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

Begin to construct an explanation supported by evidence to determine the possible causes of recent increases in white shark encounters and whether past records like the fossil record may provide us with reliable information to give context.

Investigative Phenomenon

This part of the lesson sequence introduces students to the anchoring phenomenon and then uses news reports of sharks as an investigative phenomenon: shark encounters have happened recently and seem to be increasing.

Standards

Refer to Appendix 8.1 for NGSS, CCSS (ELA and Math), California ELD, and EP&C standards.

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

This learning sequence is positioned at the beginning of the last instructional segment identified for California Middle School Integrated, grade 8, in the California Science Framework (essentially, the end of middle school). Important Disciplinary Core Idea (DCI) prior knowledge that students should bring to this learning sequence from grades 6–8 includes history of planet Earth (rock strata and the fossil record can be used as evidence to organize the relative occurrence of major historical events in Earth’s history, ESS1.C), growth and development (animals engage in behaviors that increase the odds of reproduction, LS1.B), information processing (each sense receptor responds to different inputs, transmitting them as signals that travel along nerve cells to the brain; the signals are then processed in the brain, resulting in immediate behavior or memories, MS-LS1-8), interdependent relationships in ecosystems (organisms and populations are dependent on their environmental interactions both with other living things and nonliving factors, LS2.A), ecosystems dynamics (ecosystem characteristics vary over time. Disruptions to any part of an ecosystem can lead to shifts in all of its populations. The completeness or integrity of an ecosystem's biodiversity is often used as a measure of its health, LS2.C), natural selection (both natural and artificial selection result from certain traits giving some individuals an advantage in surviving and reproducing, leading to predominance of certain traits in a population, LS4.B), adaptation (species can change over time in response to changes in environmental conditions through adaptation by natural selection acting over generations. Traits that support successful survival and reproduction in the new environment become more common, LS4.C) and wave properties. As this is at the end of middle school, students should also bring a full breadth of understanding of the 6–8 grade band progressions for the Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs).

This learning sequence primarily serves to help students to extend understanding of wave properties, deepen understanding of waves and information technologies, and begin to build an understanding of magnetic and electric fields (students will receive much more detailed instruction later in the instructional segment) with a subtle nature of science storyline focusing on the value of interpretation of data in science and its role in framing knowledge (science is a way of knowing, scientific knowledge is based on empirical evidence, scientific knowledge is open to revision in light of new evidence). Set in the context of tracking sharks, integration of life science (how we learn information from the fossil record) and Earth science (human impacts) helps students begin to build an understanding of the phenomenon of the possible increase in encounters with white sharks and subsequent public concern. It is recommended that students have prior instruction on wave properties (just wavelength, amplitude, and frequency) when they study astronomy-related DCIs earlier in the year, as this sequence will provide students the opportunity to see those properties play out with tracking devices. (It's possible for this to be addressed in this sequence, but the authors felt that to do so in a way that fosters adequate student sensemaking would take even more time in an already long sequence and deviate too far from the anchoring phenomenon.)

As this is the end of middle school, students should be at middle school level proficiency for SEPs and CCCs, although this sequence will reinforce a few. Throughout the sequence, students will be prominently using many elements of Asking Questions and Defining Problems, Developing and Using Models, Analyzing and Interpreting Data, and an intentional scaffolding of Constructing Explanations and Designing Solutions throughout, which will ultimately lead to students Engaging in Argument from
Evidence as they decide how to influence public perception of white sharks. Cause and Effect is the strongest CCC at play where all elements are used by students (with some elements of Patterns and Structure and Function).

This Engage lesson introduces students to the anchoring phenomenon of the learning sequence (Numerous reports suggest an increase in white shark encounters in the United States in recent years, and the public is worried.) and a real-world investigative phenomenon (Shark encounters have happened recently and seem to be increasing.) that they can investigate. Students use their prior knowledge to share their own ideas about sharks and deepen their ability to ask questions based on observations from text to consider how they can distinguish fact from fiction. Students build on their abilities to analyze and interpret data to provide evidence for a phenomenon by questioning the sufficiency of the data they find. They use patterns to identify cause and effect relationships that are used to begin constructing an explanation about whether or not there are really more shark encounters now than in the past, relying on cause and effect to help them identify that the phenomenon likely has more than one cause. Following this lesson, students will have an opportunity to answer their questions about whether or not the amount of shark encounters in recent history is different from the past and what historical data suggests by analyzing fossil evidence and fishers logs on white sharks.

This lesson is part of a series in the learning sequence that will culminate in students revising an idea 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.

**Overview**

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<th>STEP</th>
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<tr>
<td>Introducing an Article</td>
<td>Students learn about the investigative phenomenon and are provided an opportunity to build excitement in the room and bring opinion out into the open.</td>
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<tr>
<td>Refining Ideas</td>
<td>Students begin to move away from opinion and consider the need for evidence to address key questions. (Key questions have been pre-planned by the teacher in anticipation of what students will bring up in conversation.)</td>
</tr>
<tr>
<td>Identifying Needed Data</td>
<td>Students consider types of evidence needed to address the key questions.</td>
</tr>
<tr>
<td>Gathering More Information</td>
<td>Students use another source of information and attempt to identify a cause for patterns observed.</td>
</tr>
<tr>
<td>Beginning Explanation</td>
<td>Students make a first attempt at an explanation for what we know about white shark life history over time by evaluating three claims.</td>
</tr>
<tr>
<td>Providing a Context for More Information</td>
<td>Students recognize that their explanation is weak without context and that historical information is necessary to strengthen the explanation.</td>
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<tr>
<td>Documenting Current Thinking</td>
<td>Students complete a task to support metacognition that asks them to consider previous ideas, current thinking, and where they need to go next.</td>
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Following this lesson, students will have an opportunity to answer their questions about whether or not the amount of shark encounters in recent history is different from the past and what historical data suggests by analyzing fossil evidence and fishers logs on white sharks.

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.

### Time
90 minutes

### Engage

### Materials

#### Whole Class
- Devices with internet access
- Access to sticky notes (for adding extra information into their Science Notebook)
- 8.1.C1: Shark Encounter Claim Chart
- Video Shark Sightings Force Closure of Stretch of Sunset Beach, [https://www.youtube.com/watch?v=rVQcRCcL-R4](https://www.youtube.com/watch?v=rVQcRCcL-R4)

#### Per Group of 4
- Chart paper (not a whiteboard)
- Markers

#### Individual
- Science Notebook (personal student Science Notebook)
- 8.1.H1: CSULB Shark Lab Reports Record Breaking White Shark Sightings
- 8.1.H2: Scientist Communication Survival Kit (a good resource to keep in their Science Notebook)
- 8.1.H3: My Shark Encounter Claim Chart
- 8.1.H4: Crosscutting Concepts for Middle School Students (to become a permanent Science Notebook resource)

#### Teacher
None
8.1 Shark Encounters

Advance Preparation

1. Create **8.1.C1: Shark Encounter Claim Chart** as a classroom chart to post or display. This chart will be added to and used as a reference in several lessons. (Step 6 of Procedure)

2. Students should be seated in groups of four for the duration of the learning sequence to foster collaboration.

3. Duplicate **8.1.H1: CSULB Shark Lab Reports Record Breaking White Shark Sightings** for each student. (Step 1 of Procedure)


7. Duplicate **8.1.H5: Science and Engineering Practices (SEP) Progressions** for each student. This is a resource that can be referenced as needed when students engage with science and engineering practices.

8. Preview the video *Shark Sightings Force Closure of Stretch of Sunset Beach.*
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Procedure

Engage (90 minutes)

Ask questions about data supported by evidence to determine the possible causes of recent increases in white shark encounters and whether past records like the fossil record may provide us with reliable information to give context.

TEACHER NOTE

Throughout the entire learning sequence, articles, videos, and websites have been carefully chosen so as not to reveal information students will later discover, allowing them to develop ideas over time. This first lesson, especially, is designed to have references that provide incomplete information so students can better engage in SEPs and CCCs. If other references are preferred, review the entire learning sequence to get a sense of what students will be discovering over time before replacing.

1. Setting the Stage

To start the lesson, give students the CSULB Shark Lab press release, 8.1.H1: CSULB Shark Lab Reports Record Breaking White Shark Sightings. This article sets the stage for the investigative phenomenon: shark encounters have happened recently and seem to be increasing. For classes with little prior knowledge on white sharks, see the shark sighting video to set the context without revealing information students will learn later in the learning sequence. (Sunset Beach is near Seal Beach.)

2. Introducing an Article

Ask students to read the press release and record the following in their Science Notebook:

❯ any detail from the press release that seems important or interesting
❯ questions they have about the information in the press release
❯ their own personal experiences with sharks (or experiences of someone they know)

To move students deeper into the SEP, as they record questions facilitate them by asking groups and individual students the following questions:

❯ What questions do you have about white sharks?
❯ What was unexpected?
❯ What do you want clarified?
❯ What do you want more information on?
After time for individual processing, invite students to share with their group a detail they thought was important or interesting; a question they have or something they want clarified or more information on; and a personal experience. Give time to let some excitement in the room build. Remind students to use 8.1.H2: Scientist Communication Survival Kit to facilitate group conversations. (Use of this tool is a differentiation strategy and a strategy to promote more equal talk among students.)

3. Refining Ideas
   a. Ask each group to share one detail with the class and chart. Begin to redirect the conversation away from hype.
   b. Point out that communities where white shark encounters occur need to make decisions about how to respond to public concerns. Responsible leaders must be careful how they communicate with the public. Students’ ultimate goal in this learning sequence is to think about such communication. (They will be making a public service announcement in a few weeks.) Ask for input from students on the types of questions a leader should be asking and chart.
   c. Start guiding the conversation with students. Be sure to specifically ask and chart the following if students don’t generate these questions:
      - How can we distinguish accurate information on sharks from the fantastical stories friends and families share?
      - How can we tell if the frequency of encounters with white sharks in recent years is different than in the past? (Are they increasing, decreasing, or staying the same?)
      - If there is a difference in the frequency of encounters? What are the possible causes? (Students might initially mention there is a difference. They should identify multiple reasons for the difference; acknowledging the plausibility of multiple causes is a necessary discussion. Ideas may include that the size of the shark population is changing, the number of people has increased, and therefore, the number of people visiting the beach is changing, etc.)
      - What evidence will we need to reassure or convince the public? (Probe for student understanding of what is considered quality evidence and ask students to recall the importance of empirical evidence in supporting or refuting an explanation for a phenomenon. Adjust instruction if students do not understand. This will be addressed more specifically in Step 7.)

4. Identifying Needed Data
   a. Ask students:
      - What other information would be useful to help answer these questions?
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- What information is the article missing that you wish was included?
- Remind me what you know about patterns. (Solicit ideas until students begin to describe that we use patterns to help us organize the things we observe so we can later understand relationships and identify underlying causes.) How do you think patterns might help you answer your questions? What are some patterns you might look for?

b. Encourage students to discuss with their group and record ideas in their Science Notebook. Have each group share an idea and chart. Student ideas should identify things such as wanting more than one news article, a quote from a reliable source and actual data/statistics, etc. ▶ For students that are struggling, possible questions to facilitate their thinking include:

- Are there any patterns to what is being observed?
- Is there a cause to this pattern?
- Why might reports from the public claim that sharks are up to 10 feet in length, but the team has only been able to verify sharks of 5–7 feet?
- Would you be confident in saying that white sharks are doing something different than normal from one news article?
- So, if several news articles are reporting the same information, where are they getting their information from?
- Who collects this data?

5. Gathering More Information

Students use other sources of information in an attempt to identify a cause for patterns observed. Divide each group in half to focus research in two different areas.

a. News reports can provide us with information, while the most compelling type of evidence in science comes from data. Once students have identified the need for more information, specifically data, have some students in each group explore the following:

*Question: What data do we have on white shark encounters?*

A possible source for this is “Shark Attacks Hit All-Time High in 2015” (Clark 2016).

1. Ask students to consider what information this source (and its links) provides us on white sharks and record evidence in their Science Notebook. Remind students to cite their sources as they record information.

2. Ask students to note any patterns observed and describe how the patterns provide evidence of possible causes.
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b. In order to inform the public and to differentiate hype and inaccurate information from accurate information, students should understand basic information about sharks. Have students in each group explore the following:

**Question:** What do we know about white shark life history over time?

Ask students to record the question in their Science Notebook and record what they are able to find out about shark life history.

Possible sources:


Students working on this question can be put into smaller groups to peruse each resource, and then share what they learn with those that read a different source. Students may need clarification on what is meant by life history. Ask them for ideas of what they think life history means. Confirm and add onto student ideas to help build a class definition. You may find a definition in your curricular resources that would be useful to students. In the absence of that, the characteristics of a species’ life history are often considered to include the following:

- Reproductive behavior
- Feeding behavior and interaction with resources
- Response to change in environment
- Other social behaviors
- Lifespan and aging process

1. Ask students to consider what information this source provides about white sharks’ life history and to record the information in their Science Notebook. Remind students to cite their sources.
2. Ask students to note any patterns observed that might help us understand shark encounters.

**TEACHER NOTE**

One way to differentiate instruction for students is to suggest topics for investigation of shark life history. For the highly engaged student, the topics of “response to change in environment” and “other social behaviors” will provide a more challenging exploration and synthesis of information. Consider providing additional guidance in navigating resources for students that struggle to identify relevant information and/or suggest using a graphic organizer to help with focusing on important information. This can include sentence frames for students needing language support.

c. Facilitate a whole class discussion of what students learned about data on white shark encounters and shark life history. Encourage students to track any information in their Science Notebook that they think might be useful moving forward (anything that would help them address ideas on the class chart built in Step 3, Refining ideas. Following the discussion, direct students to identify/code/highlight information that could be used to establish a pattern. Ask students to note any patterns observed and describe how the patterns provide evidence of possible causes. Students will likely focus on simple patterns (such as how lightning has killed more people than sharks have) so expect to redirect the conversation to keep the focus on “encounters” between sharks and people (there are more people than ever before, there are more beachgoers than ever before, there is an increase in the number of sharks spotted, the number of attacks has increased slightly, etc.) as this will provide useful information for part 6 and better help with making sense of the phenomena later.

6. Beginning Explanation

Students consider possibilities to explain the following question:

**Question: Are there really more shark encounters now than in the past?**

Have students work in groups of four, creating the table below, 8.1.C1: Shark Encounter Claim Chart on chart paper. (Chart paper is recommended, as it can be added to over time throughout the learning sequence and allows groups to work collaboratively.) Students can go back to the resources used in Step 5, Gathering More Information, to look for evidence for the three claims below. Have students code information in the chart that reveals any pattern among the sources and possible causes for that pattern. Patterns could be interactions with humans or other species (like seals), reporting of encounters, fishing, etc.

- Some students may need clarification for the components of an explanation:

  - **Evidence:** Scientific data (records, observations, etc.) about the frequency of white shark encounters over time that support the claim.
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Reasoning: Learnings about white sharks’ life history that provide a logical connection between the evidence and the claim and explains why the evidence supports the claim.

Students are considering three plausible claims for an explanation at this time in the sequence as a mechanism to see which has the strongest evidence and reasoning over time. As a result, it’s likely that students will be engaging in argument from evidence as ideas are refined over time.

<table>
<thead>
<tr>
<th>Claim #1</th>
<th>Claim #2</th>
<th>Claim #3</th>
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<tbody>
<tr>
<td>There are more white shark encounters now than in the past.</td>
<td>There are fewer white shark encounters now than in the past.</td>
<td>The number of white shark encounters today is the same as in the past.</td>
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Facilitating group discussion by circulating the room and asking guiding questions can support students in this task. Examples of guiding questions include: "How does this help answer our question?" "What other evidence should you consider to support this explanation?" and "Is there another explanation that can account for this evidence?"

Once groups have worked collaboratively, ask students to attach **8.1.H3: My Shark Encounter Claim Chart** in their Science Notebook to help keep a personal account of information. (Students will be adding information to this chart throughout the duration of the sequence.) Remind students to code any information revealing patterns and possible causes of patterns.

TEACHER NOTE

Some students may ask for clarification as to what is meant by "the past." In the context of this lesson and beginning **8.1.C1: Shark Encounter Claim Chart**, it’s probably useful to think of "the past" as the overall history we have established for sharks throughout time (geologic time, evolutionary history). In subsequent lessons (by Lesson 8.3: Fisher Logs), some students may choose to use the lens of more recent history ("the past" being the last 100 or 200 years), which is fine. "Time" is a construct and should be agreed upon by the students in the class and may change depending upon usefulness.

There is likely not enough space in **8.1.H3: My Shark Encounter Claim Chart** for students to record the breadth of information they will need to record in the sequence. Offer sticky notes as a way to “extend the notebook space.”
7. Providing a Context for More Information

Remind students that their overall objective will be to communicate with the public about white sharks in a way that addresses concerns and helps communities make informed decisions.

Challenge each group to think about additional information needed to address the question, “Are there really more white shark encounters now than in the past?” This starts with examining the quality of their current explanation.

a. Ask students to evaluate the quality of information they have recorded. (► If students code evidence and reasoning that isn’t strong, have a class discussion about what makes for strong/quality evidence and reasoning.)

Code evidence according to its strength:

› underline/highlight appropriate evidence (scientifcally relevant) in color #1
› underline/highlight sufficient evidence (multiple pieces) in color #2

Code reasoning according to its adequacy:

› underline/highlight reasoning that explains why the evidence supports the claim in color #3
› underline/highlight reasoning that includes science ideas in color #4

Once this coding is completed, asking groups to brainstorm how they could strengthen each explanation (hint: look for missing colors) by expanding their chart to include a fourth component: information needed to strengthen this explanation.

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<td>The number of white shark encounters today is the <strong>same</strong> as in the past.</td>
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<th>Evidence for Claim #1</th>
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<th>Information Needed to Strengthen this Explanation</th>
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b. Ask students to make another evaluation of information to strengthen their explanation by considering two crosscutting concepts: Patterns, and Stability and Change. (Depending on time, this can be a class discussion or group discussion with teacher monitoring and facilitating.) Ask students to briefly recall what they understand about Pattern and Stability and Change. (Students have learned these concepts in middle school.) After recalling, encourage students to use 8.1.H4: Crosscutting Concepts for Middle School Students in their Science Notebook to help with their discussion.

Example of modeling use:

Teacher: Let’s look at what is written in the green box and record ideas you have about how scientists use patterns in your Science Notebook. Think of a specific way you have used patterns before. (Wait a couple of minutes.) Take a moment to discuss with your group one thing you can share with the whole class about how you understand patterns and how you have used what you have learned. (Wait a couple of minutes.) Someone from Group A, please share what your group discussed.

Student: We said that patterns can help us find a cause for something. She shared that we used this last week when we were trying to make sense of the finch data and we looked for a pattern that could help us decide what two variables we could compare.

Teacher: Tell me more about the pattern you found and how it helped you find a cause.

Student: Well, we noticed that a lot of finches died during a certain time—that's a pattern—and we noticed that all of the birds that survived that time had bigger beak depths; that’s another pattern.

Teacher: How did that help you find a cause?

Student: We remembered what we learned about beaks being able to only get some food types, so we thought that the cause of death of the birds with smaller beak depths could be that only some type of food might be available.

Teacher: Thanks for sharing. How about another group, can you please share what your group discussed?

(additional discussion)
Teacher: Ok, so we all have some experience working with the concept of Pattern. Let's look at the questions on this page now. Thinking about what you just said, which of these questions seems to “fit” here—which one might help us with our thinking about strengthening an explanation?

Student: Under Increasing Sophistication, bullet 5 helps: “What patterns provide evidence for your explanation?”

Teacher: Tell me more.

Student: Well, my group noticed that a source from Florida and California said shark populations around the world are declining, so that's a pattern in evidence.

Teacher: What else can you add? How does that pattern strengthen your explanation?

Student: Um, maybe with sufficiency in evidence.

Teacher: How so?

Student: Well, it’s more than one source saying the same thing, so that's multiple pieces.

Teacher: Thanks for sharing your thinking. You provided a useful example of how to use the resource. Ok, let's try another, but this time I’m going to throw down a challenge. Can you use something from “On-Target”? It's our goal to work from there.

*dead silence*

Teacher: This is more challenging, isn't it? What do you think is meant by “macroscopic patterns” in the first bullet? (Continue the conversation and ask students to clarify meaning. Encourage students to write on their page, adding personal notes about how they interpret each element/bullet.)

Teacher: Let's try again. Do any of these help give us a way to think about strengthening your explanation? Discuss with your group; I'll check back in with you in a couple of minutes.

Teacher: Ok, what did you discuss?

Student: My group thought the last bullet, "What cause and effect relationship(s) can you identify from the pattern" would work.

Teacher: Tell me more.
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Student: Well, we had reports showing a pattern that shark populations around the world are declining, and we also noticed that there were reports showing a pattern that the rate of sharks being captured by humans is alarmingly high, so maybe a pattern of humans capturing sharks is causing their decline.

Teacher: So you have a pattern that helped you identify a cause and effect relationship. How does that help strengthen your explanation?

Student: Um, well, we are confused because we see it in two places. It strengthens evidence for the claim that there are more encounters because we capture a lot, but we wrote that the populations are declining in the fewer column.

Teacher: So, it sounds like your group needs to continue discussing this and make a decision about where this best fits or if we need it in both places for now until we can get more information. I'll check on your group in a few minutes.

Teacher: What questions can I answer about how to use this resource?

After a few moments, encourage the students to use the resource independently, checking on groups as they start working.

TEACHER NOTE

For future use of 8.1.H4: Crosscutting Concepts for Middle School Students, each time students use a new crosscutting concept on the handout, use a similar discussion pattern—asking students to share what they understand about the crosscutting concept, how they have used it in the past, what questions they feel would help facilitate their thinking, and share examples of how to move over to the On-Target category to ensure students are engaging at the 6–8 level.

This resource can also be used as a rubric for assessing where students are on a continuum of understanding of the crosscutting concepts. Consider replacing column headers with 1-2-3. Students who are routinely using questions from Entry Level are a 1, those routinely using Increasing Sophistication are a 2, and those routinely using On-Target are a 3.

As groups work independently, ask additional questions to probe student thinking.

When researching white shark encounters and life history over time in an attempt to answer the question, “Are there really more shark encounters today than in the past”:

› What pattern emerged?
› Is the pattern clear? Are there other patterns?
What other information would we need to determine that the pattern identifies a cause and effect relationship?

If we want to know if encounters are increasing, decreasing, or remaining the same, do we have information that can tell us what is happening over time?

Are things changing quickly? Slowly? How do we know or how can we find out?

Sharks have a long history on Earth; is the time scale of the information we are looking at adequate to make a conclusion?

If 2015 was a record year, is that “normal”? Have there been other record years? How can we get some baseline data for the white shark population over a longer time period?

The goal is for students to think of establishing a pattern of population size, encounters, etc. They cannot support the claim that encounters have increased or decreased without information from the past.

Students should realize that they need a context larger than the years identified in the websites visited. Encourage groups to discuss how they can build an accurate record of information on white sharks that have visited the coast of California in the past. Have students keep a record of their conversation in their Science Notebook. We cannot establish if the population we are seeing today is normal, increasing, or decreasing without a context for what the population has done over time (or compared to the past).

For groups that seem stuck, ask:

How do we find out information about things that happened in the past? What about the deep past?

Can you think of anyone or any type of person who might have had consistent access to the coast and might have documented information on sharks?

When some groups appear to be on-target (ideas emerge about looking for fossils and/or asking lifeguards, fisherman, scientists), bring the conversation back to the whole class, and lead a discussion that reveals the fossil record and fisher logbooks as plausible sources of information. (Both will be future lessons in the learning sequence.)

Ask groups to return to their explanation chart and add ideas to “information needed to strengthen this explanation.”
8. Documenting Current Thinking

Build a class chart where each group contributes at least three things:

❯ At the beginning of class yesterday, what were some things you heard people say about white sharks?
❯ What questions did you hear about white sharks?
❯ What information have you gathered so far about white sharks?
❯ What questions do you have now?
❯ What information do you need to be able to answer those questions and build a strong scientific explanation?
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Accommodations

Ask students who need help with reading tasks to skim the article first, and identify any words for which they want clarification. Clarify the directions, then ask students to do a “group read” (have one person in the group read the article out loud), but encourage students to withhold group discussions until everyone has had a chance to do their own thinking and make notes in their Science Notebook first, then discuss with their group, and revise Science Notebook work accordingly.

By seating students in groups (groups of 4 work well) and encouraging regular conversation, students have time to interact more with content and naturally help those that need more support. Use of **8.1.H2: Scientist Communication Survival Kit**, helps to make sure that students who don't feel comfortable sharing (often because of language, literacy level, uncertainty of content knowledge, etc.) are prompted to do so in a supportive way.

Use of a sense-making Science Notebook supports student language development, conceptual development, and metacognition. Students should be prompted to use their Science Notebook for:

- prior knowledge of phenomena,
- exploration of phenomena and data collection,
- making sense of phenomena, and
- metacognition.

Consider providing sentence frames for low literacy and second language learners. The use of graphic organizers can help struggling students manage Science Notebook work. To support students learning English, allow conversations and Science 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).

References


8.1 Shark Encounters


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<td>8.1.C1</td>
<td>Shark Encounter Claim Chart</td>
<td>8.1.21</td>
</tr>
<tr>
<td>8.1.H1</td>
<td>CSULB Shark Lab Reports Record Breaking White Shark Sightings</td>
<td>8.1.22</td>
</tr>
<tr>
<td>8.1.H2</td>
<td>Scientist Communication Survival Kit*</td>
<td>8.1.23</td>
</tr>
<tr>
<td>8.1.H3</td>
<td>My Shark Encounter Claim Chart</td>
<td>8.1.24</td>
</tr>
<tr>
<td>8.1.H4</td>
<td>Crosscutting Concepts for Middle School Students*</td>
<td>8.1.25</td>
</tr>
</tbody>
</table>

* to become a permanent Science Notebook resource
Shark Encounter Claim Chart

Create a chart to post or display in the classroom.

### My Shark Encounter Claim Chart

**Question:** Are there really more shark encounters now than in the past?

<table>
<thead>
<tr>
<th>Claim #1</th>
<th>Claim #2</th>
<th>Claim #3</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are more white shark encounters now than in the past.</td>
<td>There are fewer white shark encounters now than in the past.</td>
<td>The number of white shark encounters today is the same as in the past.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Evidence for Claim #1</th>
<th>Evidence for Claim #2</th>
<th>Evidence for Claim #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Reasoning</th>
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<th>Reasoning</th>
</tr>
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<tbody>
<tr>
<td></td>
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<tr>
<th>Information Needed to Strengthen this Explanation</th>
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</table>

- **Evidence:** Scientific data (records, observations, etc.) about the frequency of white shark encounters over time that support the claim.
- **Reasoning:** Learnings about white sharks’ life history that provides a logical connection between the evidence and the claim and explains why the evidence supports the claim.
23 September 2015

CSULB Shark Lab Reports Record Breaking White Shark Sightings

Scientists from the Shark Lab at California State University, Long Beach have been busy this summer with reports of white sharks swimming off public beaches along the coast of Southern California from Seal Beach to as far south as San Onofre.

Police, lifeguards, and members of the public have reported as many as 13 white sharks at any given time with some swimming near paddleboarders and surfers. Although some public reports claim the sharks are up to 10 feet in length, the team has only verified individuals at 5–7 feet in length.

Between the months of April and August, the Shark Lab team monitored over 80 white shark sightings between these two locations. The team continues to work closely with lifeguards and responds to as many calls as possible so they can monitor the sharks and determine why the sharks are swimming closer to shore and remaining in the area. No beaches have been closed, but lifeguards and the Shark Lab team are warning beachgoers to be cautious.

###

Media contacts: Dr. Chris Lowe, sharklab@csulb.edu

CSULB Shark Lab. (2016). Long Beach, CA. [Reproduced with permission.]
## Scientist Communication Survival Kit

<table>
<thead>
<tr>
<th>SCIENTISTS SHARE THINKING</th>
<th>SCIENTISTS RESPECTFULLY CHALLENGE IDEAS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I observed _______.</td>
<td>I hear you saying _______, but would argue that _______.</td>
</tr>
<tr>
<td>Based on my observations, I think _______ because _______.</td>
<td>Interesting idea, but I am wondering _______.</td>
</tr>
<tr>
<td>For example, _______.</td>
<td>My data suggest something else _______.</td>
</tr>
<tr>
<td>Here’s something we might try _______.</td>
<td>Can you help me understand _______.</td>
</tr>
<tr>
<td>I found out from _______ that _______.</td>
<td>I hadn’t thought of that. Another idea is _______.</td>
</tr>
<tr>
<td>I would like to suggest _______.</td>
<td>I see it another way, _______.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SCIENTISTS ACKNOWLEDGE &amp; BUILD ON IDEAS</th>
<th>SCIENTISTS ENCOURAGE OTHERS</th>
</tr>
</thead>
<tbody>
<tr>
<td>We agree on _______ so what if _______.</td>
<td>_______ why don’t you share first?</td>
</tr>
<tr>
<td>My idea is similar to _______ idea that _______.</td>
<td>What do you think _______?</td>
</tr>
<tr>
<td>What _______ said about _______ makes me wonder _______.</td>
<td>We haven’t heard from you yet…</td>
</tr>
<tr>
<td>I agree with _______ and can add _______.</td>
<td>_______ tell me what you are thinking.</td>
</tr>
<tr>
<td>I’m going to add what you said about _______ to my own notebook.</td>
<td>Do you have anything to add _______?</td>
</tr>
</tbody>
</table>

### WHEN INTERRUPTED

*deep calm breath*… As I was saying _______.

_______ what were you trying to say?

I appreciate your excitement 😊, but I was trying to say _______.

Thanks, but I think _______ also had something to say.
My Shark Encounter Claim Chart

Question: Are there really more shark encounters now than in the past?

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<tr>
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<th>Claim #3</th>
</tr>
</thead>
<tbody>
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<td>There are <strong>more</strong> white shark encounters now than in the past.</td>
<td>There are <strong>fewer</strong> white shark encounters now than in the past.</td>
<td>The number of white shark encounters today is the <strong>same</strong> as in the past.</td>
</tr>
</tbody>
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- **Evidence**: Scientific data (records, observations, etc.) about the frequency of white shark encounters over time that support the claim.
- **Reasoning**: Learnings about white sharks’ life history that provides a logical connection between the evidence and the claim and explains why the evidence supports the claim.
### Crosscutting Concepts for Middle School Students

#### Cause and Effect

**Identifying the cause of an event (whether there is one cause or many) helps us decide if there is a relationship that can be explained, and, in some cases, it might inform a solution to a problem.**

**I can use evidence to identify and analyze causes of events and design tests that gather more evidence.**

- What is the cause of this event? How do you know? How does this cause help you identify a pattern? How can you design a test to gather evidence (or refute ideas) about a possible cause?

**I can identify cause and effect relationships to help explain change and the reasons for the change.**

- What cause and effect relationship(s) can you identify? How did this change happen? Why did this change happen? What conditions were needed for an event to happen? What did you learn when you tested a cause and effect relationship? Do the results of this test help you explain change? If so, how? If your observations/data show that two things happen together regularly—does it mean that one caused the other? How do you explain this? What evidence do you have that one event caused (or didn’t cause) another when the two things happen together regularly?

**I can use evidence of cause(s) and effect(s) to decide the type of relationship between them and to predict future change.**

- Is the relationship you are seeing describing a cause that directly leads to an effect? Or, is the relationship describing two (or more) events that occur together, where one may not cause the other? What predictions can you make about phenomena, with confidence, based on this cause and effect relationship? What is your evidence for this? How confident/sure are you? What else do you need to be more confident/sure? What other causes might help you explain these phenomena? How can a pattern in the effect, predicted by the cause, help describe phenomena? How likely is it that this effect is going to happen? Why is this more or less likely?
### Energy and Matter

In any system, there are amounts of energy and matter that can change, but are conserved. Tracking how these flow/cycle into, within, and out of a system help us understand how a system works.

| I can identify and describe the change in objects. |
| I can identify and describe matter moving into, within, and out of a system and the parts it’s made of. I can describe energy moving from one object to another. |
| I can identify and describe how matter and energy are conserved, how they can change, and the relationship between the two. |

- How can the object be broken down into smaller parts?
- How can smaller parts make a larger structure?
- How can the object change shape?
- How can the objects be broken down and put back together?
- How can you show/describe what this matter is made of?
- What evidence do you have that matter moved—into, within, or out of—a system?
- Where did the energy come from? Where is the energy going?
- How does the energy change? Can it change in another way?
- How can you describe/show what is happening to energy?
- What evidence do you have for changes in matter during this physical process?
- What evidence do you have for changes in matter during this chemical process?
- What happened to the amount(s) of matter as a result of these changes?
- How is matter changed, yet still conserved?
- What evidence do you have of atom rearrangement in a chemical process?
- What are the different forms of energy you can identify? Do they change? Do they move? What is your evidence?
- How can you describe/show the different forms of energy?
- How can you describe/show the path of energy flowing through a system?

Crosscutting Concepts

Patterns are used to help organize and classify observed phenomena, and ask questions about relationships and their underlying causes.

<table>
<thead>
<tr>
<th>I can make observations, find patterns, and describe them.</th>
<th>I can see similarities and differences in patterns and use them to predict and explain.</th>
<th>I can identify and infer patterns in things not easily seen.</th>
</tr>
</thead>
<tbody>
<tr>
<td>› What patterns can be you identify based on your observations?</td>
<td>› When you compare patterns, what about them is similar? What about them is different?</td>
<td>› What are macroscopic patterns you are observing?</td>
</tr>
<tr>
<td>› How can the patterns you identified be used to describe phenomena?</td>
<td>› How can you use similarities and differences to sort, classify, and help communicate understanding?</td>
<td>› What patterns can you identify from structure(s) that are microscopic?</td>
</tr>
<tr>
<td>› How can the patterns you identified be used as a way to provide evidence about phenomena?</td>
<td>› What is a rate of change between patterns you have observed?</td>
<td>› How can you describe a large pattern based on all the components of smaller patterns?</td>
</tr>
<tr>
<td></td>
<td>› What do you predict will happen in the future? How does a pattern showing change help you predict what will happen in the future?</td>
<td>› How do your observations of large patterns help you understand smaller patterns and patterns in things not directly observable?</td>
</tr>
<tr>
<td></td>
<td>› What patterns provide evidence for your explanation?</td>
<td>› What information do patterns in rates of change provide?</td>
</tr>
</tbody>
</table>

Developed by the CA NGSS K-5 Early Implementation Initiative, K-12 Alliance@WestEd; Adapted from NGSS Lead States. 2013.
Art used with permission. ©2013 Peter A’Hearn, https://crosscutsymbols.weebly.com/
Recognizing that systems and processes can be different in size, time, and in the amount of energy flowing through them helps us understand that the way things work will change with scale (like things too small or fast to observe, or those that are too large or slow making them hard to understand) and that there will be differences in rates of changes between things because of scale, and changes in scale can also change the relationship between things.

I can describe and compare the differences in scale in objects, space, and time, and I can measure length.

How can you describe differences between two objects or events? (Which is bigger/smaller? Which is hotter/cooler? Which is faster/slower?)

How can you measure the length of an object (using m, cm, or mm)?

I can estimate scale as I make sense of data. I can measure, compare, and organize quantities of weight, time, temperature, and other variables.

How can you describe and estimate the size of something very small? Very large? Very short? Very long?

Does your description sound reasonable?

How can you measure the weight of an object (using g, kg)?

How can you measure the time involved (using seconds, minutes, hours, years, etc.)?

How can you measure the temperature (using °C)?

How can you measure the volume (using mL, L)?

What is another way you can measure this?

How can you use the measurements of something to compare and organize objects?

I can use models showing different scales to help me understand phenomena, including time, space, and energy. I have a sense of how relationships change with changes in scale. I can recognize, use, and interpret mathematical representations.

How is this model used to represent very long/short periods of time (or things that are very large/small)? What does it help you understand?

How can you develop a model to represent very long/short periods of time (or things that are very large/small)? What are important considerations for this model for the scale to be understandable?

How can the model be adjusted to improve understanding of the scale of the phenomena to you or another person?

If the scale of this changes, how will the function change?

Is there a proportional relationship in the types of quantities? Can you use this to describe a property or process at larger and smaller scales?

How does this equation represent a relationship between aspects of the phenomenon?

What equation could you write to show the relationship between parts of this phenomenon?

If you change the scale, would you still be able to observe this? How would the relationships change?
## Crosscutting Concepts for Middle School Students (continued)

### Stability and Change

To help make sense of our world, we try to understand how change occurs how some parts of the system can change but the overall system stays stable.

<table>
<thead>
<tr>
<th>I can describe and explain things that don’t appear to change (remain stable) and things that change.</th>
<th>I can describe and measure change, and differences in change.</th>
<th>I can explain aspects of change including understanding of substructures, interactions between parts, and the need for feedback to maintain stability.</th>
</tr>
</thead>
<tbody>
<tr>
<td>› What things are staying the same? How do you know?</td>
<td>› How do you know a change happened? How do you measure it?</td>
<td>› What evidence do you have for when and why the change occurred?</td>
</tr>
<tr>
<td>› What things are changing? How do you know?</td>
<td>› How do you know something is stable? How do you measure it?</td>
<td>› What evidence do you have for when and why things became stable?</td>
</tr>
<tr>
<td>› How quickly or slowly is change happening?</td>
<td>› How do you determine if the change is consistent or if it fluctuates?</td>
<td>› How can you explain the changes over time? What is your evidence?</td>
</tr>
<tr>
<td>› What is affecting the speed of change?</td>
<td>› When did the change occur?</td>
<td>› How can you explain the disruption in stability? What is your evidence?</td>
</tr>
<tr>
<td></td>
<td>› When did things become stable?</td>
<td>› How do forces at different scales influence change?</td>
</tr>
<tr>
<td></td>
<td>› How can you suggest a better way to measure change and stability?</td>
<td>› How does change in one part of the system lead to change in another part?</td>
</tr>
<tr>
<td></td>
<td>› Would you describe the change as great or small? Why?</td>
<td>› How could a sudden event affect stability?</td>
</tr>
<tr>
<td></td>
<td>› What happens to the change over short periods of time?</td>
<td>› How do gradual changes over long periods of time influence overall stability?</td>
</tr>
<tr>
<td></td>
<td>› What happens to the change over long periods of time?</td>
<td>› What leads to stability?</td>
</tr>
</tbody>
</table>

Developed by the CA NGSS K-5 Early Implementation Initiative, K-12 Alliance@WestEd; Adapted from NGSS Lead States. 2013. 
Art used with permission. ©2013 Peter A’Hearn, [https://crosscutsymbols.weebly.com/](https://crosscutsymbols.weebly.com/)
Understanding how an object is shaped and how it is structured helps us understand its properties and function.

I can identify the relationship between shape, stability, and the function of an object.

- How does the shape of the structure affect its function?
- How does the shape of the structure affect its stability?
- What is the relationship between stability and function of the structure?

I can relate the structure of sub-systems and the shapes of their parts to their function.

- What evidence do you have for the type of material a substructure is made of?
- How do the shapes and parts of substructures impact their function?

I can visualize and model the structure and function of objects, sub-systems, and processes.

- What variables influence the properties of this structure? (Variables include shape, composition, relationship among its parts, etc.)
- How can this system or structure (whether complex or microscopic) and the influence of its variables be visualized, modeled, and/or used to describe how variables impact its function?
- What function does this object, sub-system or process need to do? What variables need to be taken into account when designing a structure for this particular function?
Crosscutting Concepts for Middle School Students (continued)

Systems and System Models

I can describe (through words and drawings) everything in the world as made up of smaller parts that work together.

- What are the parts that make up this object/organism?
- How can you show/describe the parts of the system?
- How do the parts of this object/organism work together as a system?
- How can you show how the parts of this object/organism work together as a system?
- What changes can you make to your plan or model of parts and how they work together so someone else can understand it?

I can describe a system based on its smaller parts and the jobs they do. The small parts have a relationship with each other and also work together to help the whole system function.

- What are the parts within this system?
- What are the functions of these parts of this system or this system as a whole?
- How can this system be described?
- How does your model show things you can't see, but have indirect evidence for?
- What do the parts do together that no single part can do alone?

I can describe a system and the smaller sub-systems that create the larger system. I can use models to represent the system, its sub-systems and how these sub-systems interact together and I can identify the limitations of those models.

- How does one system interact with another system?
- Is your system really a sub-system of a larger, more complex system? How do you know?
- What model could you use to represent the whole system? The sub-systems?
- What part of the system does the model represent? How is that shown?
- What interactions between parts are represented in the model? How are they shown?
- How does energy flow into, within, and out of the system?
- How does matter cycle into, within, and out of the system?
- How does information flow into, within, and out of the system?
- What is the model unable to show?
- What do you have to assume is true for this model to work?
- How confident are you that this model fairly represents the system? Why? Are there any changes you can make to increase confidence?
### 8.1.32 Asking Questions and Defining Problems

#### K–2 Condensed Practices
- **Describe:** Ask questions, and define problems about the natural world. Both scientists and engineers also ask questions to clarify ideas and questions about the designed world. Engineering questions clarify problems to determine criteria for successful solutions and identify constraints to solve.

#### 3–5 Condensed Practices
- **Ask:** Questions that arise from examining models or a hypothesis based on observations and scientific principles.
- **Identify:** Questions that can be investigated within the scope of the classroom, outdoor environment, and school laboratory.
- **Clarify:** Questions that can be investigated in other settings, such as museums and other public facilities.

#### 6–8 Condensed Practices
- **Identify:** Questions that can be answered by an explanation, or an engineering problem.
- **Specify:** Questions that can be tested, and testable questions within the scope of the classroom, school laboratory, research facilities, or museum.
- **Explain:** Questions that can be investigated within the scope of the classroom, outdoor environment, and school laboratory.
- **Specify:** Questions that can be investigated within the scope of the classroom, school laboratory, research facilities, or museum.

---

**Science and Engineering Practices (SEP) Progressions**

- Asking questions and defining problems:
  - Perception and gestures to describe questions.
  - Asking questions and defining problems about the natural world.
- Refining, and evaluating empirically testable questions:
  - Asking questions and defining problems about the designed world.
- Perspective and the idea of a designed world:
  - Asking questions and defining problems about the designed world.
- Development of a process or system with interacting components:
  - Asking questions and defining problems about the designed world.
  - Assembling parts and putting on a model, or a design.
- Developing a model to describe a problem and its potential solutions:
  - Asking questions and defining problems about the designed world.
- Refining a model to clarify a model, an explanation, or an engineering problem:
  - Asking questions and defining problems about the designed world.
- Identifying solutions that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints that may limit possible solutions.
- Defining a simple design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints that may limit possible solutions.
- Developing an object, tool, process or system and includes multiple criteria and constraints that may limit possible solutions.
- Testing by making predictions and designing investigations to answer questions.
- Testing by making predictions and designing investigations to answer questions.
- Refining and evaluating empirically testable questions:
  - Testing by making predictions and designing investigations to answer questions.
- Developing and evaluating empirically testable questions:
  - Testing by making predictions and designing investigations to answer questions.
  - Refining and evaluating empirically testable questions.
### Science and Engineering Practices (SEP) Progressions (continued)

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>The natural world is full of patterns and regularities. In the natural world, patterns and regularities emerge from the interactions of objects and their components. In the natural world, patterns and regularities are easy to observe. In the natural world, patterns and regularities are useful in making predictions and solving problems.</td>
<td>Developing and Using Models: A practice of both science and engineering. A practice of both science and engineering is to use and construct models to help various tasks.</td>
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<td>Develop, revise, and use models to represent concepts in the natural world.</td>
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#### Science and Engineering Practices (SEP)

**Developing and Using Models: A practice of both science and engineering.**

A practice of both science and engineering is to use and construct models to help various tasks.
Science and Engineering Practices (SEP) Progressions (continued)

<table>
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<tbody>
<tr>
<td>#1 Plan an investigation individually and collaboratively to produce data to serve as the basis for evidence as part of building and revising models, supporting explanations for phenomena, or testing solutions to questions or problems.</td>
<td>#2 Plan and carry out investigations in the field or laboratory, working collaboratively as well as independently. Their investigations are systematic and require clarifying what counts as data and identifying variables or parameters. Engineering investigations identify the strengths and weaknesses of designs, testing the effectiveness, efficiency, and durability of designs under different conditions.</td>
<td>#3 Collect data to produce data to serve as the basis for evidence, and in the design: decide on types, how much, and accuracy of data needed to produce reliable experimental design to produce data as the basis for evidence.</td>
<td>#4 Evaluate the accuracy of various methods and/or measuring a phenomenon to identify failure points or improve performance relative to criteria for success or other variables.</td>
<td>#5 Collect data about the performance of a proposed object, tool, process, or system under a range of conditions.</td>
<td>#6 Make observations (firsthand or from media) and/or measurements to produce data to support explanations or test conceptual, mathematical, physical, and empirical models.</td>
</tr>
</tbody>
</table>

**Science and Engineering Practices (SEP) Progressions (continued)**
### Science and Engineering Practices (SEP) Progressions (continued)

#### Based on Appendix F of the Next Generation Science Standards © 2013 Achieve, Inc. on behalf of the 26 NGSS Lead States.

<table>
<thead>
<tr>
<th>8.1.35</th>
<th>8.1.23</th>
<th>8.1.32</th>
</tr>
</thead>
<tbody>
<tr>
<td>Analyze data to refine a problem statement.</td>
<td>Analyze and interpret data to make sense of phenomena.</td>
<td>Analyze data to identify design features or similarities and differences in findings.</td>
</tr>
<tr>
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<td>Analyze data to refine a problem statement.</td>
</tr>
<tr>
<td>Analyze and interpret data to provide evidence for phenomena.</td>
<td>Distinguish between causal and correlational relationships in data.</td>
<td>Analyze data to determine if it works as intended.</td>
</tr>
<tr>
<td>Consider limitations of data analysis (e.g., measurement error, sample selection) when interpreting data.</td>
<td>Use observations (firsthand or from media) to describe phenomena.</td>
<td>Analyze data using tools, technologies, and/or technological tools and methods (e.g., multiple representations of data) in order to make valid and reliable scientific claims or explanations of text.</td>
</tr>
<tr>
<td>Use graphical displays (e.g., maps, charts, tables) to reveal patterns that are not obvious when the data are presented in other ways.</td>
<td>Apply concepts of statistics and probability (including variation) to scientific and engineering questions and solve problems.</td>
<td>Represent data in tables and/or various types of displays of data and/or large data sets to compare and contrast different solutions and determine how well each meets specific design criteria.</td>
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<tr>
<td>Use and share pictures, drawings, and/or writings of observations.</td>
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<td>Analyze data from tests of an object or tool to determine if it works as intended.</td>
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<td>Use observations (firsthand or from media) to describe phenomena.</td>
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<td>Compare and contrast various types of data sets (e.g., self-generated, archival) to examine the same or similar events.</td>
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</table>
Science and Engineering Practices (SEP) Progressions (continued)

8.1.36

Handout

Toolbox 8.1

Science and Engineering Practices

Using Mathematics and Computational Thinking:

In both science and engineering, mathematics and computation are fundamental tools for representing physical variables and their relationships. They are used for a range of tasks such as constructing simulations; solving equations exactly or approximately; and recognizing, expressing, and applying quantitative relationships. Mathematical and computational approaches enable scientists and engineers to predict the behavior of systems and test the validity of such predictions.

- Decide when to use qualitative vs. quantitative data.
- Decide if qualitative or quantitative data are best to determine whether a proposed object or tool meets criteria for success.
- Use counting and numbers to identify and describe patterns in the natural and designed world(s).
- Organize simple data sets to reveal patterns that suggest relationships.
- Use digital tools (e.g., computers) to analyze very large data sets for patterns and trends.
- Create and/or revise a computational model or simulation of a phenomenon, designed device, process, or system.
- Describe, measure, and/or compare quantitative attributes of different objects and display the data using simple graphs.
- Describe, measure, estimate, and/or graph quantities such as area, volume, weight, and time to address scientific and engineering questions and problems.
- Use mathematical representations to describe and/or support scientific conclusions and design solutions.
- Use mathematical, computational, and/or algorithmic representations of phenomena or design solutions to describe and/or support claims and/or explanations.
- Use quantitative data to compare two alternative solutions to a problem.
- Create and/or use graphs and/or charts generated from simple algorithms to compare alternative solutions to an engineering problem.
- Create algorithms (a series of ordered steps) to solve a problem.
- Apply mathematical concepts and/or processes (such as ratio, rate, percent, basic operations, and simple algebra) to scientific and engineering questions and problems.
- Use digital tools and/or mathematical concepts and arguments to test and compare proposed solutions to an engineering design problem.
- Apply techniques of algebra and functions to represent and solve scientific and engineering problems.
- Use simple limit cases to test mathematical expressions, computer programs, algorithms, or simulations of a process or system to see if a model “makes sense” by comparing the outcomes with what is known about the real world.
- Apply ratios, rates, percentages, and unit conversions in the context of complicated measurement problems involving quantities with derived or compound units (such as mg/mL, kg/m³, acre-feet, etc.).
### Science and Engineering Practices (SEP) Progressions (continued)

<table>
<thead>
<tr>
<th>SEP 2.5</th>
<th>SEP 3.5</th>
<th>SEP 4.5</th>
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<tr>
<td>8.1.37</td>
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<td>8.1.37</td>
<td>8.1.37</td>
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</tbody>
</table>

8.1.37 Constructing Explanations and Designing Solutions

The end-products of science are explanations and the end-products of engineering are solutions. The goal of explaining why phenomena occur is to construct explanations that are supported by evidence and ideas from multiple sources. The goal of designing solutions is to develop solutions that are supported by evidence from multiple sources.

#### Condensed Practices

<table>
<thead>
<tr>
<th>SEP 2 Condensed Practices</th>
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<tbody>
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<td>8.1.38</td>
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</table>

8.1.37 Constructing Explanations and Designing Solutions:

- **Creating an explanation** based on valid evidence consistently supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- **Designing solutions** that are supported by evidence from multiple sources.

Science and Engineering Practices

- **Formulating a problem** for a design project, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- **Applying scientific ideas, principles, and/or evidence** to design problems, taking into account possible unanticipated effects.
- **Applying scientific reasoning** to show why the data or evidence is adequate for the explanation or conclusion.
- **Making a quantitative and/or qualitative claim** supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.
- **Using evidence (e.g., measurements, yard), and in designing multiple solutions to a specific problem.**
- **Constructing an explanation** using models or simulations, and theories.
- **Identifying the evidence that supports particular points in an explanation.**
- **Constructing explanations** that specify variables, including independent variables.
- **Constructing an explanation** that includes qualitative or quantitative relationships between variables that predict(s) and/or describe(s) phenomena.
- **Generating and/or comparing multiple solutions** to a problem based on prioritized criteria, and tradeoff considerations.
- **Generating and/or comparing multiple solutions** to a problem.
- **Optimize performance of a design** by prioritizing the criteria and constraints.
- **Use tools and/or materials** to construct, and/or test a design of an object, tool, process or system.
- **Generate and/or compare multiple solutions** to a problem.
- **Undertake a design project**, engaging in the design cycle, to construct and/or implement a solution that meets specific design criteria and constraints.
- **Apply scientific ideas or principles** to design, construct, and/or test a design of an object, tool, process or system.
### Science and Engineering Practices (SEP) Progressions (continued)

<table>
<thead>
<tr>
<th>Practice</th>
<th>Kindergarten to Grade 3</th>
<th>Grade 4–5</th>
<th>Grade 6–8</th>
<th>High School</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engaging in Argument from Evidence: Argumentation in the Service of Learning</td>
<td>• Construct an argument with evidence, data, and evidence representing the natural and designed world(s).</td>
<td>• Construct an argument with evidence and scientific reasoning to support or refute an explanation or a model.</td>
<td>• Construct an argument with evidence and scientific reasoning to support or refute an explanation or a model.</td>
<td>• Construct an argument with evidence and scientific reasoning to support or refute a scientific claim, an explanation, or a model.</td>
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</tbody>
</table>
| **[8.1.H5]** | | | | **Note:**

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### Science and Engineering Practices (SEP) Progressions (continued)

<table>
<thead>
<tr>
<th>8.1.39</th>
<th>8.1.3</th>
<th>8.1.2</th>
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Next Generation Science Standards (NGSS)

As this is the Engage lesson of the learning sequence, students are only broadly introduced to ideas that touch on these Performance Expectations and will not begin building deeper understanding until later in the learning sequence.

This lesson is building toward:

<table>
<thead>
<tr>
<th>PERFORMANCE EXPECTATION (PE)</th>
<th>Description</th>
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</table>
| 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.]

| MS-ESS3-4                    | Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of evidence include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change. The consequences of increases in human populations and consumption of natural resources are described by science, but science does not make the decisions for the actions society takes.] |


<table>
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<tr>
<th>SCIENCE AND ENGINEERING PRACTICES (SEP)</th>
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<tr>
<td>Asking Questions and Defining Problems</td>
<td>- Ask questions that arise from careful observation of phenomena, models, or unexpected results, to clarify and/or seek additional information.</td>
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</table>

| Constructing Explanations and Designing Solutions | - Apply scientific reasoning to show why the data or evidence is adequate for the explanation or conclusion. |

| Engaging in Argument from Evidence | - 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 | - 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 8.1

**DISCIPLINARY CORE IDEAS (DCI)**

(This is the Engage part of the learning sequence; students do not build understanding of this, but this sets the stage for future learning.)

**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. (MS-LS4-1)

**ESS3.C: Human Impacts on Earth Systems**

- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-4)

**CROSSCUTTING CONCEPTS**

**Patterns**

- Patterns can be used to identify cause and effect relationships.
- Graphs, charts, and images can be used to identify patterns in data.

**Cause and Effect**

- [Some] phenomena may have more than one cause, and some cause and effect relationships in systems can only be described using probability.

**Stability and Change**

- Explanations of stability and change in natural or designed systems can be constructed by examining the changes over time and processes at different scales, including the atomic scale.

**Scale, Proportion, and Quantity**

- Phenomena that can be observed at one scale may not be observable at another scale.

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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.6-8.9**

Draw evidence from informational texts to support analysis, reflection, and research.
Appendix 8.1

CCSS MATH FUNCTIONS

CCSS.MATH.CONTENT.8.F.B.5
Describe qualitatively the functional relationship between two quantities by analyzing a graph (e.g., where the function is increasing or decreasing, linear or nonlinear). Sketch a graph that exhibits the qualitative features of a function that has been described verbally.

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California English Language Development (ELD) Standards

CA ELD
Part 1.2 Interacting with others in written English in various communicative forms (print, communicative technology, and multimedia)

EMERGING | EXPANDING | BRIDGING
--- | --- | ---
P1.8.2 Engage in short written exchanges with peers and collaborate on simple written texts on familiar topics, using technology when appropriate. | P1.8.2 Engage in longer written exchanges with peers and collaborate on more detailed written texts on a variety of topics, using technology when appropriate. | P1.8.2 Engage in extended written exchanges with peers and collaborate on complex written texts on a variety of topics, using technology when appropriate.

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

1.8.1: Exchanging information and ideas with others through oral collaborative discussions on a range of social and academic topics
1.8.3: Offering and justifying opinions, negotiating with and persuading others in communicative exchanges
1.8.6: Reading closely literary and informational texts and viewing multimedia to determine how meaning is conveyed explicitly and implicitly through language
1.8.11: Justifying own arguments and evaluating others’ arguments in writing
2.8.5: Modifying to add details

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California’s Environmental Principles and Concepts (EP&Cs)

EP&C

Principle 2
People Influence Natural Systems

The long-term functioning and health of terrestrial, freshwater, coastal, and marine ecosystems are influenced by their relationships with human societies.

Principle 3
Natural Systems Change in Ways that People Benefit From and Can Influence

Natural systems proceed through cycles that humans depend upon, benefit from, and can alter.