeth Sampling

Group	Quadrant	Modern Teeth	Modern Shark Population Estimate	Fossilized Teeth	Ancient Shark Population Estimate

- h. Model for students how scientists would randomly select a “study site”: flip a coin to find a vertical quadrant location (heads = top and tails = bottom), and flip a coin again to find a horizontal quadrant location (heads = left and tails = right). This will be the quadrant you will be sampling. Then model for students how to sample (get a cup and scoop the quadrant), and how to collect data (pour out the sample onto a newspaper or a tray) and record the number of color A bead (modern teeth) and color B beads (fossilized teeth) in your data table.

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- i. Give groups time to sample and collect data (as described above).
- j. Once the students have determined the data for their group, ask students to share their data and chart for the class on the Shark Teeth Data Chart.
- k. To help students make sense of their data and to make sense of this phenomenon, ask students to think about the following and discuss with their group:
 - i. What do you notice about the different percentages?
 - ii. What information is provided by the patterns in rates of change as seen on the chart?
 - iii. What cause and effect relationship(s) can you identify based on the pattern in the data on the chart?
 - iv. What assumptions did you make to come up with this conclusion? (Note the assumptions listed on the Shark Fossil Assumptions Chart and others that were new to you.)
 - v. Can we use any patterns in this data from the chart to determine the number of sharks in the water? Why or why not?
 - vi. This technique only gives us relative population size; what is meant by relative?
 - vii. What type of data would you need to gather in order to help you more accurately determine the number of sharks in the water column?

TEACHER NOTE

To differentiate the questions for students, all students should work with questions i, ii, v due to their general nature. Questions iii and vii are looking for relationships and, therefore, require application of general knowledge. For students that would like/need to dive deeper into the material and tackle something more challenging, suggest that they think about and discuss iv and vi as they require more application of knowledge to a system and a greater understanding of mathematical concepts to apply an understanding of what *relative* means.

- I. Following the discussion, ask students to write a reflection in their Science Notebook on a couple of key questions from above. (Consider suggesting questions iii. and v.) Allow for partner discussion for students needing language support.

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Some possible assumptions that students could come up with include the following:

- › Sharks do not stay in one place.
 - › Fossils are not easily found.
 - › Favorable conditions are needed for fossilization.
 - › Sharks lose multiple teeth over their lifetime.
 - › Sharks today are similar to sharks in the past. Oceanic conditions today are similar to those in the past.
- m. Once students have had a chance to discuss the questions with their group, share responses with the class.

TEACHER NOTE

This portion of the lesson reveals an important nature of science connection for students as they attempt to make sense of the phenomenon. Science assumes that objects and events in natural systems occur in consistent patterns that are understandable through measurement and observation. That being said, shark tooth fossil data is inadequate for estimating population size because too many assumptions must hold true. Many times, problems in science (such as, what was the ancient shark population) can't be solved by experiment and you are limited by what you have access to. ► Have a brief discussion with students to see what their thoughts are. If students reveal in the discussion that they aren't understanding this important point, adjust instruction. Asking questions such as, "What exactly did you observe? What were you looking for? Why were you looking for this? What is limiting your explanation? What is making you unsure? What would need to be different for you to be confident in the data?" may help, as well as providing an example from an experience students may have in their own lives. (An example could be to ask students to consider a time they were given a wrapped present. How could they know what was inside without opening it? Think of similar ways they might gather data and what assumptions they would need to make to decide.)

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Procedure

Part III

Explain (35 minutes)

Analyze and interpret data to find patterns of shark diversity, extinction and changes in life forms on a geological time scale.

5. Make Sense of the Data

Prompt students to consider what they have learned in this lesson. (Students may use the charts generated and their Science Notebook.) Ask them to discuss with their group and then record how they are making sense of the following in their Science Notebook. Before students begin work, inform students that you will be peeking into their Science Notebook to give “sticky note feedback.”

- a. What is a new understanding you have of shark life history over geologic time?
- b. From the data you collected, what do we know for sure and why?
- c. From the data you collected, what questions do you have and why?
- d. What is a limitation in the data?
- e. What data would be useful to increase understanding of past shark populations and why?
- f. How does this connect back to our anchoring phenomenon, *Numerous reports suggest an increase in white shark encounters in the United States in recent years and the public is worried?* What is one thing you now know and two wonderings you are left with about the phenomenon?
- g. I used to think _____ and now I know _____

Examples of sample student responses:

- *I noticed from the ratios in the different sampling tubs that there were always more modern teeth than ancient.*
- *A question I have is how many ancient sharks were present where the ancient teeth were found so we could compare the ratios.*
- *It looks like, over time, there is more and more diversity of sharks, but how else do we know that besides studying fossil teeth, which forces us to make a lot of assumptions?*
- *Depending on how many teeth there are, you can possibly determine the number of sharks. But sometimes, the number of teeth cannot accurately determine the number of sharks because sharks don't stay in one place.*

8.2 Fossil Evidence

- › Consider if one shark dropped multiple teeth, and we were counting each tooth as one shark; that would lead people to a false conclusion.
- › The type of data that would help me is numeric data, where you see the numbers either going up or down.
- › One way to capture data that would help me more accurately determine the number of sharks over time is to put a camera in one area and see how many sharks pass by.
- › We really just need better data where we don't have to guess things.
- › I don't think this was useful to help us figure out if the white shark population is increasing.
- › I used to think fossils could tell us everything about sharks in the past, but now I know it's hard to know for sure.

6. Leave Feedback

- ▶ When students are finished, take time to read Science Notebook responses and leave sticky note feedback. Return Science Notebooks to students and ask them to review the feedback and, if helpful, to discuss questions they may have with their group. After discussing any questions, ask students to consider the feedback and refine their work. Ask students to identify their revisions in some way so that you can check on their progress.

TEACHER NOTE

A primary purpose for the use of Science Notebooks is for students to record their understanding of phenomena as it builds over time. A secondary purpose is for teachers to see where students are in their understanding, what misconceptions they may still have, and to use that information to plan classroom activities that will advance student learning. Teachers do look at Science Notebooks, but, because they are used by students as scientists would use them, it is not appropriate for teachers to assign grades to them. The Science Notebook belongs to the student, just as a scientist's notebook belongs to the scientist.

- ❑ Formative Feedback: Using the method of sticky note feedback is a way to encourage students to modify thinking, given input from a teacher or peer. Feedback should be constructive to give students a pulse on their progress in making sense of phenomena and building 3D understanding, and can give direction where they are on target as well as how to improve. Using a sticky note (rather than writing directly on the student notebook page) sends a signal that the teacher or peer respects that the notebook work is the student sense-making space and belongs to the student.
- ❑ Grading: While the Science Notebooks are not graded, products that use evidence from the notebooks could be. Such products might include an informational paper or a claim with multiple lines of evidence from hands-on investigations documented in the student's notebook. These formal products provide opportunities to address English language arts goals, such as writing for different audiences and for different purposes.

8.2 Fossil Evidence

TEACHER NOTE (CONTINUED)

For more information on this, see: Tyler, B., & DiRanna, K. (2018). Next Generation Science Standards in practice: Tools and processes used by the California NGSS Early Implementers. San Francisco, CA: WestEd. Retrieved from: http://www.k12alliance.org/docs/NGSS-In-Practice-Report_FINAL.pdf

Accommodations

The Engage activity connects students' past learning and experiences about the geologic time scale to the present lesson. Most students own or have seen shark teeth and that experience can be recalled as they begin the lesson. By writing about the topic in their Science Notebook BEFORE discussing, second language learners and low language students can gain confidence and organize their thoughts before speaking in front of a group. Also, sharing ideas in small groups throughout the rest of the lesson lowers the affective filter of low language students. To support students learning English, allow conversations and notebook work to happen in the language that the student is most comfortable expressing understanding, and then encourage expression using simple English phrases (or more complex for students with increasing proficiency). Having students work in teacher-selected partnerships or groups allows the teacher to match students in a way that they are being supported. Allow advanced or motivated students to have the opportunity to explore additional questions that arise.

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8.2 Fossil Evidence

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Expert Group A

Why do we only find shark's teeth and not much else in the fossil shark record?

- ❑ Sharks are a type of fish with an internal skeleton made of cartilage, so they are called cartilaginous fishes. The only hard parts of their bodies are their teeth and dermal denticles. (Instead of scales, sharks have small tooth-like structures on their skin). *Denticle* means *tooth*—the dermal denticles are actually modified teeth all over their skin!
- ❑ Cartilage is the soft connective tissue inside the body that gives support to the body. It's the same type of cartilage that you have in the tip of your nose and top of your ears. Because it is a soft tissue, cartilage does not fossilize like bones do, so we usually do not find it in the fossil record. However, in very rare cases, the skeleton can form an imprint in soft rock like shale.
- ❑ Shark teeth are made of the same material as human teeth. Because they are hard, they are the most common part of the shark to fossilize.
- ❑ Adult white sharks have about 300 teeth arranged in rows. The first two rows of teeth are used to grab and cut, while the teeth in the other rows replace the front teeth when they are broken or worn down, or when they fall out. While biting activity could cause damage, the jaw holding the teeth is made of cartilage, making it easier for teeth to fall out. Sharks are able to replace teeth, one at a time. The front teeth are fully replaced every few weeks, giving the shark a constant supply of teeth.

Fun Fact: White sharks go through about three different patterns of teeth throughout their lifetime. They have one tooth shape before they are born (small blunt teeth), a second shape when they are young and eat fish (thin and pointy), and a third, more triangular shape with serrated edges when they are older and can prey on larger animals like sea lions.

Sources: Helfman, G. & Burgess, G. H. (2014) and University of Florida (2018)

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Expert Group B

How do shark teeth become fossilized?

It's been estimated from sharks in captivity that a shark may lose and regrow as many as 30,000 teeth in its lifetime. In order for these teeth to fossilize, conditions have to be just perfect. Teeth that sink to the seafloor must be buried fast! Being quickly covered by sediment is important in order for teeth to turn into fossil teeth.

- ❑ The sediment cover protects the teeth by keeping them in place and hidden from other animals, and by helping avoid the damaging effects of moving water (similar to weathering).
- ❑ The sediment cover also helps prevent decomposition due to its lower oxygen and bacteria levels.

Fossilizing a shark tooth takes a long time. Over thousands of years, various minerals in the water that seeps through the sediment are left behind in tiny spaces in the tooth. Different minerals account for the different colors we see in fossil shark teeth. This long process of turning the tooth into a fossil is called *permineralization*.

Fun Fact: Shark poop sometimes fossilizes! It is called *coprolite*!

Sources: Helfman, G. & Burgess, G. H. (2014) and University of Florida (2018)

Expert Group C

Where can you find fossil shark teeth and why are they important?

Because of the process by which they form, fossils are commonly found in marine sediments like sand and mud, and in rocks formed by marine sediments. The earliest sharks lived in freshwater habitats, so those fossils are found in river sediments.

There have been constant fluctuations in Earth's climate over time and this leads to expansion and retraction of the sea levels, depending on temperature and glacial activity. Because of this, some marine sediments and marine sedimentary rock may be found inland. It's also possible that in some places these sediments are still under water.

Some popular places in California where there are inland marine sediments with fossil shark teeth include Bakersfield (Kern County) and Scotts Valley (Santa Cruz County).

It's more common to find such fossils in areas that were once shallow marine environments. In the case of Bakersfield, the teeth were preserved during a time when the Central Valley of California was a shallow inland sea. Such shallow seas can be ideal places for some sharks, offering warmth and protection, and making it easier to catch prey.

Fossil shark teeth are important because they give us a record of ancient shark history spanning more than 400 million years. The record indicates that evolutionary change in sharks is very slow and gradual. That slow speed can be a challenge to capture detail in the record. It's also challenging to use fossil teeth as a marker of species because distinctions in the teeth aren't always preserved in the fossil, making it hard to tell one species from another. Scientists, however, have managed to gather enough information to learn some big ideas about the history of sharks.

Sources: Helfman, G. & Burgess, G. H. (2014), Sanders, R. (2009), and University of Florida (2018)

Expert Group D

How can you determine if a shark tooth is modern or a fossil?

There are a few clues scientists use to determine if a shark tooth is modern or a fossil:

1. Because of the process by which it forms, color can sometimes be a good indicator of the age of a tooth. Modern teeth tend to retain that “pearly white” coloration. In contrast, fossil teeth that are made of minerals usually have other colors that make them appear darker.
2. Where the tooth is found can also be a good indicator of modern vs. fossil. If the tooth is found further inland in marine sediments, it’s probably not a modern tooth and is a fossil. If the tooth is found inland in freshwater sediments, it’s likely a fossil that is very ancient. If the tooth is found at the beach it may be modern.
3. Perhaps the best way to answer the question is to find out the age of surrounding sediments. Other species found in the same layer as the shark tooth can give a clue to age. If the tooth is found among shells of modern clams, the tooth is likely modern. If the tooth is in sediments or rock with shells of ancient clams, the tooth is probably also ancient and a fossil.

Of course, being able to identify the species of shark can also answer the question. But even this can be tricky because teeth from the same individual shark can look different. There is a lot of variability in tooth shape and size depending on the age of the shark and where in the mouth the tooth came from: there can even be variability between males and females.

Sources: Helfman, G. & Burgess, G. H. (2014), Martin, R. A. (2003), and University of Florida (2018)

Time Scale Card: Earliest Sharks

You are a *paleoichthyologist*, an expert in fossil fish! You and your research group are investigating a rock layer in Brazil that is about 400 million years old. Your group finds a tooth and quickly makes a drawing of the front and back to send to an expert at the nearby university for identification.

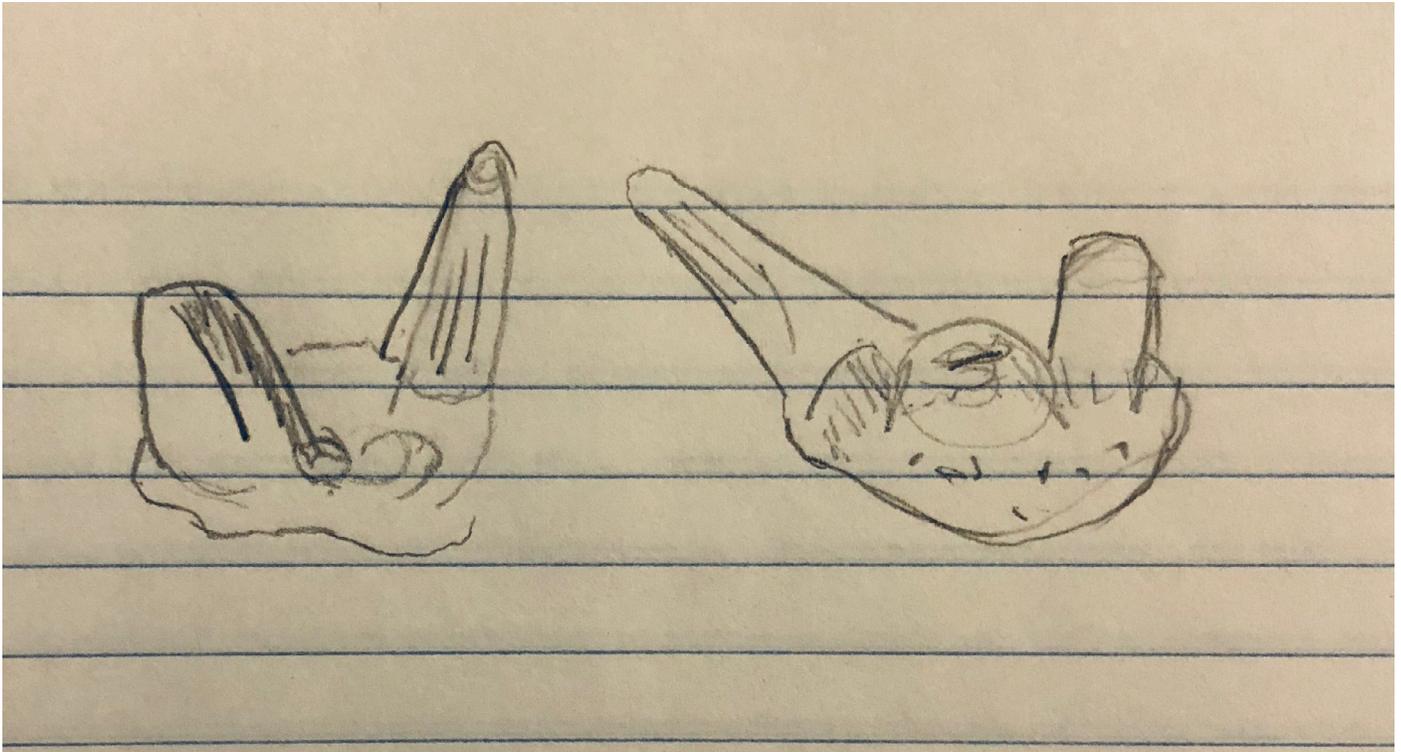


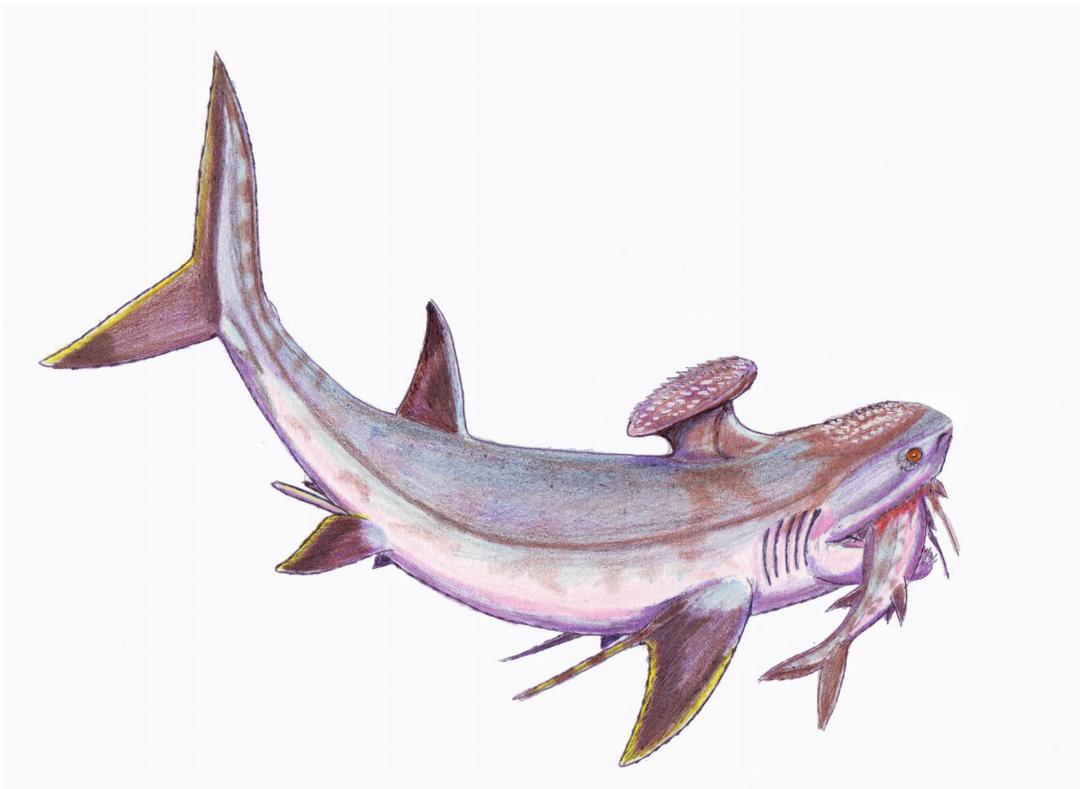
Image by Jill Grace via WestEd [CC BY-NC-SA 4.0]

Your expert replies and identifies the fossil as *Xenacanthus* (gr. *xenos*, lat. *acathos* = “strange spine”), the earliest known shark tooth fossil. These fossils are very rare; not many of these have been found. Your colleague wonders out loud, “Does that mean there were not many sharks living on earth?” Another asks, “Can the number of sharks living at that time be determined?” You are curious about what other life was like during this time, so you pull up your geologic time scale and write “**Earliest Sharks**” to indicate when they first appeared.

Source: Pauliv, V. E., Dias, E. V., Sedor, F. A., & Ribeiro, A. M. (2014)

Time Scale Card: Ancient Sharks

You and your research group are working in a natural history museum, and come across artist sketches of what some early sharks may have looked like, based on rare imprint fossils found in soft shale. The fossils were found in Montana and Scotland in rock layers that are between 360 and 286 million years old. You know that during this time sharks were found all over the world. The fossil record indicates that this was a period of diversification of sharks. *Stethacanthus* are the earliest sharks in the fossil record with dermal denticles (rather than smooth skin). There were even more shark families than there are today! Some of these types of sharks, like *Stethacanthus* pictured below, survived through the Triassic Period. Is it possible to know how many sharks were alive at that time?



Stethacanthus

Image by [Dmitry Bogdanov](#) via Wikimedia Common [CC BY-SA 3.0]

You are curious what other life was like during this time, so you pull up your geologic time scale and write “**Ancient Sharks**” to indicate when they first appeared.

Sources: Martin, R. A. (2003), and University of Florida (2018)

Time Scale Card: Origin of Modern Sharks

As a paleoichthyologist specializing in ancient shark identification, you receive a photo of a rare imprint fossil as well as some fossilized teeth.



Hybodus fraasi

Image by [Haplochromis](#) via Wikipedia Commons: [\[CC BY-SA 3.0\]](#)



Hybodus plicatilis

Image by [Ghedoghedo](#) via Wikipedia Commons: [\[CC BY-SA 4.0\]](#)

You immediately recognize the fossil and teeth as belonging to the genus *Hybodus*, a very common genus found worldwide that were largely marine, but some lived in freshwater. You know that the earliest fossils were found in rocks that are about 280 million years old. You recall that the youngest *Hybodus* fossils (about 66 million years old) were found in the famous Dinosaur Park Formation in southern Alberta, Canada. No fossils have been found that are younger than that.

You decide to place "**Origin of Modern Sharks**" on your timeline, indicating when they first appeared, 280 million years ago. You realize that this species survived the greatest mass extinction of all time—the Permian–Triassic extinction! Approximately 99% of marine species disappeared. How did *Hybodus* survive? You recall that not having food available was the major reason species disappeared. You realize that *Hybodus* probably was able to dive deeper and was able to eat a variety of food, allowing it to survive. Knowing that *Hybodus* has been found in rock layers over a time period of 214 million years (modern people have been on Earth for less than 2 million years), can you determine how many sharks there were during this time?

Sources: Averianov, A. (2014), Discovery Channel (2018), Martin, R. A. (2003), and National Aquarium (2017)

Time Scale Card: Rise of Modern Sharks

A friend recently posted these images after digging around on the internet for images of fossil sharks. She claimed that there was no way they could be fossils! The left image looks just like a ray her family caught while fishing off the pier, and the one on the right looks like a shark she recently saw at the aquarium.



Heliobatis radians

Image by [Daderot](#) via Wikipedia Commons
[CC 1.0]



Galeorhinus cuvieri

Image by [Ghedoghedo](#) via Wikipedia Commons [CC BY-SA 3.0]

She wrote to you because she knows you are an expert in shark fossils.

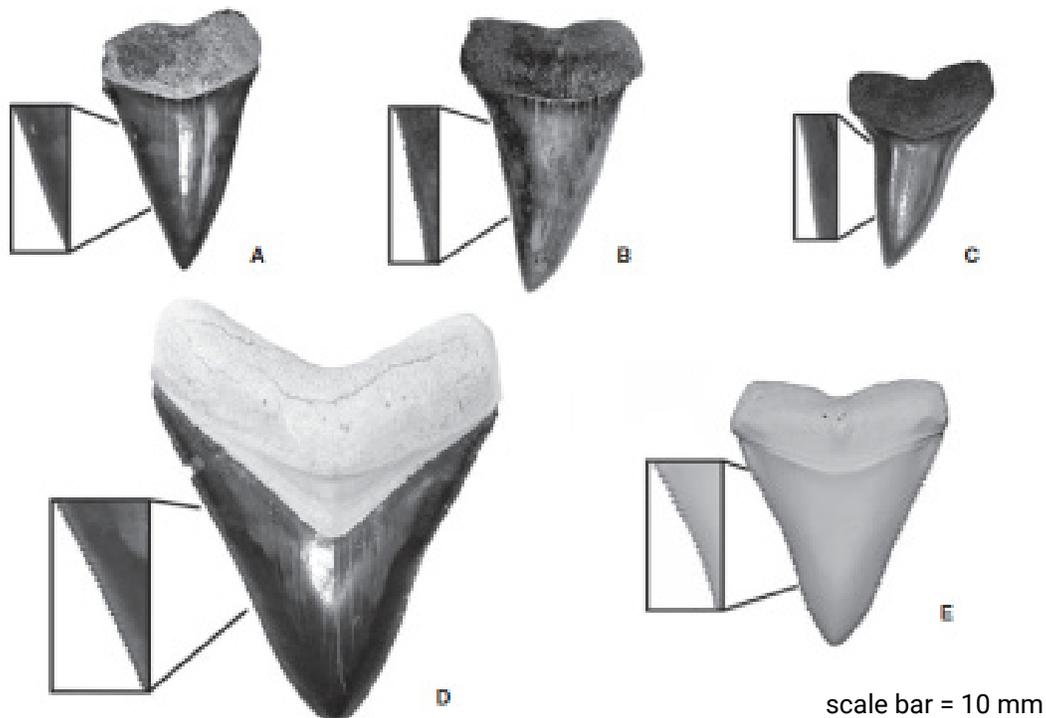
Her question was, “These look like modern animals. The one on the left looks like a ray; the one on the right looks like a typical sand shark. Could they really be fossils?”

You wrote back, assuring her that yes, they really were fossils. You explained that these were some of the first modern sharks. Even though the one on the left lived about 200 million years ago and would be considered one of the oldest modern sharks, and the one on the right around 55 million years ago, today’s sharks have not changed very much from these now extinct relatives. You decide to add “**Rise of Modern Sharks**” to your timeline.

Sources: Fanti, F., Minelli, D., Conte, G. L., & Miyashita, T. (2016) and Martin, R. A. (2003)

Time Scale Card: White Shark Evolution

As a paleoichthyologist, you often get strange images sent to you. Today is no exception. A colleague came across this figure and was wondering if you knew what it was:



Comparison of Serration Types

Image by Palaeontology, 2012 Wiley [Used with permission]

Of course you recognized it immediately! It is a figure from a study trying to resolve the hotly debated evolutionary history of white sharks. The **earliest white shark** fossils date to about 65 million years ago. It's taken a lot of work to piece together the history after that.

There is a hypothesis that the ancestor of those white sharks is the megatooth shark (image D) because of similar tooth characteristics with the white shark (image E). But a discovery of a new fossil (nearly complete set of teeth, jaw, and some hardened vertebrae) in 2012 is uprooting that, suggesting that an extinct shark (image A) is the ancestor of modern mako sharks and modern white sharks and that the new fossil find (image B) is the intermediate between the ancestor (image A) and modern white sharks (image E). Using several lines of evidence such as teeth characteristics, relative dating of sediment layers, and absolute dating of mollusks found at the site, this **modern white shark** fossil (image B) is between 9.5–6.5 million years old.

Source: Ehret, D. J., Et al. (2012)

Geologic Time Scale

*MYA means millions of years ago

Era	Period	Epoch	MYA*	Plant and Animal Development	
Cenozoic	Quaternary	Holocene	0.01	First written language, Beginning of human history	
		Pleistocene	1.6	Modern humans, Many extinctions	
	Tertiary	Pliocene	5	First hominids	
		Miocene	23	Rodents, grasses, kelp	
		Oligocene	35	Modern mammal families	
		Eocene	57	First whales	
		Paleocene	65	Carnivorous mammals, monotremes	
Cretaceous–Paleogene Extinction					
Mesozoic	Cretaceous		145	Many extinctions, including dinosaurs and sea reptiles, first flowering plants	
	Jurassic		208	First rays, first birds, dinosaur diversity/dominance	
	Triassic–Jurassic Extinction				
	Triassic		245	First dinosaurs and mammals	
Permian–Triassic Extinction					
Paleozoic	Permian		290	First mammal-like reptiles	
	Carboniferous		360	First tetrapods, large coal swamps	
	Late Devonian Extinction				
	Devonian		408	First insects	
	Silurian		440	Fish dominant, first land plants	
	Ordovician–Silurian Extinction				
	Ordovician		510	First fishes with jaws, first fishes with cranium	
Cambrian		570	Oldest bone fragments, first organisms with shells		
Precambrian			4650	First one-celled and multicelled organisms, oldest life on earth, origin of Earth	

Source: Martin, R. A. (2003)

Geologic Time Scale Key

(ANSWERS IN CAPS)

*MYA means millions of years ago

Era	Period	Epoch	MYA*	Plant and Animal Development	
Cenozoic	Quaternary	Holocene	0.01	First written language, Beginning of human history	
		Pleistocene	1.6	Modern humans, Many extinctions	
	Tertiary	Pliocene	5	First hominids MODERN WHITE SHARK	
		Miocene	23	Rodents, grasses, kelp	
		Oligocene	35	Modern mammal families	
		Eocene	57	First whales	
		Paleocene	65	EARLIEST WHITE SHARK	
				Carnivorous mammals, monotremes	
Cretaceous–Paleogene Extinction					
Mesozoic	Cretaceous		145	Many extinctions, including dinosaurs and sea reptiles, first flowering plants	
	Jurassic		208	RISE OF MODERN SHARKS First rays, first birds, dinosaur diversity/dominance	
	Triassic–Jurassic Extinction				
	Triassic		245	First dinosaurs and mammals	
	Permian–Triassic Extinction				
Paleozoic	Permian		290	ORIGIN OF MODERN SHARKS First mammal-like reptiles	
	Carboniferous		360	ANCIENT SHARKS First tetrapods, large coal swamps	
	Late Devonian Extinction				
	Devonian		408	EARLIEST SHARKS First insects	
	Silurian		440	Fish dominant, first land plants	
	Ordovician–Silurian Extinction				
	Ordovician		510	First fishes with jaws, first fishes with cranium	
	Cambrian		570	Oldest bone fragments, first organisms with shells	
Precambrian			4650	First one-celled and multicelled organisms, oldest life on earth, origin of Earth	

Source: Martin, R. A. (2003)

Appendix 8.2

Fossil Evidence

Next Generation Science Standards (NGSS)

This lesson is building toward:

PERFORMANCE EXPECTATION (PE)	
MS-ESS1-4	Construct a scientific explanation based on evidence from rock strata for how the geologic time scale is used to organize Earth's 4.6-billion-year-old history. [Clarification Statement: Emphasis is on how analyses of rock formations and the fossils they contain are used to establish relative ages of major events in Earth's history. Examples of Earth's major events could range from being very recent (such as the last Ice Age or the earliest fossils of homo sapiens) to very old (such as the formation of Earth or the earliest evidence of life). Examples can include the formation of mountain chains and ocean basins, the evolution or extinction of particular living organisms, or significant volcanic eruptions.] [Assessment Boundary: Assessment does not include recalling the names of specific periods or epochs and events within them.]
MS-LS4-1	Analyze and interpret data for patterns in the fossil record that document the existence, diversity, extinction, and change of life forms throughout the history of life on Earth under the assumption that natural laws operate today as in the past. [Clarification Statement: Emphasis is on finding patterns of changes in the level of complexity of anatomical structures in organisms and the chronological order of fossil appearance in the rock layers.] [Assessment Boundary: Assessment does not include the names of individual species or geological eras in the fossil record.]

NGSS Lead States. 2013. Next Generation Science Standards: For States, By States. Washington, DC: The National Academies Press.

SCIENCE AND ENGINEERING PRACTICES (SEP)
Analyzing and Interpreting Data
<ul style="list-style-type: none">Analyze and interpret data to provide evidence for phenomena.Consider limitations of data analysis (e.g., measurement error), and/or seek to improve precision and accuracy of data with better technological tools and methods (e.g., multiple trials).
Using Mathematics and Computational Thinking
<ul style="list-style-type: none">Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.
Constructing Explanations and Designing Solutions
<ul style="list-style-type: none">Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion.
Engaging In Argument from Evidence
<ul style="list-style-type: none">Construct, use, and/or present an oral and written argument supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon or a solution to a problem.
Obtaining, Evaluating, and Communicating Information
<ul style="list-style-type: none">Critically read scientific texts adapted for classroom use to determine the central ideas and/or obtain scientific and/or technical information to describe patterns in and/or evidence about the natural and designed world(s).

Appendix 8.2

DISCIPLINARY CORE IDEAS (DCI)

This lesson is intended for students to apply DCI knowledge, as the DCIs listed would have been addressed earlier in the year. To help solidify student understanding of the DCIs, a novel context is presented, providing the opportunity for students to apply and reinforce concepts. In particular, one new context presented is shark tooth fossils. Although fossil evidence provides scientists with much information, fossil evidence is not always the best evidence. The fossils have limitations in this context, but the artifacts and accompanying concepts presented are setting the stage for learning that will take place in high school (where other lines of evidence are used to establish common ancestry and diversity). In this lesson, students only explore similarities and differences among selected shark species and infer white shark evolution from their location in geologic strata.

LS4.A: Evidence of Common Ancestry and Diversity

- The collection of fossils and their placement in chronological order (e.g., through the location of the sedimentary layers in which they are found or through radioactive dating) is known as the fossil record. It documents the existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.

ESS1.C: The History of Planet Earth

- The geologic time scale interpreted from rock strata provides a way to organize Earth's history. Analyses of rock strata and the fossil record provide only relative dates, not an absolute scale.

CROSCUTTING CONCEPTS (CCC)

Patterns

- Patterns can be used to identify cause and effect relationships.
- Patterns in rates of change and other numerical relationships can provide information about natural and human-designed systems.
- Graphs, charts, and images can be used to identify patterns in data.

Scale, Proportion, and Quantity

- Time, space, and energy phenomena can be observed at various scales using models to study systems that are too large or too small.

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Common Core State Standards (CCSS)

CCSS ELA SPEAKING & LISTENING

CCSS.ELA-LITERACY.SL.8.1

Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher-led) with diverse partners on grade 8 topics, texts, and issues, building on others' ideas and expressing their own clearly.

CCSS ELA WRITING

CCSS.ELA-LITERACY.WHST.6-8.1

Draw evidence from informational texts to support analysis, reflection, and research.

Appendix 8.2

CCSS ELA SCIENCE & TECHNICAL SUBJECTS

CCSS.ELA-LITERACY.RST.6-8.1

Cite specific textual evidence to support analysis of science and technical texts.

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California English Language Development (ELD) Standards

CA ELD

Part 1.1 Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics

EMERGING

P1.8.1 Engage in conversational exchanges and express ideas on familiar topics by asking and answering yes-no and wh- questions and responding using simple phrases.

EXPANDING

P1.8.1 Contribute to class, group, and partner discussions by following turn-taking rules, asking relevant questions, affirming others, adding relevant information, and paraphrasing key ideas.

BRIDGING

P1.8.1 Contribute to class, group, and partner discussions by following turn-taking rules, asking relevant questions, affirming others, adding relevant information and evidence, paraphrasing key ideas, building on responses, and providing useful feedback.

In addition to the standard above, you may find that you touch on the following standards in this lesson as well:

- 1.8.4:** Offering and justifying opinions, negotiating with and persuading others in communicative exchanges
- 1.8.5:** Listening actively to spoken English in a range of social and academic contexts
- 1.8.6:** Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language
- 1.8.12:** Selecting and applying varied and precise vocabulary and other language resources to effectively convey ideas
- 2.8.6:** Connecting ideas
- 2.8.7:** Condensing ideas

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