Tagging & Tracking Marine Predators:

Scientific Investigation and Environmental Advocacy

A marine science curriculum for 9th and 10th graders

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OVERVIEW

This curriculum, "Tagging and Tracking Marine Predators," was designed for the Monterey Bay Aquarium's Teacher Institute. It consists of three broad thematic units divided into seven lessons. Through this curriculum, 9th and 10th grade students will learn core skills that scientists use to investigate the migration patterns of pelagic predators. In reflecting on this process, students are encouraged to think deeper about issues such as: how scientists make hypotheses about regions they cannot observe directly; and what animals need to sustain their lives. In addition, by getting to know marine animals and ecosystems better, we hope students will become advocates for ocean stewardship.

Each lesson provides scaffolding for the final project. Lessons are designed to be presented sequentially in order to provide students with the information and tools necessary to proceed with confidence. All lessons are aligned with National Science Education Standards and California Science Standards in order to integrate with other content covered in high school. In addition, both broad and specific goals for this curriculum are listed below and are tied to the lessons in which they are covered. The culminating project and corresponding assessment rubric are also aligned with these curriculum goals.

We hope that you and your students enjoy this investigative experience while learning more about marine animals and how we all can take action to improve the ocean ecosystem.

Unit 1: Tagging & Tracking Marine Predators: What does it mean? What can it tell us?

- ***Lesson 1 (50 minutes):*** *Connect to students' prior knowledge and encourage interest and caring about ocean animals.*
- ***Lesson 2 (30 minutes):*** *Read tagging maps and form hypotheses.*
- ***Lesson 3 (50 minutes):*** *Investigate what different tags tell us.*

Unit 2: Student Investigation: Students use the scientific process to gather data, hypothesize, and test their conclusions.

- ***Lesson 4 (90 minutes):*** *The Mystery of Sharks: What's their next target!?*

Unit 3: Ocean Stewardship: Students investigate threats, design solutions, and take action.

- ***Lesson 5 (90 minutes):*** *Investigate Threats: Considering competing needs*
- ***Lesson 6 (70 minutes):*** *Come Up With Solutions: Inspiring environmental behavior change*
- ***Lesson 7 (75 minutes):*** *Come Up With Solutions: Create a Product for Change*

ENDURING UNDERSTANDINGS

We hope that through this curriculum students will learn core skills that scientists use to investigate the migration patterns of marine predators, as well as gain enduring understandings about sustaining life, the scientific process, and environmental advocacy. A schematic of enduring understandings (left) and supporting topical understandings (right) is presented below:

<table>
<tr><td>1</td><td>Animals migrate for a variety of reasons in order to sustain life. (Lessons 1, 2, 3, 4)</td><td colspan="2">Pelagic predators have preferred climates, food sources, and mating grounds. (Lessons 1, 2, 3, 4)</td></tr>
<tr><td rowspan="4">2</td><td rowspan="4">The scientific process helps people to systematically draw conclusions about marine life. (Lessons 1, 2, 3, 4, 6, 7)</td><td>a) Scientists tag pelagic animals to learn more about their lives and to gather information about ocean ecosystems. (Lessons 1, 2, 3, 4, 6, 7)</td><td>Different tags collect different data and are appropriate for different animals. (Lesson 3)</td></tr>
<tr><td>b) Reading and interpreting maps can help people draw conclusions from the data. (Lessons 1, 2, 4, 6, 7)</td><td>Reading map data from pelagic predators can help people form hypotheses about these animals' lives and the ocean ecosystems where they live. (Lessons 1, 2, 4, 6, 7)</td></tr>
<tr><td>c) Mapping data over time can help scientists identify patterns. (Lessons 1, 2, 4, 6, 7)</td><td>Oceanographers make conclusions about animal migration patterns and habits based on different resources including but not limited to satellite data from tags, ocean temperature maps, and chlorophyll maps. (Lessons 1, 2, 4)</td></tr>
<tr><td colspan="2">d) The scientific process can be messy and does not always match expectations or result in clear answers. (Lesson 4)</td></tr>
<tr><td rowspan="2">3</td><td rowspan="2">Animal and human needs sometimes come into conflict, causing threats to marine animals; being aware of this means people can do something to make a difference. (Lessons 5, 6, 7)</td><td colspan="2">a) Overfishing and pollution (plastics and oil) are significant threats to marine animals. (Lessons 5, 6, 7)</td></tr>
<tr><td colspan="2">b) Effective environmental advocacy addresses barriers to pro-environmental behaviors and provides the support that can empower people to take action. (Lessons 6, 7)</td></tr>
</table>

MONTEREY BAY AQUARIUM

The Monterey Bay Aquarium is located on the Pacific Shoreline in Monterey, California. Since its opening in 1984, it has expanded to hold thousands of plants and animals and 623 separately named species. The mission of the non-profit Monterey Bay Aquarium is to "inspire conservation of the oceans" (Monterey Bay Aquarium, 2012, About Us). Their efforts include collaboration and partnerships with other organizations to "further ocean research, education and conservation" (Monterey Bay Aquarium, 2012, Our Conservation Efforts). Regarding education, the Aquarium holds a number of programs for children, parents, young adults, and teachers. The Aquarium stresses that their "hands-on approach creates an emotional connection that encourages learning, and caring, and ultimately, gives kids confidence that they can make a difference for the oceans" (Monterey Bay Aquarium, 2012, Children's Educational Endowment Fund).

THE TEACHER INSTITUTE

One of the Aquarium's successful, long running educational programs is the "Teacher Institute," in which "hundreds of teachers and school administrators come to the Aquarium to enhance their knowledge and add to their collection of classroom activities," (Monterey Bay Aquarium, 2012, Teacher Programs). The Aquarium hosts three separate week long Teacher Institutes: a Coastal Systems Teacher Institute for 3rd to 5th grade teachers, a Middle-School Project Based Science Institute, and a Connecting with Marine Science Teacher Institute for high school teachers. At the end of the institute the teachers leave with a set of materials including curricula developed by the Aquarium, with several lessons, and tools to help them implement what they have learned during the week. Depending on the type of institute (e.g. Coastal Systems, Middle School Project-Based Science, Connecting with Marine Science), teachers are required to carry out certain activities, such as implementing the provided curriculum, integrating hand-held technology in the classroom, or conducting an event at their school. These requirements are outlined on the application each attendee must submit. They must also participate in a yearlong online professional learning community and present their results at the end of the year.

This curriculum was developed for high school teachers attending the Aquarium's Connecting with Marine Science Teacher Institute. Its focus is "Tagging and Tracking," and it explores how and why marine predators' movements are tracked. The Aquarium staff will share this curriculum, along with several others developed in-house, with attendees of the Teacher Institute, and train them on how to carry it out in their classrooms. The teachers will then take the curriculum and materials back to their classrooms for implementation with their high school students.

Many of these teachers teach chemistry, biology, or physics; however, there are occasionally non-science teachers as well. Some teach in private schools and others in low-income public schools. There is also diversity in experience, with teachers ranging from novice teachers to veteran teachers of 30 years. Most of these teachers hail from California and many are from the San Francisco/San Jose area and local towns such as Salina, Monterey, Santa Cruz, and Watsonville. Many of these schools have a large population of English Language Learners with Spanish as their native language.

This curriculum is designed for the 9th and 10th graders in these schools. It is built as a technology based curriculum for classrooms that have access to computers and internet. By emphasizing vocabulary, collaborative work and discussions, and providing opportunities for students to draw on prior knowledge and connect to their own lives, we hope this curriculum supports diverse students, including English Language Learners, in developing a greater understanding of and passion for marine life.

IDEOLOGIES

Monterey Bay Aquarium's mission is to "inspire conservation of the oceans" (Monterey Bay Aquarium, 2012, About Us). The Aquarium stresses that their "hands-on approach creates an emotional connection that encourages learning, and caring, and ultimately, gives kids confidence that they can make a difference for the oceans." (Monterey Bay Aquarium, 2012, Children's Endowment Fund). In order to honor the Aquarium's mission, this curriculum is designed using a combination of several different ideologies, which incorporate the ideas of caring for the ocean, sparking curiosity, nurturing inquiry, and creating engaging learning experiences.

Nurturing Care for the Environment

Nodding's ideology of Care emphasizes compassion and empathy for one's self and for others. It includes a moral responsibility to treat people with respect and sensitivity regardless of personal or cultural differences. This idea of caring, respect, and compassion also extends to the animal world. As Noddings (1992) writes, "Our moral attitude toward animals should be a major center of care and concern" (p. 56). Plants, as living creatures, are also included in the philosophy of care: "Our children should also learn an appreciation for plant life" (Noddings, 1992, p. 58). This ideology of caring for plants and animals fits well with the Monterey Bay Aquarium's mission of stewardship and conservation for the ocean and its inhabitants. This philosophy of care and compassion underlies our curriculum.

Exploring Through Experience

Monterey Bay Aquarium emphasizes child-centered, hands-on, experience-based learning. Visitors to the Aquarium are encouraged to explore, inquire, and touch. Entire exhibits are created to engage visitors in a unique underworld experience that will spark interest, curiosity, and

exploration. Dewey (1938), a Progressivist, emphasizes the importance of setting up intriguing experiences for learners: "A primary responsibility of educators is that they not only be aware of the general principle of the shaping of actual experience by environing conditions, but that they also recognize in the concrete what surroundings are conducive to having experiences that lead to growth" (p. 22). Experience-based learning is central to both the Progressivist ideology and to the Monterey Bay Aquarium because these types of experiences foster the kind of "growth" and deeper learning that Dewey refers to. Furthermore, Dewey's ideas align with the Aquarium's hands-on learning method for the majority of their educational programs and exhibits. Our curriculum is designed to scaffold understanding of marine life and issues through the lens of prior and personal experiences.

Sparking Curiosity

A central feature in the Monterey Bay Aquarium's philosophy is an emphasis on inquiry. One way to achieve this is to use questions to tap into students' prior knowledge and engage their curiosity. As Eleanor Duckworth describes, "Curriculum work has to pose questions such as: How do you get learners intrigued by this field? How do their ideas develop once they are intrigued by it?" (as quoted in Meek, 1991, p. 33). Duckworth emphasizes the importance of gauging student knowledge as a way of engaging students in a lesson, "My way of teaching was an extension of finding out what the kids did and didn't understand...The more they told me about their explorations, the more their understanding developed" (as quoted in Meek, 1991, p. 30). This philosophy of using questioning to both connect to prior knowledge and spark interest underlies our curriculum. This is especially important because the students who use the Monterey Bay Aquarium curricula have diverse backgrounds, including varying levels of knowledge.

Taking on the Role of the Scientist

Our activities also emphasize observation and discovery through scientific inquiry. This reflects the ideas of Bruner (1960), who says, "It is easier for [the student] to learn physics behaving like a physicist than doing something else" (p. 14) as well as Gardner (1999), who states that "students should probe with sufficient depth a manageable set of examples so that they come to see how one thinks and acts in the manner of a scientist" (p. 118). We believe that taking on the role of scientist will provide students with a more authentic experience as they investigate marine life.

OVERALL RATIONALE

Care and Conservation of the Ocean

The mission of the Monterey Bay Aquarium to "inspire conservation of the oceans" creates a central theme that runs throughout our curriculum. Through understanding of and compassion for ocean life, we hope that students will be inspired to take action in their personal lives and to help spread the word about the importance of protecting the health of our oceans.

Personal Connections

Because students may not have any direct experience with the ocean and its inhabitants, we felt it was important to create ways for students to connect the practice of tagging and tracking to their own lives. In addition, to create a sense of caring, we wanted to provide students with a chance to get to know a specific animal more intimately and to care about its survival. By creating links to students' personal lives and then encouraging them to learn more about these animals, we hope to create connections that will spark both interest and care.

Inquiry-based Learning

We strongly believe that through inquiry-based work, students will develop their own, thorough understanding of the curriculum's topics. By doing investigative activities and using tools to gather and analyze data, they will learn how to think deeply and critically, as well as how to tie evidence to explanations. Students take on the role of a scientist by engaging in authentic tasks.

Alignment to Standards

Recognizing that teachers are strapped for time, and following Monterey Bay Aquarium's goals, we align our curriculum with California Science Standards and National Science Education Standards so that this curriculum builds upon the knowledge that students "must" learn.

Fortunately, issues surrounding tagging and tracking of marine animals provide ample space to address these standards.

Collaboration

We believe collaboration fosters deeper learning. We hope that by working together, the students will generate ideas they would not have thought of while working independently. In addition, having the opportunity to challenge each others' thinking and defending their ideas will push them towards richer understanding. Finally, this style of learning can assist students with diverse abilities and varied English language proficiency with participating in discussions and activities.

References:

Bruner, J. (1960). *The Process of Education.* Cambridge: Harvard University Press. p. 14.

Dewey, J. (1938). *Experience and Education*. New York: Collier Books. pp. 22

Meek, A. (March 1991). On Thinking about Teaching: A Conversation with Eleanor Duckworth. *Educational Leadership*, pp. 30.

Noddings, N. (1992). *The Challenge to Care in Schools*. New York: Teachers College Press. pp.56-68.

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Unit 1: Tagging & Tracking Pelagic Predators: What does it mean? What can it tell us?

- **Lesson I (50 minutes):** Connect to students' prior knowledge and encourage interest and caring about ocean animals.
- **Lesson 2 (30 minutes):** Read tagging maps and form hypotheses.
- **Lesson 3 (50 minutes):** Investigate what different tags tell us.

Lessons 1-3: Tagging & Tracking Pelagic Predators: What does it mean? What can it tell us?

Topics
Migration, Map reading

Grades
9-10

Site
Indoors

Duration
3 lessons

- Lesson1 (50 minutes)
- Lesson 2 (30 minutes)
- Lesson 3 (50 minutes)

Materials

- Map It! My Map
- Map It! Animal Map
- Tracking the Elephant Seal Worksheet
- Tracking the Elephant Seal Teacher's Guide
- Tag Type Worksheet
- Tag Type Handout
- Sustaining Marine Life Project (handout)
- Sustaining Marine Life Project Assessment Rubric

Vocabulary
Chlorophyll: The green pigment found in plants, algae, and bacteria that converts light to energy.

Migration:
Moving or travelling long distances in search of necessities such as food, water, mates, or a more suitable habitat.

Overview

What can we tell about people from the places they go? Similarly, what clues do animals give us about their lives based on where they go? Why do animals migrate? What role does migration play in animals' life cycles? Students will reflect on the role of migration and explore paths of ocean animals made visible through tagging and tracking.

Objectives

Students will be able to:

- Discuss the similarities and differences between animal and human movement patterns.
- Explain how animal migration helps to sustain life.
- Explain how tagging and tracking can help scientists understand the ocean ecosystem.
- Understand that there are different types of tags that are used for different purposes.
- Investigate maps of animal migrations and form hypotheses.

Background

According to the TOPP Tagging of Pacific Predators (2010) website: "Tagging of Pacific Predators (TOPP) began in 2000 as one of 17 projects of the Census of Marine Life, an ambitious 10-year, 80-nation endeavor to assess and explain the diversity and abundance of life in the oceans, and where that life has lived, is living, and will live.

Several dozen TOPP researchers from eight countries began venturing into offshore waters, remote islands, and along rugged coastlines to attach satellite tags to 22 different species of top predators that roam the Pacific Ocean. As of 2007, they have tagged more than 2,000 animals, including elephant seals, white sharks, leatherback turtles, squid, albatross and sooty shearwaters.

As these animals began sending back data via Argos, a polar-orbiting satellite, they opened the door to a world we'd never seen before: a picture of their migration routes and their ecosystem...through their eyes. We humans were finally able to witness their journeys through, what is to our human perspective, featureless blue waters. We've learned that many of these animals use those routes as regularly as college students migrating to Florida

Pelagic: Open ocean.

Predator: An animal that hunts for and eats other animals.

Tagging:
Placing a device on an organism in order to identify it and/or track its movement.

Tracking:
Using feedback from a tracking device on an organism for purposes such as: following the organism's physical location; monitoring the organism's condition; or gathering data from the environment around the organism.

National Science Education Standards
Science as Inquiry (9-12)
Ability to do scientific inquiry
Understanding about scientific inquiry

Life Science (9-12)
Interdependence of organisms
Behavior of organisms

Science and Technology (9-12)
Understanding about science and technology

History and Nature of Science (9-12)
Science as a human endeavor

for spring break. Marrying other satellite imagery to the animals' tracks, we've started to identify the ocean equivalent of desert oases or the watering holes of African savannahs, where the animals gather to feed and to breed. A big question is: how do these ocean animals know where to find these "hot spots" that continuously form and swirl through the seas?

These voyagers are giving us better data to protect the endangered species among them, such as leatherback turtles, black-footed albatross and blue whales. They're also providing information to better manage fisheries -- such as bluefin tuna, yellowfin tuna, and swordfish -- that risk collapse or threaten the survival of other species caught in nets and long-lines." (Tagging of Pacific Predators, 2010)

Procedure

Lesson 1 (50 minutes): Connect to students prior knowledge and encourage interest and caring about ocean animals.

1. INTRODUCE MIGRATION AND TIE TO STUDENTS' LIVES (7 minutes)
   Whole class discussion. Prompts: *What do people need to live? Where do they go to get what they need? What can you tell about people from where they go? Where do you go in a typical day? Do you have a cell phone or know someone who does? Many cell phones contain Global Positioning System (GPS) technology. If turned on, this technology can identify the location of a phone. If you are carrying the phone, the GPS can track where YOU go. In addition, there are apps that allow you to share your location with friends and family. They can "track" where you go. If other people have agreed to share their information, you can also "track" them to find out where they go or even their current location.*(If time and technology allows, play this 1:26 min video explaining how Google Latitude can be used to track friends and family: http://www.youtube.com/watch?v=Q-Oq-9enE-k)

2. INDIVIDUAL ACTIVITY: MAP YOUR DAY (15 minutes)
   Teachers should make a sample map of their day to show students what a basic map would look like along with sample 'where' and 'why' answers. Also, based on your location and your students' familiarity with maps, let them know the level of detail you expect on their maps.
   - Give each student a "Map-It! My Map" worksheet. Scenario: If students were carrying a GPS enabled cell

phone and had agreed to share their location "data," what would the map of their day look like? Have students draw their map on the worksheet. Once they have finished, they can fill in the 'My Where' and 'My Why' columns.

- Have students fold their paper to hide their 'Where' and 'Why' answers and then exchange maps with a partner. Partners examine each other's maps and write their own hypotheses by filling in the 'Where' and 'Why' columns on the bottom of the page. When finished, they can unfold the page to discover if their hypotheses were correct!

- Class discussion: *Was it difficult to form hypotheses based on the map information? Were the hypotheses correct? What additional information would have made it easier to formulate hypotheses from the maps?*

3. WHY DO ANIMALS MIGRATE? (15 minutes)
   Talk to students about how scientists can form hypotheses about animal migration by following their movements. Just like GPS enabled phones can trace people's movements, special "tags" can help scientists "track" animals. Show the following 3 minute video that shows the tagging of an elephant seal. (Emphasize that scientists are very careful during this process to keep the animal safe.) http://www.youtube.com/embed/kh-1JkScKEQ Have students work in pairs to hypothesize about where this elephant seal might go and why. Have them fill out the "Map It! Animal Map" Worksheet and make one hypothesis. As a class, discuss different hypotheses.

4. INVESTIGATE ACTUAL MIGRATION PATTERNS (8 minutes)
   Watch 3-minute TOPP overview video http://www.youtube.com/v/6qNSaK9-UjY&hl=en Have students changed their hypotheses based on this new information? Have them add additional hypotheses to their worksheet.

5. PREVIEW LESSON AND INTRODUCE FINAL TASK (5 minutes)
   Distribute "Sustaining Marine Life Project" handout and "Assessment Rubric" for the final project. Explain to students that over the next few class periods they will be learning more about the tagging and tracking of pelagic (open ocean) predators. They will be working in teams to track a specific species and learn more

about where it goes and why. They will also explore threats their animal may face. At the end of this unit, they will create a product that will help convince others at the school to help protect their animal. They will need to include the information from the rubric in their product, so as they learn about their animals, they should keep in mind how they will present their findings to others.

Teacher tip: *Formative assessment - have students turn in their Map It! worksheets. Examine their hypotheses to gauge the level of their understanding and the sophistication of their responses. Are any clarifications necessary before proceeding to the next lesson? Does any vocabulary need to be further defined? Are any modifications needed for the English Language Learners in your class?*

Lesson 2 (30 minutes): Read tagging maps and form hypotheses.

1. EXAMINE THE DATA (20 minutes)
   Hand out the "Tracking the Elephant Seal: Reading the Data" worksheet. If students have access to the web, have them go to the following site so they can "animate" the animal movements (below each map are buttons to control the animation): http://las.pfeg.noaa.gov/TOPP/sp06_anm.html Have students form small groups to explore and discuss. What do students notice about the patterns? How can they fine-tune their hypotheses? What additional questions do they have? Ask students to answer the questions on the worksheet.

   Teacher tip: *If students do not have access to the web to view the maps, provide larger printed maps to share or display maps on an overhead projector so students can see the details.*

2. DISCUSS MAP FEATURES AND INFORMATION (10 minutes)
   Whole class discussion about what students discovered. Did they find any new information? Did they change their hypotheses? What additional questions came up? Where can they go to find answers to those questions?

   Teacher tip: *Formative assessment - as students are discussing their findings and filling out the worksheet, circulate around the room and examine their responses. Are they using key information from the maps to adjust their hypotheses? Is any clarification necessary before moving on?*

Lesson 3 (50 minutes): What do different tags tell us?

1. INVESTIGATE DIFFERENT TAGS AND CONNECT TO PRIOR KNOWLEDGE (10 minutes)
   Pass out "Tag Type Worksheet". Discuss the elephant seal example at the top of the sheet. Relate the subject to the earlier cell phone example. If students could design a device that would track their friends in the most unobtrusive way possible, what would it look like and what features would it have? Ask students to draw a picture of their friend with device and answer the questions about its features and functionality.

2. PELAGIC PREDATOR TAGS (20 minutes)
   Divide the class into small groups and assign each group an animal (tuna, leatherback turtle, white shark, whale, salmon shark, sea lion). Have them go to http://topp.org/about_topp or give them the "Handout for Tag Type Exercise". Using this information have the groups draw a picture of their animal with its tag and fill out the information about the tag.

3. JIG SAW (10 minutes)
   Rearrange the groups so there are different animals represented in each group. Have students discuss the similarities and differences between their animals and the tags used to track them.

4. SHARE OUT (10 minutes)
   Have each group designate a spokesperson to give a summary to the class.

   Teacher tip: *Formative assessment - as students are discussing their findings and filling out the worksheet, circulate around the room and examine their responses. Were they able to extrapolate the information about the tags and apply it to their animals? Is any clarification necessary before moving on?*

	Standards **California Science Standards** Ecology (9-12) 6 Investigation and Experimentation (9-12) 1d, 1h,1i **Resources** TOPP Youtube Channel: http://www.youtube.com/TOPPpredators Additional TOPP videos on the TOPP Youtube Channel **References** Tagging of Pacific Predators (2010). About TOPP. Retrieved February 14, 2012, from: http://topp.org/about_topp

LESSON I-3 APPENDICES

Map It! My Map (Lesson 1)

Draw a map of where you go on a typical day. Be sure to include any relevant information such as street names and other landmarks. Once you are done, fill out the 'My Where' and 'My Why' columns explaining the reasons you go to each location.

← (fold here)

Draw Your Map Here:	My Where	My Why

(To be filled out by partner): Without looking at your partner's answers, can you figure out where they go and why based on their map?

← (fold here)

Where:	Why:

Map It! Animal Map (Lesson 1)

Draw your animal map below. Be sure to include relevant features such as the coastline.

Draw Your Animal Map Here:	Where	Why

Hypotheses:

1st hypothesis:
2nd hypothesis:
3rd hypothesis:
My questions:

Sustaining Marine Life Project **(Lessons 1 and 7)**

In this project, you will collaborate with your group to design a product that increases awareness and inspires people at your school to help sustain marine life. Some things to consider: What knowledge do they likely have and what further knowledge do they need to appreciate and care for marine life? What barriers may prevent behavior change? How can you help people overcome these barriers? It is probably a good idea to focus on one anthropogenic threat, and you should draw from the research you have already done on the animal you tracked, however you may also bring in outside research.

It is up to you to decide what kind of product you would like to create, but examples include:

- In-class Assignment
    - An informational brochure (see sample)
    - A poster

The list above is not exhaustive. Be creative!

Along with your group product you will each submit a brief description (1-2 pages) of your process of developing the product, including a clear explanation and defense of how your product will educate and inspire people to take action.

You will be assessed with the following criteria:

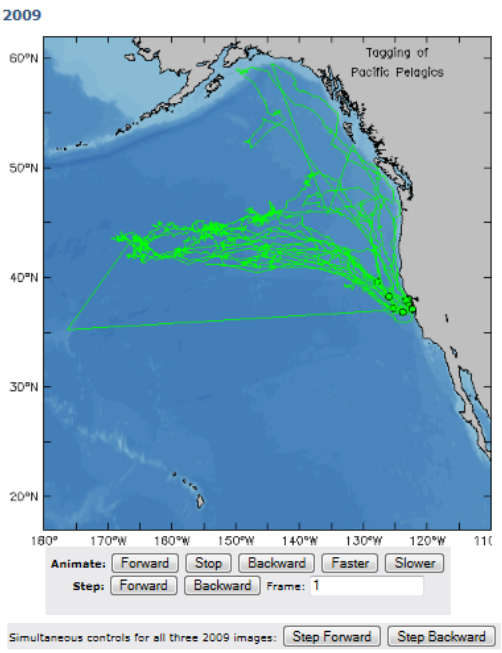
- Description of animal and its life cycle
- Incorporation of research on animal migration patterns
- Incorporation of specific, accurate, and relevant information on how the threat affects marine life
- Persuasive call for behavior change
- Clear organization of content
- Explanation and defense of process and product

Sustaining Marine Life Project Assessment Rubric (Lessons 1 and 7)

Criteria	***0 Points***	***1 Point***	***2 Points***	***3 Points***
Description of animal and its needs for sustaining life	No description of animal or elements of its life	Limited or vague description of animal and its life	Good description of animal and several points about its life	Solid description of animal and clear, relevant description of its life cycle
Incorporation of animal migration patterns	No incorporation of animal migration patterns	Irrelevant or very little incorporation of animal migration patterns	Information includes visual representations as well as ideas of chlorophyll / food **or** temperature in explaining animal migration patterns	Relevant and extensive description including visual representations as well as chlorophyll / food **and** temperature
Incorporation of specific, accurate, and relevant information on how the threat affects marine life	No incorporation of information on how the threat affects marine life	Vague or very little information about how the threat affects marine life	Accurate and relevant information on how the threat affects marine life, but lacking specificity	Specific, accurate and relevant information on how the threat affects marine life
Persuasive call for behavior change that addresses: targeting specific audience; reducing barriers to behavior change; providing meaningful information; creating commitment	No call for behavior change	Weak call for behavior change	Somewhat persuasive call for behavior change	Persuasive call for behavior change
Clear organization of content	Complete lack of organization	Attempt at organization	Somewhat clear organization (information grouped by topic, use of headings, etc.)	Clear organization with easy to read headings, topical information and supporting details
Explanation and defense of process and product	No explanation or defense of process and product	Limited explanation and weak defense of process and product	Good explanation but weak defense of process and product	Good explanation and strong defense of process and product

Tracking the Elephant Seal: Reading the Data (Lesson 2)

Images from: http://las.pfeg.noaa.gov/TOPP/sp06_anm.html



Looking at the map, answer the following questions:

What does the horizontal axis tell you? _____

What does the vertical axis tell you? _____

What does the blue represent? _____

What does the gray represent? _____

Can you identify your location on the map? Where are Alaska, California, and Hawaii? _____

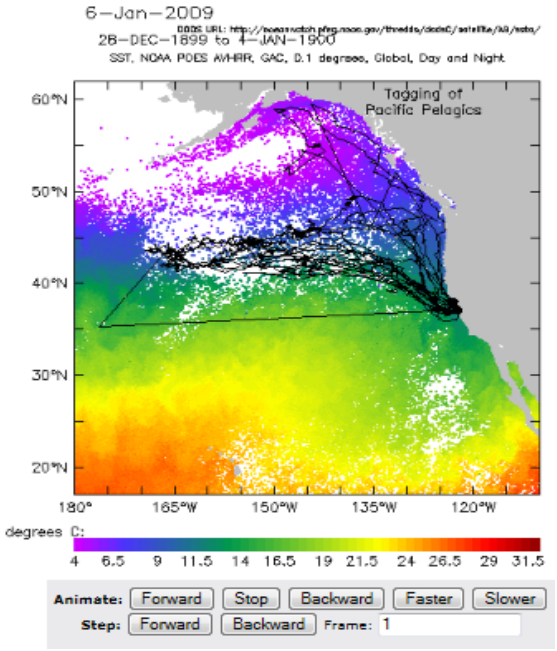
_____

What do the green lines represent? _____

_____

What about the green dots? _____

_____



Look at the legend for this map. What additional information does this map provide? How does this information help you form hypotheses about the elephant seal? _____

_____

_____

_____

_____

_____

_____

The term “pelagic” is an adjective that refers to living in the open ocean. Where do elephant seals spend most of their time? Would “pelagic” be a good word to describe them? Why or why not?

_____

Look at the legend for this map. What additional information does this map provide? Does this information help you? (Hint, the measurement has to do with chlorophyll levels) _____

_____

_____

_____

_____

_____

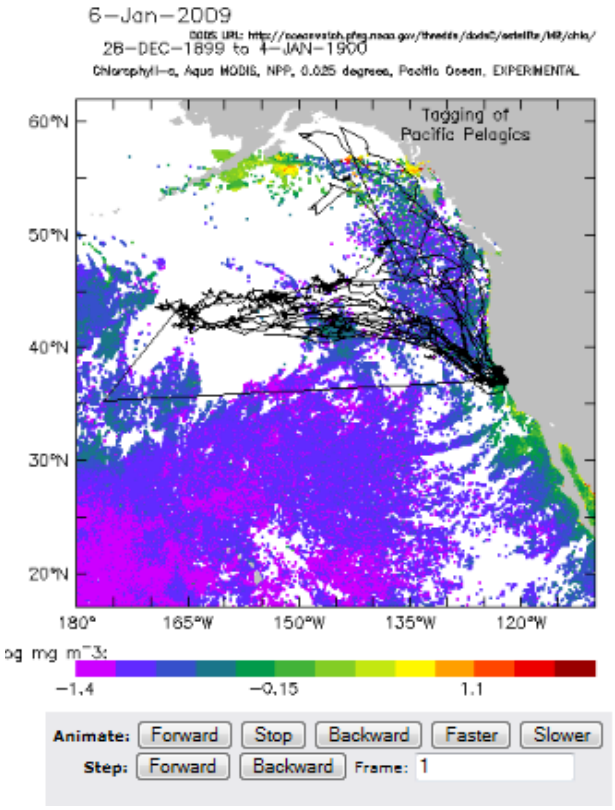
What is a “predator”?

_____

What do you think elephant seals eat? Do you think they are predators? _____

_____

Does knowing what elephant seals eat help you form hypotheses about where they go? _____



_____

_____

TOPP stands for “Tagging of Pacific Predators”. This is the organization that tags ocean animals and tracks their movements. Why would it be important to tag these animals? What information do these scientists hope to find? _____

_____

Refine your hypothesis about where the elephant seals go and why: _____

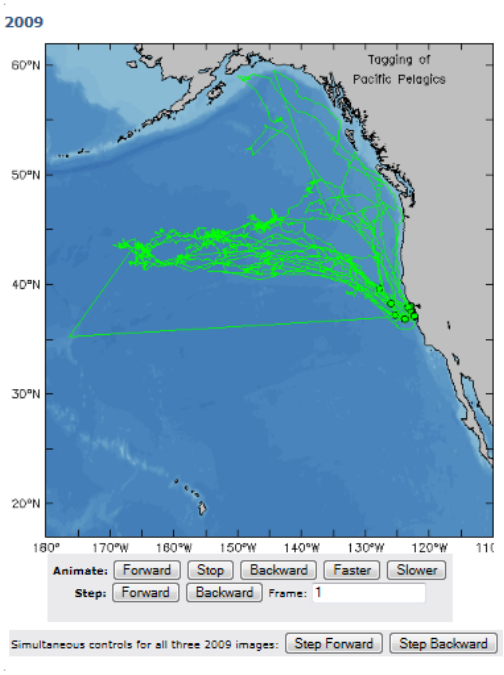
_____

What additional questions do you have that you would like to investigate? _____

_____

Tracking the Elephant Seal: Reading the Data (Teacher's Guide)

From: http://las.pfeg.noaa.gov/TOPP/sp06_anm.html



Looking at the map, answer the following questions:

What does the horizontal axis tell you? *Latitude*

What does the vertical axis tell you? *Longitude*

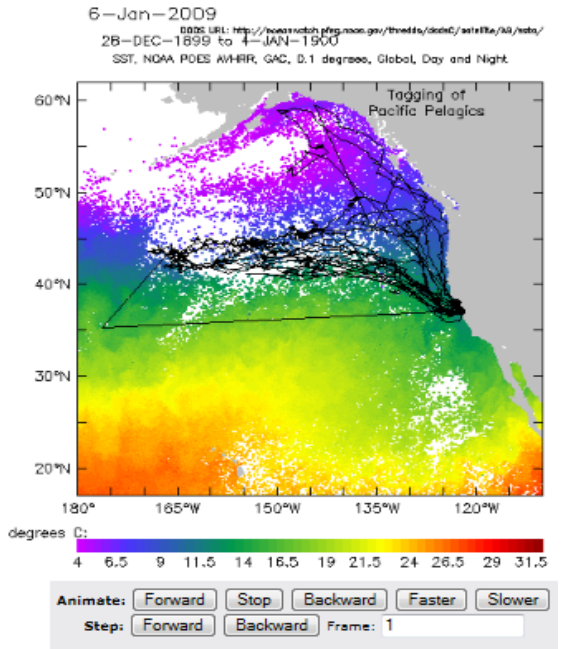
What does the blue represent? *Water*

What does the gray represent? *Land*

Can you identify your location on the map? Where are Alaska, California, and Hawaii? *Alaska is at the top of the map, the elephant seals are coming in and out of California and the set of islands in the ocean are the Hawaiian Islands.*

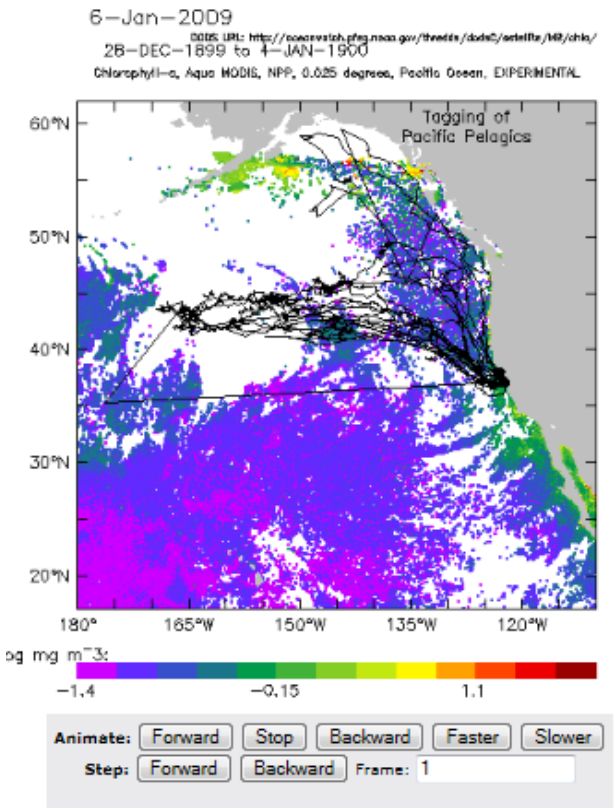
What do the green lines represent? *The lines represent the movement of elephant seals.*

What about the green dots? *Green dots represent individual elephant seals who have been tagged.*



Look at the legend for this map. What additional information does this map provide? How does this information help you form hypotheses about the elephant seal? *This map provides additional information about water temperature. It helps show that elephant seals like cold water.*

The term "pelagic" is an adjective that refers to living in the open ocean. Where do elephant seals spend most of their time? Would "pelagic" be a good word to describe them? Why or why not? *Yes! elephant seals spend most of their time in the open ocean and they venture far from land.*



Look at the legend for this map. What additional information does this map provide? Does this information help you? (Hint, the measurement has to do with chlorophyll levels) *This map shows chlorophyll levels in the water. Chlorophyll helps support life by providing nutrients needed at the bottom of the food chain. Chlorophyll is eaten by animals which are then eaten by larger animals. So, elephant seals may go to places rich in chlorophyll to find the animals they like to eat.*

What is a "predator"? *A predator hunts for and eats other animals.*

What do you think Elephant Seals eat? Do you think they are predators? *Elephant seals hunt for and eat other ocean animals such as fish, squid, skates, octopi, and even small sharks, so they are considered predators.*

Does knowing what elephant seals eat help you form hypotheses about where they go *Elephant seals may move and migrate in order to find food, so they may be going to places where they can find animals they like to eat.*

TOPP stands for "Tagging of Pacific Predators". This is the organization that tags ocean animals and tracks their movements. Why would it be important to tag these animals? What information do these scientists hope to find? *There are many reasons! Some include: predators are at or near the top of the food chain so they are important indicators of ocean health; many ocean predators travel very far in search of food, so they can help scientists explore a lot of different areas; many of these animals dive deep in their search for food, which helps scientists learn about features of the ocean at different depths; learning about how these animals live (finding food, mating, etc.) can help us conserve their habitats and protect them.*

Refine your hypothesis about where the Elephant Seals go and why: *By now student hypotheses should start to include some of the ideas above.*

What additional questions do you have that you would like to investigate *Student answers will vary.*

Handout for "Tag Type" Exercise (Lesson 3)

(Tagging of Pacific Predators, 2010, About Us) http://topp.org/about_topp

The Tags

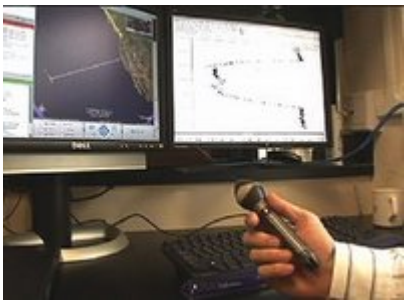
People have been tagging fish for more than 125 years to track their migrations -- the first fish tagged were Atlantic salmon in 1873, in Maine's Penobscot River. After sonar (**SO**und **N**avigation **A**nd **R**anging technology that uses sound to detect objects underwater) was perfected in the 1940s and 1950s, researchers began using acoustic tags. In the 1970s and 80s, data loggers were developed. These tags measured time, depth, internal temperature, swim speed and heart rate. Researchers had to catch, tag, and recatch an animal to retrieve the tag and its data. The big breakthrough came in the 1990s, when advances in computer and satellite technology increased the amount of data a tag could hold (some tags record every four seconds) and made data accessible remotely.

We use:

Archival tags

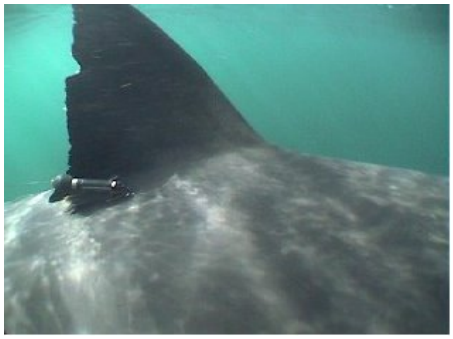
They're small, powerful, and can last up to 10 years. Researchers surgically implant them into the bellies of tuna, where the tags record – as often as every few seconds -- pressure (for depth of dives), ambient light (to estimate location), internal and external body temperature, and, in some cases, speed of travel. The tags are small and light enough to be attached to the outside of an animal, such as the tail feathers of red-footed boobies.

Their drawback: they have to be retrieved. So, they're useful for fish that are likely to be caught as popular seafood, such as bluefin or yellowfin tuna. And for animals that return to rookeries or nesting beaches, such as boobies and leatherback turtles.



Pop-up archival tags (PAT)

These larger tags are designed to release from an animal at a pre-set time – such as 30, 60, or 90 days after the tag's attached – and float to the surface. A tag then sends samples of its data to the polar-orbiting Argos satellite for about two weeks, the life of its battery. After the battery dies, the data survives so that if the tag is found, researchers can download the entire data set. This tag is useful for animals that don't spend a lot of time at the surface, and aren't caught often.



It collects information about pressure (for depth of dives), ambient light (to estimate location), internal and external body temperature.

We've tagged quite a few white sharks with this tag. White shark researcher Sal Jorgenson holds a pop-up tag in the photo above. That tag was attached to this white shark. He attached the tag by inserting a small surgical titanium anchor into the shark. (Do sharks notice when they're being tagged? Some flinch. Others show no reaction, says Sal.) On elephant seals, the tag is glued to the

fur. Connecting the tag to the anchor is a thin line that loops around a metal pin at the base of the tag. This metal pin is connected to a battery. A clock in the tag turns the battery on at a preprogrammed time. When the battery turns on, the attachment pin dissolves. The tag floats to the surface and starts transmitting data to one of the Argos satellites.

SPOT – Smart Position or Temperature Transmitting Tag

This is an ideal tag for air-breathing marine animals (seals, whales and sea turtles) and animals that often swim close to the surface (salmon sharks, blue sharks and makos). When the antenna breaks the surface, it sends data to a satellite. The data includes pressure, speed, and water temperature. Location is estimated by calculating the Doppler shift in the transmission signal in successive transmissions. When the animal goes beneath the surface, a saltwater switch turns off the tag. The tag, made by Wildlife Computers, lasts about two years.

SRDL – Satellite Relay Data Logger

These tags compress data so that more information can be transmitted through the Argos satellite. These can be outfitted with CTD tags that record salinity, temperature and depth, data that oceanographers need to identify ocean currents and water . Elephant seals, sea lions and leatherback sea turtles wear these tags.

Tag Type Worksheet (Lesson 3)

(Screen shot from TOPP video http://www.youtube.com/v/6qNSaK9-UjY&hl=en accessed 2/25/2012)

Hi TOPPS! Can you hear me? I'm transmitting via my cool SRDL tag. I've been swimming way out to sea and diving deep to find food. I hope you can use the information I'm sending you to make sure the ocean stays healthy so all of us elephant seals can continue to find food, mate and have elephant seal pups.

Device to track your friends:

If you were designing a GPS device to track your friends and family: What features would it have? What information would you like to collect? How easy would it be to carry around? Could your friends wear it around their necks, on their wrists, on their belt? How often would it send information back to you? Every second? Every minute? Or only when their location changed? Design your device below:

Picture of my friend with the GPS device I designed:	Information it would collect: How it would be carried: How often it would send data:

Tag to track your animal:

My animal: _____

Use the "Tag Type Handout" or go to http://topp.org/about_topp to find out about different types of animal tags. Draw a picture of your animal with its tag and specify the information it will collect and send to scientists.

Picture of my animal with its tag:	Name of the tag: What information it collects and how it works:

Unit 2: Student Investigation: Students use the scientific process to gather data, hypothesize, and test their conclusions.

- **Lesson 4 (90 minutes):** The Mystery of Sharks: What's their next target!?

Lesson 4: The Mystery of Sharks: What's their next target!?

Topics
Migration, Map reading

Grades
9-10

Site
Indoors

Duration
90 minutes

Materials
- Animal fact tag bands (see appendices)
  - Blue Shark
  - Shortfin Mako Shark
  - Salmon Shark
- Observation Entry Sheets
- Individual Reflection Sheet
- Internet access

National Science Education Standards
Science as Inquiry (9-12)
Ability to do scientific inquiry
Understanding about scientific inquiry

Life Science (9-12)
Interdependence of organisms
Behavior of organisms

Science and Technology (9-12)
Understanding about science and technology

History and Nature of Science (9-12)
Science as a human endeavor

Overview

How do scientists read and interpret tagging and tracking data? How do oceanographers predict and understand animal migration patterns? What additional information do scientists use other than tracking data to supplement their hypotheses? Students will use real data to investigate the migration patterns of sharks and will use this experience to reflect on the purpose of tagging and tracking and its importance in understanding marine life.

Objectives

Students will be able to:

- Explain how migration helps sustain their assigned animals' lives.
- Explain how tagging and tracking can help scientists understand these marine animals and their needs.
- Investigate maps of their assigned animals' migrations and form hypotheses about the animals' past and future movements.
- Observe and interpret changes, patterns, and outliers in the data that yield information about their assigned animals.
- Take all the information gathered and supplement it with additional research about their assigned animals to support their hypotheses.
- Understand and apply the scientific method.

Background

"By combining data from a diverse number of highly migratory species, and overlaying them with oceanographic data, it is possible to glimpse the processes that influence how open ocean ecosystems work. [The] objective is to understand the factors that influence animal behavior in the blue ocean and to build the tools required for protecting their future. In addition, animals carrying tags quickly become animal ocean sensors and can contribute millions of data records that can help climate scientists build a better understanding of planet Earth," (GTOPP, 2012).

Some of the maps that help with developing understandings about marine life include chlorophyll and temperature maps (see appendices).

Vocabulary

Migration:
Moving or travelling long distances in search of necessities such as food, water, mates, or a more suitable habitat.

Tagging:
Placing a device on an organism in order to identify it and/or track its movement.

Tracking:
Using feedback from a tracking device on an organism for purposes such as: following the organism's physical location; monitoring the organism's condition; or gathering data from the environment around the organism.

Chlorophyll:
A green pigment found in almost all plants, algae, and cyanobacteria. Chlorophyll is vital for photosynthesis, which allows plants to absorb energy from light. Like plants on land, phytoplankton in the ocean use chlorophyll and other light-harvesting pigments to carry out photosynthesis, absorbing atmospheric carbon dioxide to produce sugars for fuel.

Procedure

1. BRIDGE THE CELL-PHONE EXAMPLE TO THE MYSTERY INVESTIGATION (5 minutes)
   Remind student's of the previous lesson and introduce today's lesson: *If you were observing saw your friends all go to the same location at the same time, what would you think? What if I told you it was 9 o'clock? What if I told you it was 9AM? What if I told you it was 9PM? What if I told you it was during the school year? What if I told you it was a hot summer day? Keep these questions in mind as you investigate where sharks go in today's activity.*

2. ORGANIZE THE CLASS INTO GROUPS OF FOUR AND ASSIGN EACH GROUP AN ANIMAL (8 minutes)
   "Tag" each student with his or her appropriate animal fact tag band.

   Note: The same animal can be assigned to more than one group. Have groups review the list of brief basic facts

   ***Teacher Tip**: If you have a lot of ELL students, make sure that each group has at least one native English speaker. This may help in later group activities, which involve reading and synthesizing information.*

   Explain to students that each group will be given access to data to make predictions about the animals that they have been assigned. Explain to students that, similar to a mystery, there will be new clues introduced to them throughout the activity, which they should use to solidify their hypotheses. Stress that the investigation process is not always easy and straightforward and they may have some difficulties reading, interpreting, and extrapolating from their data. Furthermore, emphasize how scientists today encounter these same obstacles, and questions arise everyday in the field, with some staying unanswered.

3. OBSERVATION ENTRY SHEETS (2 minutes)
   Distribute observation entry sheets and explain: *The purpose of these observation entry sheets is to record the observations you make using the clues (i.e. satellite maps, etc). There will also be key questions to answer to help you hone in on your hypotheses.*

Teacher tip: *Formative assessment - have students turn in their observation entry sheets. Examine their hypotheses to gauge the level of their understanding and the sophistication of their responses. Are any clarifications necessary before proceeding to the next lesson? Does any vocabulary need to be further defined?*

4. TASK 1: EXAMINE CLUE #1 (SATELLITE MAPS) (15 minutes)
   Provide students the link to the satellite maps:
   Blue Shark: http://las.pfeg.noaa.gov/TOPP/sp01_anm.html
   Shortfin Mako Shark:
   http://las.pfeg.noaa.gov/TOPP/sp02_anm.html
   Salmon Shark: http://las.pfeg.noaa.gov/TOPP/sp03_anm.html

   Note: Because all of the maps will be simultaneously viewable on the screen, instruct students to focus on the map on the left hand side rather than the chlorophyll and sea surface temperature maps, which are on the right hand side

   Have students jot down the March 1 map reading (location / time) to anchor their observations. After they write down that reading, encourage them to "animate" the maps to get their additional data points and observations. Walk around while they are viewing the maps and encourage them to jot down patterns, outliers, and big changes that they see on the *2011 maps* in a chart along with associated observations, hypotheses, and questions.

   Note: Students may have difficulty grappling with the information that they are collecting. Remind them:
   You may have many questions after this task. Remember, this is a common thing for scientists today. What is important to consider is that these investigations are meant to further your knowledge through making observations and refining your hypotheses. The ocean holds many mysteries and questions that scientists are still trying to uncover. Today you will be taking on that role of the scientist and investigating one of those mysteries.

5. DEBRIEF TASK #1 (5 minutes)
   Write the following questions from the students' observation entry sheet on the board: "Did your group notice any patterns, changes, or outliers and if so, what kind? What kind of hypotheses did you make from just the satellite maps? What

	additional information do you need to fine-tune or supplement your hypotheses?" Have a representative from each group report on what they found based on the above questions. 6. TASK #2: EXAMINE CLUE #2 (CHLOROPHYLL AND SEA SURFACE TEMPERATURE MAPS) (15 minutes) Instruct students to look at chlorophyll and sea surface temperature maps to supplement and verify data. Provide students an overview of chlorophyll and sea surface temperature maps and content if needed (see appendices). Walk around while the students are viewing the maps and remind them to record patterns, outliers, and big changes that they see on the additional **2011 chlorophyll and sea surface temperature maps** in the chart along with the associated observations, hypotheses, and questions. Make sure they also jot down important map readings (e.g. location/time of animals movements, sea surface temperature, and chlorophyll readings) to back up their observations, hypotheses, and questions, and to remind themselves of where they made their observations. **Remind students:** *Don't forget to look at your previous observations and see if there are any connections.* ***Teacher tip:*** *If your students are stuck, try to connect the activity back to the prior tracking friends activity - What would the map of your friends look like if they were all hungry? What if it were a sunny day?* 7. DEBRIEF TASK #2 (5 minutes) Write the following questions from the students' observation entry sheet on the board: "Did your group notice any new patterns, changes, or outliers with the new clue? How did your new clue (chlorophyll and sea surface temperature maps) supplement, change, or debunk your existing hypotheses? What else do you need to fine-tune or supplement your hypotheses?" Have a representative from each group (different from the last representative) report on what they found based on the above questions.

8. TASK #3: EXAMINE CLUE #3 (TOPP SITE) (15 minutes)
   Allow students to look at the TOPP website pages for their animal to supplement and verify data.

   Extension: *If there's time, there is an extension where you can bring in experts in the field! See appendices.*

   Write these websites on the board for students to review facts on their animals:
   - http://topp.org/species/salmon_shark
   - http://topp.org/species/mako_shark
   - http://www.sharks-world.com/blue_shark.html OR http://www.pelagic.org/montereybay/pelagic/blueshark.html (As of 3/2012, there is no TOPP site for blue shark)

   Have students jot down new findings from their additional research in the chart on the third observation entry sheet, tying them to the hypotheses they support or contradict, and writing down any additional questions they might have.

   Teacher tip: *If the students are having some trouble, the "Ocean of Know" has additional information about shark migration (http://oceanofk.org/tag/Tagmigrate/cfactorscause.html).*

   For the last 5 minutes, ask each group to summarize their final hypotheses and send one person up to write them on the board.

9. DEBRIEF TASK #3 (5 minutes)
   Write the following questions from the students' observation entry sheet on the board: "What new observations did your group make with the new clue (TOPP website)? How did the additional information supplement, debunk, or change your group's existing hypotheses? Is there anything else that you could use to fine-tune or supplement your hypotheses?"

   Expert Extension Questions: *What new information did your expert provide? How did this support or contradict your hypotheses? In what ways did your expert use tagging and tracking information?*

   Have a representative (different from the last representative) from each group present their list of final hypotheses and report on

what they found based on the above questions.

10. INDIVIDUAL REFLECTION: SOLVING THE MYSTERY (15 minutes)
    Students write based on the following prompt:
    - Take 15 minutes to reflect on all the information and findings you have gathered on the provided sheet. How do you believe it could be used in oceanography? How can this research contribute to ocean conservation? What difficulties and obstacles did you run into during the activity?

    *A reflection sheet is provided.

    ***Teacher Tip**: There are no right answers for this writing activity. It is meant to incite students to start developing their own opinions about and reach a newfound understanding of oceanography and ocean conservation. Good entries show thoughtful, personal reflections on the activity.*

Standards

California Science Standards (California Department of Education, 2000)
Grades 9-12: Biology/Life Sciences 6b
Investigation and Experimentation 1m

Resources

Satellite Map Data: http://las.pfeg.noaa.gov/TOPP/TOPP_tracks010.html

Additional website about Shark migratory patterns:
http://oceanofk.org/tag/Tagmigrate/cfactorscause.html

References

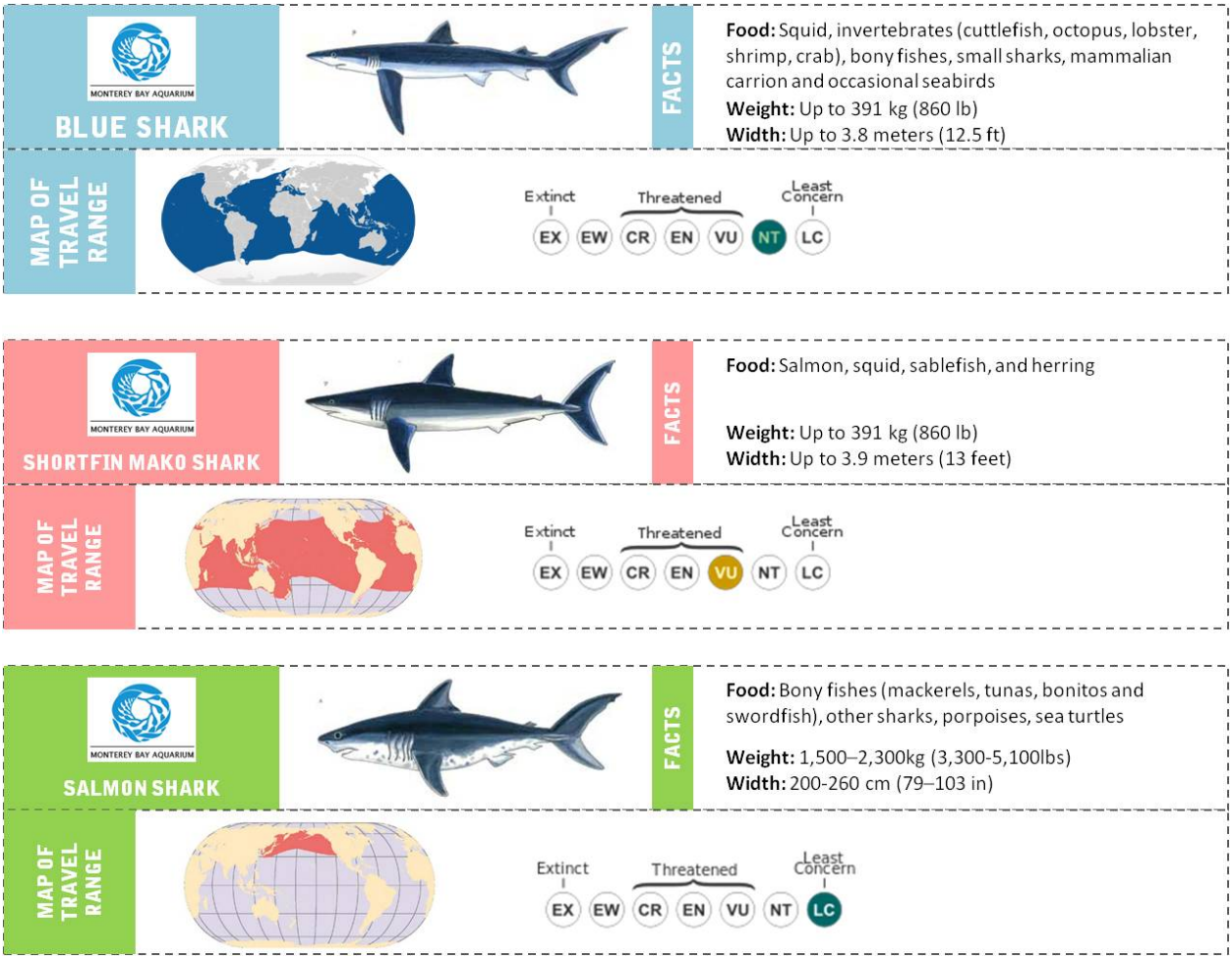
GTOPP. (2012). About GTOPP. Retrieved March 1, 2012, from: http://gtopp.org/about-gtopp/programs/background.html

Earth Observatory. (2002). Chlorophyll Global Maps. Retrieved February 19, 2012, from: http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MY1DMM_CHLORA

Earth Observatory. (2002). Sea Temperature Global Maps. Retrieved February 19, 2012, from: http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MY1DMM_CHLORA&d2=MYD28M

Lesson 4 Appendices

Animal Fact Tag Bands



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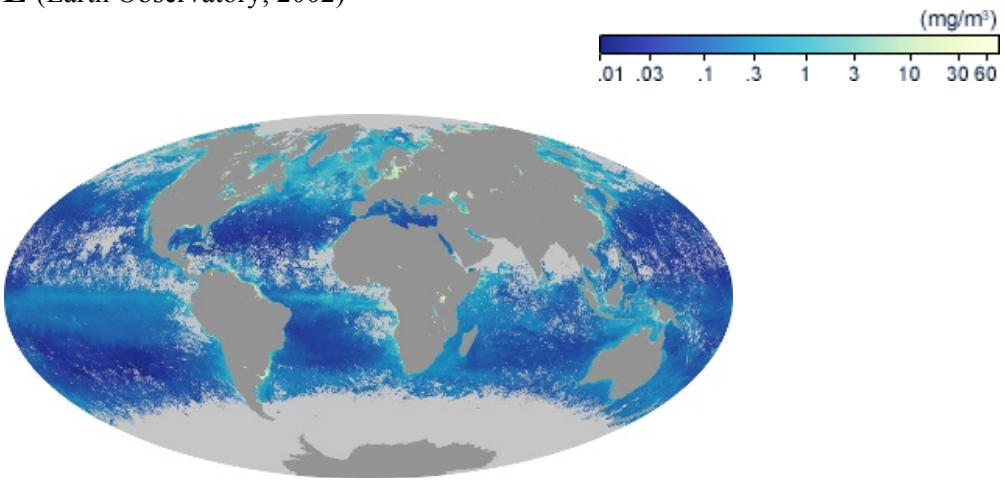
Fisheries and Oceans Canada. (2011). Sharks of British Columbia. Retrieved February 19, 2012, from: http://www.pac.dfo-mpo.gc.ca/publications/docs/sharks-requins-eng.htm

New Brunswick.net. (2011). Shortfin Mako Shark. Retrieved February 19, 2012, from: http://new-brunswick.net/new-brunswick/sharks/species/sfmako.html

CHLOROPHYLL (Earth Observatory, 2002)



Quicktime movie of the chlorophyll development:
http://eoimages.gsfc.nasa.gov/images/globalmaps/data/mov/MY1DMM_CHLORA.mov

At the base of the ocean food web are single-celled algae and other plant-like organisms known as phytoplankton. Like plants on land, phytoplankton use chlorophyll and other light-harvesting pigments to carry out photosynthesis, absorbing atmospheric carbon dioxide to produce sugars for fuel. Chlorophyll in the water changes the way it reflects and absorbs sunlight, allowing scientists to map the amount and location of phytoplankton. These measurements give scientists valuable insights into the health of the ocean environment, and help scientists study the ocean carbon cycle.

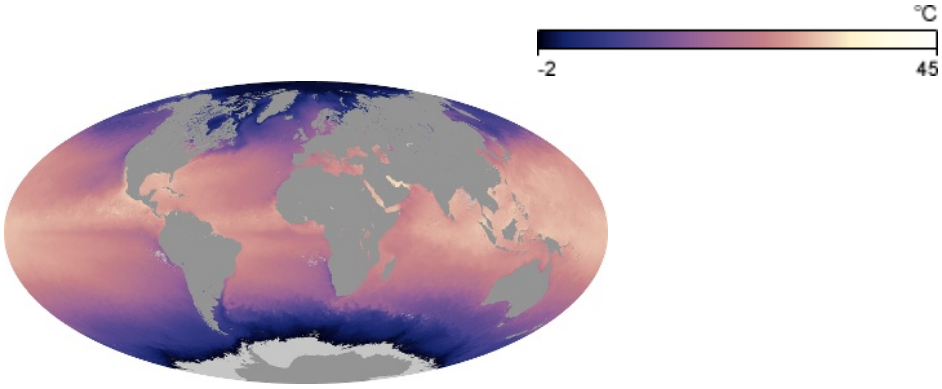
These chlorophyll maps show milligrams of chlorophyll per cubic meter of seawater each month. Places where chlorophyll amounts were very low, indicating very low numbers of phytoplankton are blue. Places where chlorophyll concentrations were high, meaning many phytoplankton were growing, are yellow. The observations come from the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite. Land is dark gray, and places where MODIS could not collect data because of sea ice, polar darkness, or clouds are light gray.

The highest chlorophyll concentrations, where tiny surface-dwelling ocean plants are thriving, are in cold polar waters or in places where ocean currents bring cold water to the surface, such as around the equator and along the shores of continents. It is not the cold water itself that stimulates the phytoplankton. Instead, the cool temperatures are often a sign that the water has welled up to the surface from deeper in the ocean, carrying nutrients that have built up over time. In polar waters, nutrients accumulate in surface waters during the dark winter months when plants can't grow. When sunlight returns in the spring and summer, the plants flourish in high concentrations.

A band of cool, plant-rich waters circles the globe at the Equator, with the strongest signal in the Atlantic Ocean and the open waters of the Pacific Ocean. This zone of enhanced phytoplankton growth comes from the frequent upwelling of cooler, deeper water as a result of the dominant easterly trade winds blowing across the ocean surface. In many coastal areas, the rising slope of the sea floor pushes cold water from the lowest layers of the ocean to the surface. The rising, or upwelling water carries iron and other nutrients from the ocean floor. Cold coastal upwelling and subsequent phytoplankton growth are most evident along the west coasts of North and South America and southern Africa.

View, download, or analyze more of these data from NASA Earth Observations (NEO):
Chlorophyll / http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MY1DMM_CHLORA

TEMPERATURE (Earth Observatory, 2002)



Download a Quicktime animation of this dataset (3 MB)

Sea surface temperatures have a large influence on climate and weather. For example, every 3 to 7 years a wide swath of the Pacific Ocean along the equator warms by 2 to 3 degrees Celsius. This warming is a hallmark of the climate pattern El Niño, which changes rainfall patterns around the globe, causing heavy rainfall in the southern United States and severe drought in Australia, Indonesia, and southern Asia. On a smaller scale, ocean temperatures influence the development of tropical cyclones (hurricanes and typhoons), which draw energy from warm ocean waters to form and intensify.

These sea surface temperature maps are based on observations by the Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Aqua satellite. The satellite measures the temperature of the top millimeter of the ocean surface. In this map, the coolest waters appear in blue (approximately -2 degrees Celsius), and the warmest temperatures appear in pink-yellow (45 degrees Celsius). Landmasses and the large area of sea ice around Antarctica appear in shades of gray, indicating no data were collected.

The most obvious pattern shown in the time series is the year-round difference in sea surface temperatures between equatorial regions and the poles. Various warm and cool currents stand out even in monthly averages of sea surface temperature. A band of warm waters snakes up the East Coast of the United States and veers across the North Atlantic—the Gulf Stream.

Although short-lived weather events that influence ocean temperature are often washed out in monthly averages, a few events show up. For example, in December 2003, strong winds blew southwest from the Gulf of Mexico over Central America toward the Pacific Ocean, driving surface waters away from the coast, and allowing cold water from deeper in the ocean to well up to the surface. These winds are a recurring phenomenon in the area in the winter; they are known as Tehuano winds.

View, download, or analyze more of these data from NASA Earth Observations (NEO):
Sea Surface Temperature

http://earthobservatory.nasa.gov/GlobalMaps/view.php?d1=MYD28M

Additional Article about Sea Temperature and Ocean Life:
http://www.scientificamerican.com/article.cfm?id=how-will-warmer-oceans-affect-sea-life

MYSTERY ACTIVITY - OBSERVATION ENTRY SHEET #1

GROUP # _____ ANIMAL _____

OBSERVATION (Ex. Patterns, outliers, changes, etc)	**CORRESPONDING EVIDENCE (Ex. Map Reading, Information with citation from outside sources, etc)**	**DATE RECORDED**	**QUESTIONS**	**HYPOTHESES / FINDINGS**
A cluster of ___ moved to North Eastern Pacific on 9/9/2010	*Map reading – 9/9/2010 Long: -120, Lat: 34*	*3/4/2012*	*What is in that part of the ocean? Is it warmer there? Is there food there?*	

Summary Questions

Did you notice any patterns, changes, or outliers and if so, what kind?

What kind of hypotheses did you make from just the satellite maps?

What additional information do you need to fine-tune or supplement your hypotheses?"

MYSTERY ACTIVITY - OBSERVATION ENTRY SHEET #2

GROUP # _____ ANIMAL _____

OBSERVATION (Ex. Patterns, outliers, changes, etc)	**CORRESPONDING EVIDENCE (Ex. Map Reading, Information with citation from outside sources, etc)**	**DATE RECORDED**	**QUESTIONS**	**HYPOTHESES / FINDINGS**
A cluster of ___ moved to North Eastern Pacific on 9/9/2010 where water was very warm	*Map reading – 9/9/2010 Long: -120, Lat: 34, 29°C*	*3/4/2012*	*Is there food in the warmer waters? Do___ like warmer waters?*	*Hypothesis: ___ feed on ___ that like warmer waters.*

Summary Questions

Did you notice any new patterns, changes, or outliers with the new maps?

How did your new clue (chlorophyll and sea surface temperature maps) supplement, change, or debunk your group's existing hypotheses?

What else do you need to fine-tune or supplement your group's hypotheses?

MYSTERY ACTIVITY - OBSERVATION ENTRY SHEET #3

GROUP # _____ ANIMAL _____

OBSERVATION (Ex. Patterns, outliers, changes, etc)	**CORRESPONDING EVIDENCE (Ex. Map Reading, Information with citation from outside sources, etc)**	**DATE RECORDED**	**QUESTIONS**	**HYPOTHESES / FINDINGS**
A cluster of ___ moved to North Eastern Pacific on 9/9/2010 where waters were very warm	*Map reading –9/9/2010 Long: -120, Lat: 34, 29°C*	*3/4/2012*		*___ feed on ___ which tend to like warmer waters.*

Summary Questions

What new observations did your group make with the new clue (TOPP website)?

How did the additional information supplement, debunk, or change your group's existing hypotheses? ***Jot down your final hypotheses.***

Is there anything else that you could use to fine-tune or supplement your hypotheses?

Individual Reflection: Solving the Mystery

GROUP # _____ ANIMAL _____

Take 15 minutes to reflect on all the information and findings you have gathered on the provided sheet. How do you believe it could be used in oceanography? How can this research contribute to ocean conservation? What difficulties and obstacles did you run into during the activity?

Extension: Bringing in the Experts

For the Mystery Activity, you can bring in experts from the field as the third clue! The TOPP website has some experts that may be available for interview via phone or e-mail. If possible, try contacting marine biology experts in your community.

Instructions

- Go to the following websites and click on "People Involved" to schedule time with 1 or 2 experts for your classroom activity.
  http://www.topp.org/species/salmon_sharkhttp://topp.org/species/mako_shark
- Provide the e-mail or phone number of the expert to your students as the third clue.
- Have them consider the following potential questions to ask their expert:
  - Potential Questions: How do see this research being used beyond your work? What additional data do you look at when tagging and tracking an animal?

Unit 3: Ocean Stewardship: Students investigate threats, design solutions and take action.

- **Lesson 5 (90 minutes):** Investigate Threats: Considering competing needs
- **Lesson 6 (70 minutes):** Come Up With Solutions: Inspiring environmental behavior change
- **Lessons 7 (80 minutes):** Come Up With Solutions (Part II): Creating a Product for Change

Lesson 5: Investigate Threats: Considering competing needs

Topics
Threats to marine life, Conflicts between human and environmental needs

Grades
9-10

Site
Indoors

Duration
90 minutes

Materials
- Individual Reflection Sheet
- White board or poster paper
- Markers
- Skit Info Sheets (Oil Contamination, Plastics, Overfishing, and Shark Conservation)
- Optional: Internet access

Vocabulary
Anthropogenic Threat: A negative impact on the environment/biodiversity, which is caused by human actions.

Overfishing: Reducing fish stocks below an acceptable level

Stakeholder: A person, group, or organization who

Overview
What are the implications of knowing where animals migrate, feed, or breed? What threats do animals encounter during their migrations? What challenges or threats may humans pose? How do human and animal needs conflict? What can be done to alleviate some of these threats? Students will research how human actions threaten marine life and consider the ways we can care for marine life even when it conflicts with human needs or desires.

Objectives
Students will be able to:
- Define *anthropogenic threat*
- Identify some of the anthropogenic threats that marine animals encounter
- Explain how anthropogenic threats hinder marine animals' abilities to survive
- Explain some of the conflicts between human and animal needs

Background
"Though they have swum the oceans since before the dinosaurs, they have never faced a predator as voracious as industrialized humanity." – Peter Knights and Steve Trent (WildAid, 2007, p. 3)

This quote about sharks by the executive director and president of WildAid, an organization dedicated to ending the illegal wildlife trade, speaks to the magnitude of human impacts on the world's ecosystems and animals. **Anthropogenic threats**, threats caused by human actions, are wreaking havoc on marine and terrestrial ecosystems. According to the National Oceanic and Atmospheric Administration, the ocean "covers 71 percent of the Earth's surface" and "supports the life of nearly 50 percent of all species on Earth" but "95 percent of the underwater world remains unexplored," (NOAA, 2012). For a long time, this great unknown expanse seemed indestructible and inexhaustible, but advances in marine science and plummeting fish stocks have begun to demonstrate the detrimental impacts that our actions are having on what is in fact a fragile ocean ecosystem.

Anthropogenic threats to marine animals are too numerous to list,

is involved in or affected by a course of action or enterprise

National Science Education Standards (National Research Council, 1996)

Life Science (9-12)
Interdependence of organisms
Behavior of organism

Science in Personal and Social Perspectives (9-12)
Natural resources
Environmental quality
Science and technology in local,
national, and global challenge

however a few bear mentioning. Overfishing has historically been recognized as one of the most significant threats to marine biodiversity. A study published in *Science* in 2006 predicted the collapse of all fisheries by 2048 (Worm *et al.*, 2006). The significance of pollution has come to the forefront in the last few decades with the discovery of the Great Pacific Garbage Patch, a patch of swirling plastic debris, estimated to be the size of Texas, and the press on several high-profile oil spills. Plastics harm animals through ingestion or entanglement and oils and other chemicals disrupt physiological processes and alter the chemistry of seawater.

The threats are numerous and the need for conservation is clear. This issue is how to address the needs of marine life, while simultaneously fulfilling human needs. After all, fish provide a crucial source of protein to many coastal communities, plastics provide benefits in spheres as disparate as medicine and recreation, and fossil fuels power many industries, not to mention the transportation sector. Balancing these competing needs will be crucial to the future of the oceans and the Earth as a whole.

Procedure

1. INTRODUCE THE TOPIC OF MARINE THREATS TO STUDENTS (8 minutes)
   Yesterday we explored how tagging and tracking research can inform scientists about how marine animals migrate to survive. Today we are going to consider marine animal survival through a different lens, by thinking about conservation and the threats that animals may face during their migrations. To start, let's brainstorm some of these threats. Write threats on a white board or poster while students brainstorm.

   ***Teacher Tip**: There are many possible answers for this brainstorm. The point is to just get students thinking. Still, if students are having trouble coming up with threats, prompt them with questions like:*
   - *What can kill a marine animal before it dies naturally of old age?*
   - *What things near the shore might affect the water in which the animals swim?*

2. INTRODUCE THE CONCEPT OF ANTHROPOGENIC THREATS TO STUDENTS (7 minutes)
   Which of the threats that we brainstormed do humans cause? We call human-caused threats anthropogenic threats.

Circle all of the anthropogenic threats. If they haven't been mentioned already, add **overfishing**, and **pollution** to the list (students will further investigate these threats later). Explain that overfishing occurs when fishermen reduce fish stocks to unacceptable levels, which may be too low to sustain the stocks. Also mention that there are different kinds of pollution, including plastic pollution, which can lead to animals accidentally getting tangled or eating plastic, and chemical pollution from events like oil spills.

What motivates the behaviors that cause these threats? (e.g. economic incentives to keeping fishing) Are there things people could do to minimize these anthropogenic threats?

3. GROUP ACTIVITY TO INVESTIGATE COMPETING NEEDS OF HUMANS AND ANIMALS IN SELECTED THREATS (25 minutes)
   Explain to students that they will be investigating certain threats in more depth. Have students work in their groups from the tagging and tracking activity and assign groups to one of three threats: overfishing, plastic pollution, or oil contamination.

   Explain to students that each group will be given materials to learn about some of the stakeholders involved in certain threats. Instruct students to use this information and their own creativity/knowledge to create a short skit (~5 minutes) about a meeting between the stakeholders, in which they discuss management and alleviation of the threat. Stress that their skits should demonstrate an understanding of the major arguments of each stakeholder. Encourage students to draw on their knowledge of the specific sharks they researched through the tagging and tracking activity. All students must collaborate to write the skit but they need not all act in the skit.

   Pass out appropriate skit info sheets to each group.

   Note: Each group will get a shark conservation info sheet along with their relevant threat info sheet.

***Teacher Tip**: If you have a lot of ELL students, make sure that each group has at least one native English speaker, who could read the information sheet out loud. Or, alternatively, you could choose to have all groups make skits about the same threat, and read the info sheet to them, yourself.*

***Teacher Tip:** If students are confused about the task, provide an example: If my group was looking at habitat loss as a threat, some possible stakeholders might be marine animal conservationists, large corporations that want to develop the coast for tourism, which could destroy land that some animals use for mating or having babies, and local people. In my skit, the tourist corporation might argue that tourism would be profitable, marine animals conservationists might try to explain why the development would be bad for the animals and argue why the animals are important to protect, and local people might support the tourism to bring in money or they might support the conservationists because the animals have cultural significance to them. Maybe they will all come to some agreement that allows each stakeholder to benefit, or maybe they will remain in disagreement. The point is that they articulate their position clearly and in doing so, illuminate some of the complicated conflicts that emerge.*

***Extension**: If you have extra time to devote to the lesson, you could direct students to further research their threat on the internet before developing their skit. Suggested web resources are provided on skit info sheets.*

4. SHOW SKITS AND DEBIEF (40 minutes)
   Have each group present their skit to the class.
   Debrief as a class: *What kinds of conflicts arose between stakeholders? What keeps people from eliminating or reducing threats? What can be done to help?*

5. INDIVIDUAL REFLECTION: THREATS TO MARINE ANIMALS (10 minutes)
   Students choose one of the following prompts to write on:
   - In your opinion, do our needs matter more than marine animals' needs? Why, why not?
   - Are there any actions that you partake in, which may contribute to the threats your animal faces? Are there things you can change about your actions to reduce the impact on marine animals?

   *A reflection sheet is provided.

***Teacher Tip**: You may want to mention that there are no right answers for this journal entry. The activity is meant to incite students to start developing their own opinions, which will help them engage with the issues and begin to develop the moral compass that will guide their personal thoughts and actions throughout life.*

Standards

California Science Standards (California Department of Education, 2000)
Grades 9-12: Biology/Life Sciences 6b
Investigation and Experimentation 1m

References

NOAA. (2012). Ocean. Retrieved February 28, 2012, from: http://www.noaa.gov/ocean.html

WildAid. (2007). *The End of the Line?* (2nd ed.). San Francisco, CA: WildAid.

Worm *et al.* (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science, 314*(5800), pp. 787-790.

Lesson 5 Appendices

Skit Info Sheet: Oil Contamination

You may choose which stakeholder(s) on the pro -oil side to represent in your skit. You may also choose to identify stakeholders on the anti-oil side, besides shark conservationists. Use the following information to inform your decision about who may be pro- or anti-oil and why.

In April 2010, a huge oil spill occurred in the Gulf of Mexico. Though spills of this size may be relatively uncommon, they cause havoc on marine environments. Perhaps the most iconic images are those of birds covered in oil, which damages their feathers, making the birds more sensitive to cold or hot temperatures and more vulnerable to predators and starvation (International Bird Rescue, 2011). However, birds are not the only organisms affected by oil spills. Plankton, the tiny organisms at the bottom of the food chain, get smothered by oil and are no longer able to eat (Hayes, 2010). If plankton die, that means their predators don't have as much food so crab, oysters, shrimp, etc. die. If those animals die, their predators don't have as much food so…you get the picture.

Sharks are not exempt from this devastation either. Some sharks may die through ingesting too much oil. For example, the whale shark, which eats plankton, filters its food through a mesh in its throat (Parker, 2010). You can imagine how attempting to filter oil through this mesh would have lethal consequences. Other consequences may be non-lethal, but still significant. For example, oil spills may reduce sharks' reproductive rates, creating long-term problems for populations. During the 2010 oil spill in the Gulf of Mexico, disoriented sharks also came closer to shore, perhaps as a result of oil-related changes in the chemistry of the water (Parker, 2010). With big deepwater sharks so close to shore, people begin to wonder about how safe the waters are for swimming and surfing.

Despite the negative consequences of oil spills, we have to ask ourselves, can we live in a world without oil? On their website, BP, the company responsible for the 2010 spill, says: "Whether you are driving, flying or taking that cruise of your lifetime, BP may have provided the fuel that makes your trip possible. If you've received goods or bought products that came from a long way away, our fuels and lubricants may well have powered the ship or aircraft that delivered them," (BP, 2012). Most of us buy foods from far away and drive cars to get to school or work, and these actions depend on oil. So are we willing to change the way we live to protect animals from potential oil spills?

For more information, check out these resources:

- Overview of U.S. oil consumption: http://topics.nytimes.com/top/news/business/energy-environment/oil-petroleum-and-gasoline/index.html
- Effects of oil spills on marine animals: http://www.amsa.gov.au/marine_environment_protection/educational_resources_and_information/teachers/the_effects_of_oil_on_wildlife.asp

References:

BP. (2012). Selling fuels and products. Retrieved February 27, 2012, from: http://www.bp.com/sectiongenericarticle.do?categoryId=9021493&contentId=7040013

Hayes, A. (2010, Apr. 29). Oil spill could be disaster for animals, experts say. *CNN*. Retrieved March 5, 2012, from: http://articles.cnn.com/2010-04-29/us/oil.spill.wildlife_1_oil-spill-oil-rig-explosion-director-of-bird-conservation?_s=PM:US

International Bird Rescue. (2011). http://bird-rescue.org/our-work/research-and-education/how-oil-affects-birds.aspx

Parker, L. (2010, Jun 11). Oil spill may be pushing sharks toward Fla. Beaches. *AolNews*. Retrieved February 27, 2012, from: http://www.aolnews.com/2010/06/11/oil-spill-may-be-pushing-sharks-toward-fla-beaches/

Skit Info Sheet: Plastics

You may choose which stakeholder(s) on the pro -plastics side to represent in your skit. You may also choose to identify stakeholders on the anti-plastics side, besides shark conservationists. Use the following information to inform your decision about who may be pro- or anti-plastics and why.

"We may not think about them often, but versatile plastics inspire countless innovations that help make life better, healthier and safer every day. For example, plastics make possible bicycle helmets and child safety seats. They're in the airbags that protect us and the cell phones that connect us. And plastics help keep the foods we eat and serve our families safer and fresher than ever before."

–American Chemistry Council, 2012

Think about your day so far. How many plastic objects did you encounter? It is undeniable that plastics have become an integral part of most of our lives. From automotive design to building and construction to electronics to packaging, plastics constitute many of the objects we use and interact with each day. Furthermore, the plastics industry is the third largest manufacturing industry in the U.S., employs 876 million workers, and creates more than $341 billion annually (SPI, 2009). They're lightweight and recyclable, and they allow innovation in a number of industries, and they support the U.S. economy, so what's the problem? There's too much plastic and a lot of it ends up in the wrong places.

In 2010, the U.S. generated *31 million tons* of plastic waste but only 8 percent was recovered for recycling (U.S. Environmental Protection Agency, 2012). So what happened to the rest? Much of it went to landfills, but unfortunately some of it ended up in our oceans. Once plastics enter the ocean, currents carry them far from their source, swirling them in a huge gyre until, eventually they end up in giant "garbage patches". In the ocean, plastics break down into tiny pieces, making cleanup difficult, but persist for hundreds or even thousands of years. Unsuspecting marine animals can mistake plastic debris for food and then get full of plastics and end up starving to death. Often, plastics also carry chemical pollutants, which further harm the animals that ingest them. Animals can also get entangled in plastic packaging, ropes, or nets, which can wound animals, impair their ability to catch prey, or in some cases to strangulation.

Increasing awareness of plastic pollution has led to some attempts to reduce plastic consumption, for example, reusable bag campaigns at grocery stores. However, considering the prevalence of plastics in our daily lives, plastic pollution is unlikely to disappear anytime soon.

For more information, check out these resources:

- More information about plastic products and innovations: http://plasticsmakeitpossible.com/
- More information on plastic pollution in the ocean:http://saveourseas.com/threats/pollution

References:

American Chemistry Council. (2012). Plastics. Retrieved March 6, 2012, from: http://plastics.americanchemistry.com/

SPI: The Plastics Industry Trade Association. (2009). A Few Fast Facts on…Plastics and the Economy. Retrieved March 6, 2012, from: http://www.plasticsindustry.org/AboutPlastics/content.cfm?ItemNumber=787&navItemNumber=1280

U.S. Environmental Protection Agency. (2012). Plastics. Retrieved March 6, 2012, from: http://www.epa.gov/osw/conserve/materials/plastics.htm

Skit Info Sheet: Overfishing

You may choose which stakeholder(s) on the pro-fishing side to represent in your skit. You may also choose to identify stakeholders on the anti-fishing side, besides shark conservationists. Use the following information to inform your decision about who may be pro- or anti-fishing and why.

Overfishing is the leading threat to marine biodiversity. By one estimate, all fisheries may collapse by 2048 given the current catch rates (Worm *et al.*, 2006). Many scientists believe we are "fishing down the food chain," depleting the ocean's largest fish first, then working on down to smaller fish once those become scarce. This means that sharks may be among the first to disappear. However demand for seafood is high and the fishing industry is a powerful force behind the politics that govern our seas. With regard to shark fishing, there are also some interesting cultural dynamics that come into play.

Shark fin soup is a popular item in Chinese cuisine, especially at special events, like weddings. In response to a proposed ban on shark fin sale, the Asian American Rights Committee of California (AARCCA) stated: "Shark fin soup is an Asian cultural delicacy with origins in the Ming Dynasty. It is a ceremonial centerpiece of traditional Chinese banquets, as well as celebrations of weddings and birthdays of one's elders," (Sherbert, 2012). Others suggest that this emphasis on historical cultural significance is misplaced. Shark fin soup does date back to the Ming Dynasty, but back then it was a rare and expensive delicacy eaten exclusively by the wealthy (WildAid, 2007, p. 21). Only within the past couple decades has an upsurge in East Asian economies and a growth in the Chinese middle class made shark fin soup a more common commodity.

Regardless of cultural history, in the present day, shark finning is an extremely profitable business. Shark fins commonly sell for $400 per kilogram and sometimes for as much as $1000 per kilogram (WildAid, 2007, p. 21). In comparison, shrimp sell for about $6 per kilogram (WildAid, 2007, p. 21). Some estimates suggest that Hong Kong's largest shark fin dealers make at least $12 million per year (WildAid, 2007, p. 21). Though a ban on shark finning may help the sharks, those in the business are adamantly opposed. With regard to the proposed ban in California, the AARCCA argued that "AARCCA's members face potential criminal sanctions for ongoing business activities that they have legitimately pursued for as many as 35 years, in which they have invested substantially, and on which the vast majority of their income depends," (Sherbert, 2012). With livelihoods and cultural values at stake, shark fishing is a highly contested topic in thorny political and social terrain.

For more information, check out these resources:

- Article on Shark Fin Soup, published in Food Safety News: http://www.foodsafetynews.com/2011/06/shark-fin-soup---a-cultural-war-environmental-nightmare-and-multi-million-dollar-business/
- Article on the debate between conservationists and shark fishers in India, published in The Times of India: http://articles.timesofindia.indiatimes.com/2002-03-24/mumbai/27116807_1_shark-fins-shark-sightings-marine-conservationists

References:

Sherbert, E. (2012, Feb 2). Asian American Group Sues to Stop State Ban of Shark Fin Soup. *SF Weekly.* Retrieved February 27, 2012, from: http://blogs.sfweekly.com/thesnitch/2012/02/asian_american_group_sues_to_s.php

WildAid. (2007). *The End of the Line?* (2nd ed.). San Francisco, CA: WildAid.

Worm *et al.* (2006). Impacts of biodiversity loss on ocean ecosystem services. *Science, 314*(5800), pp. 787-790.

Skit Info Sheet: Shark Conservation

Shark conservationists are concerned with the preservation of shark biodiversity into the future. The specific arguments that the pro-shark side makes in your skit may differ depending on the threat you are investigating, however the general information below may inform your development of the shark conservationist role.

Sharks are remarkable animals and some shark species have been thriving in the world's oceans since before the dinosaurs arose (WildAid, 2007). Therefore, they have survived mass extinction events while keeping their diversity relatively intact (WildAid, 2007). However, as top predators in the ocean, they are naturally relatively scarce and characteristics of their life cycles make them vulnerable to human activity. In fact, some environmentalists believe the sharks will be some of the first marine animals to go extinct due to human activity (WildAid, 2007).

The looming threat of shark extinctions is disconcerting for many reasons. As discussed above, sharks represent a remarkable branch of the evolutionary tree and chopping off that branch would be devastating. Furthermore, as top predators, sharks play an important role in controlling marine food webs. Removing sharks could affect the abundances of other fish species in unpredictable ways and drastically destabilize marine ecosystems.

Sharks are not only important to marine ecosystems, they are also valuable to humans. The unique information that scientists learn about sharks can inform human developments and designs. For example, *Fastskin* is a swimsuit developed by Speedo, which is modeled after the unique structures on shark skin that reduce drag and turbulence and increase swimming speeds (WildAid, 2007). The US Navy and NASA also study shark skin and propulsion in developing submarines and space shuttles (WildAid, 2007). Beyond the future discoveries that research could reveal, humans rely on sharks directly for many resources. Among these, humans use shark meat and fins for consumption, liver oil for lubricants, cosmetics and vitamin A, skin for leather, and jaws and teeth for trinkets (WildAid, 2007). Sharks provide a major source of protein to many poor coastal communities and also have spiritual significance for many cultures around the world (WildAid, 2007). For example, Hawaiians revere sharks as the greatest Aumakua (guardian angel) and Fijians believed that their high chiefs were direct descendants from Dakuwaqa, the shark god (WildAid, 2007). Shark-based ecotourism also supports many coastal economies. For these reasons and many more, it is crucial to protect the well-being of sharks around the world.

For more information, check out these resources:

- Oceana and WildAid Report: *The End of the Line: Global Threats to Sharks*: http://oceana.org/sites/default/files/reports/EndoftheLine_Spread_sm1.pdf
- A list of resources on Shark Conservation compiled by the Pew Environmental Group: http://www.pewenvironment.org/campaigns/global-shark-conservation/id/8589941059/resources/

References:

WildAid. (2007). *The End of the Line?* (2nd ed.) San Francisco, CA: WildAid.

Individual Reflection: Threats to Marine Animals

Choose one of the following prompts to reflect and write about:

- *In your opinion, do our needs matter more than marine animals' needs? Why, why not?*
- *Are there any actions that you partake in, which may contribute to the threats your animal faces? Are there things you can change about your actions to reduce the impact on marine animals?*

Lesson 6: Come Up with Solutions: Inspiring environmental behavior change

Topics
Threats to marine life, behavior change, environmental advocacy

Grades
9-10

Site
Indoors

Duration
70 minutes

Materials
- Sticky notes
- Poster or white board
- "Sustaining Marine Life Project" sheet
- Seafood Watch pocket guides

National Science Education Standards
Science in Personal and Social Perspectives (9-12)
Natural resources
Environmental quality
Science and technology in local,
national, and global challenge

Overview
How can humans reduce the number and intensity of threats marine migrators face? In this activity, students will explore barriers to behavior change and create a product to inspire marine conservation.

Objectives
Students will be able to:
- Identify barriers to and motivations for behavior change.
- Identify barriers unique to environmental behavior change.
- Apply knowledge from previous lessons to tackle a real-world problem

Background
With all the gloom and doom of environmental destruction, inspiring and empowering people to take action to protect the environment becomes essential. Some people question the benefit or impact of individual actions, however arguments for encouraging individual behavior change abound. Nicole Ardoin (2009), a Stanford professor and environmental education researcher, outlines several:
- "Encouraging easily implemented behaviors may develop self-efficacy and enhance a sense of personal control" (pp. 61-62)
- "Smaller actions can accumulate to create greater benefits" (p. 62)
- "Support, engagement, and active involvement of local populations are necessary for conservation efforts to succeed in the long term" (p. 62)

The challenge is in figuring out how to motivate this environmental behavior change. Monroe (2003) identifies two broad avenues for encouraging conservation behaviors: social marketing tools and cultivation of environmental literacy. Social marketing tools focus on targeting specific audiences, reducing barriers to behavior change (a significant factor with many environmental behaviors), providing meaningful information, and creating a sense of commitment, sometimes through incentives (Monroe, 2003). Environmental literacy, on the other hand, refers to a longer-term connection to and stewardship for the environment, and is often supported by significant life experiences or education. Regardless of the method, there is no time better than today to cultivate a caring society and empower people to take action to protect our planet's fragile biodiversity.

Procedure

1. REVIEW CLASS DISCUSSIONS FROM THE LESSON ON THREATS TO MARINE LIFE (5 minutes)
   What were some of the human actions that threaten marine life? Why do people engage in these actions? Why don't people seem to care about the animals?

2. INTRODUCTION TO BARRIERS TO BEHAVIOR CHANGE (ACTIVITY MODIFIED FROM ARDOIN, 2012) (5 minutes)
   Have students record their answers to the following question for each of these actions: Answer yes or no if you have or have not done this action every day for the past five days:
   - Eat five servings of fruit and vegetables.
   - Drink 8 glasses of water.
   - Wear sunscreen.
   - Exercise for at least 30 minutes.
   - Floss.

   Debrief: *How many people said yes to all five actions? Four? Three? Two? One? How many of you have heard that these suggestions are good for your health? So why don't you follow them? Are there barriers to certain behaviors that are out of your control?*

3. IN PAIRS, STUDENTS THINK-PAIR-SHARE ABOUT MOTIVATIONS FOR BEHAVIOR CHANGE (5 minutes)
   Divide students into pairs and have them think-pair-share (think silently then share with their partner) about a behavior they have changed and what made them change it. Give each pair a couple of post-it notes and have them write their behavior change and the motivation for it on a post-it.

4. AS A CLASS, STUDENTS DEBRIEF MOTIVATIONS FOR BEHAVIOR CHANGE (10 minutes)
   On a poster or white board, write broad categories of motivations (increased knowledge, financial incentive, social/peer pressure, fear, life-changing experiences, etc.) Have students come up and place their post-it under the relevant heading.
   Debrief: *What seems to motivate people most? Why do you think so?*

5. IN SMALL GROUPS, STUDENTS BRAINSTORM A CAMPAIGN TO INSPIRE BEHAVIOR CHANGE (15 minutes)
   Give groups two minutes to decide on a behavior change that is relevant to their lives, (e.g. eating more fruits and vegetables, turning homework in on time, etc.). Then, keeping in mind the list of motivators on the board, have the groups brainstorm a campaign to inspire their peers to change this behavior. Groups briefly share their ideas with the whole class.

6. AS A WHOLE CLASS, DISCUSS THE UNIQUE BARRIERS TO ENVIRONMENTAL BEHAVIOR CHANGE (8 minutes)
   Using the discussion questions below, facilitate a discussion on unique barriers for environmental behavior change.
   - *What are the primary barriers to engaging in behaviors that you know are good for you?*
   - *Are there additional barriers for doing behaviors that don't directly benefit you?*
   - *What do you think some of the major barriers are to acting in ways that protect the health of the oceans and marine animals?* (e.g. lack of knowledge, lack of awareness, lack of interest, no direct benefit, issue of convenience)

7. INTRODUCE THE SEAFOOD WATCH POCKET GUIDES AS AN EXAMPLE OF AN ENVIRONMENTAL ADVOCACY CAMPAIGN (6 minutes)
   Introduce the idea of environmental advocacy campaigns that try to overcome these barriers and get people to change their behaviors to benefit the environment. Ask if the students can think of any environmental campaigns they have seen or participated in.

   Introduce the Seafood Watch pocket guides as an example of how to inspire behavior change and reduce some barriers (knowledge, awareness, convenience—people don't have to look the information up for themselves, etc.). Show students the Seafood Watch pocket guides (download guides at http://www.montereybayaquarium.org/cr/cr_seafoodwatch/download.asp).

   Discuss: *How do the pocket guides help people protect the environment?* (They provide information on what seafood to buy

in order to decrease pressure on overfished species.) *Do you think they are successful? Would you change you use these to guide your consumption choices?*

8. RE-INTRODUCE ADVOCACY PROJECT (8 minutes)
   Tell students that now they will have a chance to create their own advocacy and awareness project to educate and inspire their peers! Review the "Sustaining Marine Life Project" handout that students received in Lesson 1 and discuss the criteria, considerations, and options.
   *Scaffolding for this project is provided in Lesson 7.

9. INDIVIDUAL WRITING ACTIVITY: ENVIRONMENTAL BEHAVIOR CHANGE (8 minutes)
   Students write on the following prompt:
   - What are some of the barriers you can see with regards to environmental behavior change? How can you convince people to overcome these barriers?

   *A reflection sheet is provided.

Standards

California Science Standards

Grades 9-12: Investigation and Experimentation 1m

References

Ardoin, N. (2009). Behavior-change theories and free-choice environmental learning. In J. Falk, J. Heimlich, and S. Foutz (eds.), *Free-Choice Learning and the Environment* (pp. 57-76). Lanham, MD: AltaMira Press.

Ardoin, N. (15, Feb. 2012). Learning beyond museums: Environmental education and its outcomes. *EDUC 357X: Science and Environmental Education in Informal Environments*. Lecture conducted from Stanford University, Stanford, CA.

Monroe, M.C. (2003). Two avenues for encouraging conservation behaviors. *Human Ecology Review, 10*(2), pp. 113-125.

Lesson 6 Appendices

Individual Reflection: Environmental Behavior Change

Reflect and write about the following questions:

- *What are some of the barriers you can see with regards to environmental behavior change? How can you convince people to overcome these barriers?*

Lesson 7: Come Up With Solutions (Part II): Creating a Product for Change

Topics
Environmental advocacy

Grades
9-10

Site
Indoors

Duration
75 minutes

Materials
- "Sustaining Marine Life Project" handout
- "Sustaining Marine Life Project Assessment Rubric"
- "Sample Brochure"
- Paper for brochures
- Poster board
- Colored markers
- Tape
- Scissors
- Construction paper

National Science Education Standards
Science in Personal and Social Perspectives (9-12)
Natural resources
Environmental quality
Science and technology in local,
national, and global challenge

Overview

In this activity, students will create a product to inspire marine conservation.

Objectives

Students will be able to:

- Apply knowledge from previous lessons to tackle a real-world problem
- Display, explain, and defend their ideas by developing a product or solution with a written explanation

Procedure

1. REVIEW (10 minutes)
   Whole class discussion to review the unit. Discussion prompts may include:
   - *Why do scientists tag animals?*
   - *What kinds of tags can be used for tracking?*
   - *What can people learn about animals by tracking them?*
   - *What can people learn about the ocean ecosystem by tracking marine animals?*
   - *What are some of the threats to marine ecosystems?*
   - *How can people help?*

2. CLASS TIME FOR PROJECT (45 minutes)
   Ensure that students have the "Sustaining Marine Life Project" handout and "Sustaining Marine Life Project Assessment Rubric" from the beginning of the unit. Pass out the "Sample Brochure." Review instructions on the "Sustaining Marine Life Project" handout. Remind students that they must include all the required elements from the rubric. They can use the questions on the sample brochure as a general guideline, but emphasize that they are not limited to this format or these questions.

3. SHARE OUT (15 minutes)
   Have groups share their product with the class and discuss how they will use this product to convince people at the school to take action to help their animal.

	4. INDIVIDUAL HOMEWORK ASSIGNMENT (5 minutes) Go over assignment and answer questions. In order to assess individual reasoning on this assignment, have students write a brief description (1-2 pages) of their process in developing their product along with their reasoning of how this product will inspire others to take action. ***Extensions:*** ● *For a more in-depth project, encourage students to continue their work outside of class and to be creative in choosing an appropriate format for their project. See Extension: Sustaining Marine Life Project, Version 2 in the appendices for more information.* ● *Once students have completed their projects, hold an expo to display products; bring in experts/aquarium personnel if possible.* ● *Have students identify additional audiences for their product and disseminate it! (For example, if they write an informational brochure on plastic pollution, they could pass out their brochure in front of the grocery store and encourage customers to use reusable bags instead of plastic bags.)* **Standards** **California Science Standards** Grades 9-12: Investigation and Experimentation 1m

Lesson 7 Appendices

Sustaining Marine Life Project **(Lessons 1 and 7)**

In this project, you will collaborate with your group to design a product that increases awareness and inspires people at your school to help sustain marine life. Some things to consider: What knowledge do they likely have and what further knowledge do they need to appreciate and care for marine life? What barriers may prevent behavior change? How can you help people overcome these barriers? It is probably a good idea to focus on one anthropogenic threat, and you should draw from the research you have already done on the animal you tracked, however you may also bring in outside research.

It is up to you to decide what kind of product you would like to create, but examples include:

- In-class Assignment
    - An informational brochure (see sample)
    - A poster

The list above is not exhaustive. Be creative!

Along with your group product you will each submit a brief description (1-2 pages) of your process of developing the product, including a clear explanation and defense of how your product will educate and inspire people to take action.

You will be assessed with the following criteria:

- Description of animal and its life cycle
- Incorporation of research on animal migration patterns
- Incorporation of specific, accurate, and relevant information on how the threat affects marine life
- Persuasive call for behavior change
- Clear organization of content
- Explanation and defense of process and product

Extension: Sustaining Marine Life Project, Version 2

If you have the time and resources, you may want to give students the opportunity to design a more creative product outside of class time.

Some examples include:

- A newsletter
- A short video
- A piece of creative writing
- A table-top demo or experiment
- A song or rap

Teacher Tip: *To give your class some guidance for their project, you may want to provide some examples of different types of advocacy campaigns. Here is a list of links for some examples; however it is worth mentioning that these are not necessarily perfect examples, nor do they align with the criteria.*

- Video on plastic pollution: http://www.youtube.com/watch?v=sxdwVQtNfng
- Use less plastic video: http://vimeo.com/11064723
- Plastic Pollution song: http://www.youtube.com/watch?v=aze7aoPIKyI
- Plastics are forever poster:
    - in English: http://apusenvironment.com/poster%20downloads/english%20poster.pdf
    - in Spanish: http://apusenvironment.com/poster%20downloads/english%20poster.pdf
- Plastics are forever brochure (in English and Spanish):
    - side 1: http://apusenvironment.com/leafletdownloads/englishspanishside1.gif
    - side 2: http://apusenvironment.com/leafletdownloads/englishspanishside2.gif
- A letter to a California senator supporting the "Single-use Bag Reduction Act": http://plasticpollutioncoalition.org/2010/06/letter-to-senator-simitian-state-of-california/

Sustaining Marine Life Project Assessment Rubric (Lessons 1 and 7)

Criteria	***0 Points***	***1 Point***	***2 Points***	***3 Points***
Description of animal and its needs for sustaining life	No description of animal or elements of its life	Limited or vague description of animal and its life	Good description of animal and several points about its life	Solid description of animal and clear, relevant description of its life cycle
Incorporation of animal migration patterns	No incorporation of animal migration patterns	Irrelevant or very little incorporation of animal migration patterns	Information includes visual representations as well as ideas of chlorophyll / food **or** temperature in explaining animal migration patterns	Relevant and extensive description including visual representations as well as chlorophyll / food **and** temperature
Incorporation of specific, accurate, and relevant information on how the threat affects marine life	No incorporation of information on how the threat affects marine life	Vague or very little information about how the threat affects marine life	Accurate and relevant information on how the threat affects marine life, but lacking specificity	Specific, accurate and relevant information on how the threat affects marine life
Persuasive call for behavior change that addresses: targeting specific audience; reducing barriers to behavior change; providing meaningful information; creating commitment	No call for behavior change	Weak call for behavior change	Somewhat persuasive call for behavior change	Persuasive call for behavior change
Clear organization of content	Complete lack of organization	Attempt at organization	Somewhat clear organization (information grouped by topic, use of headings, etc.)	Clear organization with easy to read headings, topical information and supporting details
Explanation and defense of process and product	No explanation or defense of process and product	Limited explanation and weak defense of process and product	Good explanation but weak defense of process and product	Good explanation and strong defense of process and product

Sample Brochure (Lesson 7)

Inside brochure (1st side of paper to be folded in thirds):

(left inside panel)	(center inside panel)	(right inside panel)
Think about: • Describe your animal. • Where does it go? • How does it live? • What does it eat? • What does it need to survive? • Why should people care?	**Think about:** • What are some of the threats to this animal? • What contributes to these threats? • What does this mean for the future of the animal? • Why should people care?	**Think about:** • What actions can people take to help these animals and other ocean creatures? • What impact will individual action make? • How can people get started right away?

Front, back and inside flap (2nd side of paper to be folded in thirds)

(inside flap)	(back of brochure)	(cover)
Think about: • What have scientists learned from tagging and tracking this animal? • Why is this information important to people?	**Think about:** • Any final thoughts? • Be sure to give credit to the creators! (list team members, date, school, etc.)	**Think about:** • Making it eye-catching! • What do you want people to see? • What will make them want to open the brochure and read more? • What is your key message for this brochure?

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