5TH GRADE

TEACHER RESOURCE GUIDE

THEME:

Seaweeds and submerged plants share some characteristics with terrestrial plants but are specially adapted to the marine environment and provide essential habitat and food within marine ecosystems.

CRITICAL ISSUE:

Marine Protected Areas, Climate Change

CONTENTS:

Aquarium of the Bay
a division of bay.org

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MISSION STATEMENT:

Aquarium of the Bay's Education and Conservation Department's mission is to promote literacy in ocean and watershed health, climate change issues, and science career development through the lens of critical issues such as sustainable seafood, marine protected areas, marine debris and plastics, climate change and fresh water flows.

ACKNOWLEDGEMENTS:

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S. D. BECHTEL, JR. FOUNDATION
STEPHEN BECHTEL FUND

LESSON 1

SEAWEEDS AND TREES

Enduring Understanding: Seaweeds share some physiological characteristics with plants, but they have unique structures that allow them to survive in the marine environment.

Materials

- Seaweed cutout guide with labeled parts (stipe, blade, air bladder, holdfast) (attached)
- "Seaweeds and Trees" information sheet
- Blue construction paper
- Scissors, glue
- Coloring supplies
- Diagram of tree with labeled structures (roots, trunk, branches, leaves) (attached)
- Writing paper
- Pencils, markers, chalk (as needed)
- Whiteboard or blackboard

SETUP:

1. Make copies of seaweed cutout.
2. Make copies of "Seaweeds and Trees" information sheet.
3. Make three or four copies of tree graphic.
4. Prepare art materials.
5. Draw the seaweed structures on a whiteboard or blackboard.
6. Draw a simple comparison table with two columns: "Seaweeds" and "Trees."

PROGRAM OUTLINE:

Pass out the "Seaweeds and Trees" information sheets.

- Have a student volunteer read the first paragraph out loud. You may choose to write the major ideas on the board. Be sure to explain any terms that they don't understand.
- What is seaweed?
  - Seaweed is a plant-like organism that grows in water instead of on land.
  - Seaweed captures energy from the sun and converts it to food in a process called photosynthesis. It also makes oxygen.
  - Seaweed doesn't have roots, stems, leaves or a trunk like a tree, but it has structures that resemble them.
- Seaweed parts
  - Have students take turns reading the different structures of the seaweed. Point them out on your drawing.
- Seaweed and trees
  - Have students silently read the two paragraphs. Ask for volunteers to come up and write a comparison of seaweeds and trees on the table you created during setup. For example, in the "Seaweeds" column they would write that seaweeds grow only in water. In the "Trees" column they would write

that trees grow only on land.

- Distribute the art supplies and seaweed cutout guide. Explain that each student is to color their seaweed structure, cut it out, and glue it together in the appropriate places.

Compare and contrast seaweeds and trees

- Divide your class into three to five groups. Have them sit together with their crafted seaweeds.
- Pass out one tree visual guide to each group.
- Give each group two different questions, one from Level 1 and one from Level 2. They may use the "Seaweeds and Trees" information sheet to answer their questions.

  - Level 1 questions

    - How is a seaweed holdfast different from the roots of a tree? Why?
    - How is a seaweed stipe different from a tree trunk? Why?
    - How are seaweed blades different from tree leaves? Why?
    - What is the purpose of air bladders? Why don't trees have them?
    - Do trees have mucus like seaweeds do? Why or why not?
    - How are seaweeds similar to trees?

  - Level 2 questions

    - What is the same or different in the environments in which seaweeds and trees grow?
    - What are essential things that both trees and seaweeds need to survive?
    - What do both seaweeds and trees provide for the environment and other organisms around them?
    - What is the difference between how seaweeds get energy and how trees get energy?
    - What would happen if all the trees in the world disappeared or died off? What would happen if all the seaweeds in the oceans disappeared? How might this impact other animals?

- Have each group discuss their answers among themselves. Have them write their responses in complete sentences using developmentally appropriate scientific terminology, including the physical structures of trees and seaweeds. Encourage them to use comparative language, such as in contrast, similarly, likewise, on the other hand, in comparison, etc.
  - If time allows, you may choose to assign this as homework and encourage your students to use online resources to support their responses.
- Each group will then present their answers to the rest of the class, using their seaweed cutouts and trees as visual guides to aid their explanation. Explain that each person in the group must play an active role in the presentation.

TEACHER BACKGROUND:

Seaweeds are multicellular algae that are separated into three classifications: red, brown, and green. They are not actually plants, although they do share many characteristics with them. They are not grouped with true plants because they lack a specialized vascular system, roots, stems, leaves, and enclosed reproductive structures (flowers, cones, etc.). They do not need an internal conducting system because all parts of the seaweed are in constant contact with the surrounding water and are thus able to absorb nutrients and carbon dioxide. Terrestrial plants absorb nutrients and water from soil through their roots, and the nutrients and water are carried throughout the plant by specialized vascular tissue. Both plants and seaweeds get most of the materials they need for growth from carbon dioxide and photosynthesis.

Habitat

Seaweeds are typically found in the shallow, rocky intertidal zone, where they are able to photosynthesize. Sunlight is captured by chlorophyll and other light-absorbing pigments within their cells, which are responsible for the various colors of seaweeds. Photosynthesis is a biochemical process that uses water, carbon dioxide, and sunlight to produce sugars and oxygen. The sugars are used for food and the oxygen is released into the water. Just as vascular plants produce energy at the base of the terrestrial food web, seaweeds are the producers for the ocean food web. Seaweeds provide vital habitat and a major source of food for numerous invertebrates and fish. Some types of seaweed are also consumed by humans. We also use extracted compounds from seaweeds in many foods and products.

Physical Structures of Seaweeds

Rather than roots, seaweeds have holdfasts, which attach them to rocks or other substrates on the sea floor. In contrast to plant roots, holdfasts are not necessary for water and nutrient uptake. Instead, they act as an anchor to keep the seaweeds from floating away in the turbulent waves of the rocky intertidal or other habitats. The stipe is the seaweed stalk or stem. The stipe functions as the support structure for the rest of the plant. It can be stiff, flexible, filled with gas, very long, very short, or completely absent. The leaf-like structures of seaweeds are called blades. They function as the main surface for absorbing sunlight. The blades of some seaweeds hold the reproductive structures. Some seaweeds have only one blade, while others have many. Many types of seaweed have air bladders, which are hollow, gas-filled floats. Air bladders keep the seaweeds buoyant so they float toward the surface in the sun, allowing them to maximize their ability to photosynthesize.

Other Adaptations

Seaweeds need to be submerged in water for at least part of the day. Many produce a slimy mucus layer that keeps their soft tissues from drying out when they're exposed to the sun during low tides. Most seaweeds are also flexible, an adaptation that allows them to bend in currents and waves. A stiff structure like a tree trunk would break easily in the marine environment.

GLOSSARY:

Algae: Any of numerous groups of photosynthetic aquatic organisms that range from single-celled forms to multicellular forms more than 100 feet long; distinguished from plants by the absence of true roots, stems, leaves, and vascular tissue

Blade: Flattened, leaf-like structure of seaweeds that contains photosynthetic pigment and sometimes reproductive structures

Gas Bladder: Hollow air-filled structure that floats

Holdfast: Stalked structure by which algae attach to a substrate

Organism: Individual living thing that can grow, reproduce, and react to stimuli

Photosynthesis: Process by which green plants, algae, and some other organisms use sunlight to synthesize food energy from carbon dioxide and water

Primary Producer: Organism in an ecosystem that converts light energy into organic matter

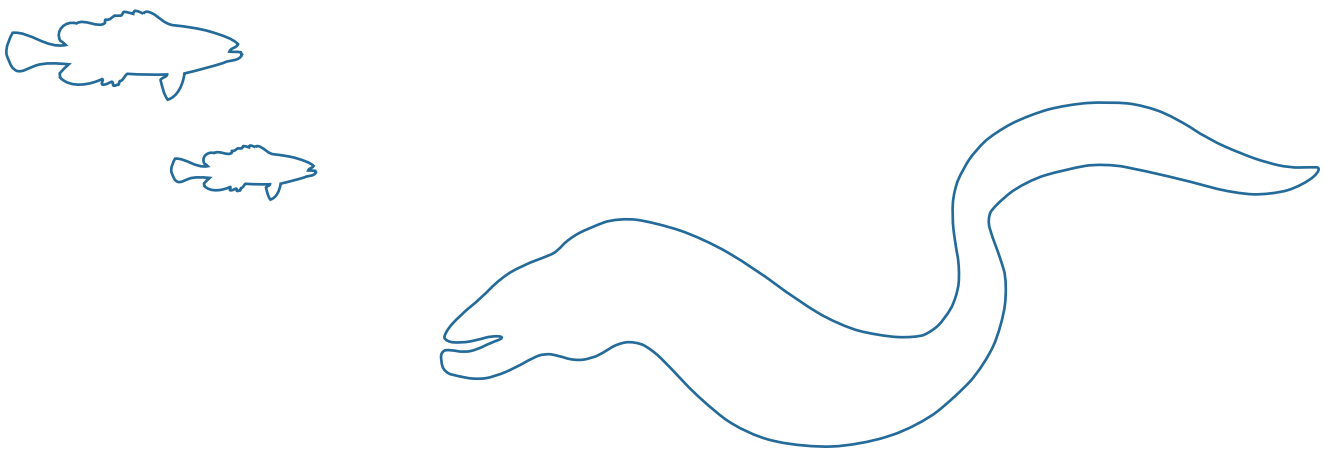
Rocky Intertidal Zone: Rocky shores at the edge of the ocean and land between high tide and low tide that support a tremendous amount of biodiversity

Seaweeds: Macroscopic, multicellular, benthic algae that grow beneath the high-tide mark

Stipe: Stalk or stem of seaweed

Thallus: Complete structure of seaweed, including holdfast, stipe, blades, and gas bladders

Vascular System: Plant tissue consisting of organized structures (such as ducts or vessels) that convey water, nutrients, and other materials through the plant



5TH GRADE STANDARDS:

California Common Core Standards

Writing

- SL.5.1. Engage effectively in a range of collaborative discussions (one-on-one, in groups, and teacher led) with diverse partners on grade 5 topics and texts, building on others' ideas and expressing their own clearly.
  a. Come to discussions prepared, having read or studied required material; explicitly draw on that preparation and other information about the topic to explore ideas under discussion.
  b. Follow agreed-upon rules for discussions and carry out assigned roles.
  c. Pose and respond to specific questions by making comments that contribute to the discussion and elaborate on the remarks of others.
  d. Review the key ideas expressed and draw conclusions in light of information and knowledge gained from the discussions.

California Science Content Standards

- 2.a. Students know many multicellular organisms have specialized structures to support the transport of materials.
- 2.f. Students know how plants use carbon dioxide (CO2) and energy from sunlight to build molecules of sugar and release oxygen.

California Next Generation Science Standards

- 5-LS1-1. Support an argument that plants get the materials they need for growth chiefly from air and water.

- Plants acquire their material for growth chiefly from air and water.
- Support an argument with evidence, data, or a model.

PROGRAM MATERIALS:

- "Seaweeds and Trees" information sheet
- Seaweed cutout guide
- Diagram of tree

Name: _____

Date: _____

SEAWEEDS AND TREES

Seaweeds grow in water. They have special **adaptations** that allow them to survive and thrive. They share some features with trees and other plants that grow on land, but they are not actually plants. Like trees, seaweeds are able to **photosynthesize**. They get energy from the sun and turn it into food. And like trees, they also make **oxygen**. Seaweeds do not have roots, stems, leaves, or trunks like trees do. They do have structures that resemble them.

The Parts of Seaweed

1. The **holdfast** of seaweeds looks like tree roots. But it does not take up nutrients the way roots do. The purpose of a holdfast is to fasten the seaweed to something, like rocks or boulders. It keeps the seaweed in one spot so it doesn't float away.
2. The **stipe** is the part of seaweed that connects the holdfast to the blades. It isn't hard and stiff like the trunk of a tree. The stipe is soft and flexible so it can move with the waves and currents of the water. If the stipe were stiff like a tree, the movement of the water would easily break the seaweed.
3. The **blades** of seaweeds are often long and flat. Sometimes they look like the leaves of a tree. Even though the seaweed stipe and blades can bend, they're also very strong so that water currents and waves don't break them apart.
4. The **gas bladders** of seaweeds float like a beach ball in a swimming pool. They keep the blades and stipe near the surface of the water. This helps the seaweeds grow up toward the sun, and makes it easier for them to photosynthesize.
5. The **thallus** is the body of seaweed, including holdfast, stipe, blades, and gas bladders. On the thallus is a slimy layer of mucus. This mucus keeps the seaweed from drying out during low tide, when it may be exposed to the air for several hours.

Seaweeds and Trees

Seaweeds grow only in water. Trees grow only on land. Trees usually can only photosynthesize through their leaves. Seaweeds can photosynthesize through any part of their thallus. Trees get most of the energy and materials they need to grow from the air and the sun. They also absorb, or take up, water and nutrients from the soil. Seaweeds do not rely on soil for nutrients. They grow only through photosynthesis and by absorbing nutrients from the water around them.

Both seaweeds and trees are primary producers. This is the group of organisms that make their own food through photosynthesis. They don't need to eat other plants or animals for energy, so they are at the very bottom of the food chain. Many animals eat them. Just like trees, seaweeds create important habitat for animals. Many animals rely on them for shelter, food, and protection from predators.

LESSON 2

SEAWEED DISCOVERY LAB

Enduring Understanding: Producers, such as seaweeds, serve as the foundation for ocean food webs and also provide vital habitat for marine organisms.

Materials

- Edible seaweed—found at many supermarkets (optional)
- Microscope or magnifying glass (optional)
- Printed photo of seaweed cells under a microscope (attached)
- Photos of ice cream cone and sushi roll (attached)
- Tube of toothpaste
- Jar of peanut butter
- "Seaweed Discovery Lab" worksheet
- "National Marine Sanctuaries in California" handout (attached)

SETUP:

1. Make copies of the "Seaweed Discovery Lab" worksheet.
2. Print and cut out arrows.
3. Print several copies of the "National Marine Sanctuaries in California" handout.
4. Set up the stations.

- Station 1: Piece of edible seaweed in a dish (if you have a microscope or magnifying glass, place it by the dish); photo of magnified seaweed

- Station 2: Photos of the sun, giant kelp, sea urchins, sea otter, Turkish towel seaweed (demonstrating diversity of seaweeds in kelp forest), abalone, fish, shark, seabird, seal, and bacteria (in random order); arrows

- Station 3: Computer or other multimedia device with Internet connection open to and ready to play http://www.pbs.org/kqed/oceanadventures/video/kelp (Jean-Michel Cousteau: Ocean Adventures: "Kelp Forest"); set sound so it won't disturb other stations. (Alternate activity: If you don't have Internet access or a device on which to stream the video, print the attached "An Ecosystem out of Balance." The questions on the worksheet remain the same.)

- Station 4: Photos of ice cream and sushi roll; tube of toothpaste; jar of peanut butter; small pieces of edible seaweed (on napkin, plate, or other sanitary surface)

- Station 5: Several copies of the "National Marine Sanctuaries in California" handout (You may choose to have this station be at the student's desks.)

Materials continued

- Writing materials
- Printed photos of the sun, giant kelp, sea urchins, sea otter, Turkish towel seaweed, abalone, fish, shark, seabird, seal, and bacteria (attached)
- Set of printed arrows (attached)
- Computer or other multimedia device with Internet access, with viewing screen and speakers (optional) (See below.)
- Video clip Jean-Michel Cousteau: Ocean Adventures: "Kelp," available for streaming on PBS website; read the PBS Customer Service notes on limited public performance rights; (Alternate activity: read the attached "An Ecosystem out of Balance" information sheet.)

PROGRAM OUTLINE:

Introduction to the Seaweed Discovery Lab

- Walk through and explain what the students will encounter at each station; use the following terminology: cells, photosynthesis, ecosystem, producer, consumer, decomposer.
- Break class into groups; hand out "Seaweed Discovery Lab" worksheets and pencils.
- Have the groups rotate through each station, spending 10 to 15 minutes at the first four stations while they answer the questions.
- Allow students to spend 20 minutes at their last station. Explain that they will be presenting their answers to that station to the rest of the class (each person in the group will need to participate in the presentation to some extent). If you have limited class time, consider completing the lab over two or three days.

Seaweed Discovery Lab Stations

- Station 1: Seaweed Up Close
  - Students discover what seaweed tissue looks like up close through (1) using a device such as a microscope or magnifying glass or (2) looking at a photo of magnified seaweed or (3) both of these options and you specify which one you want them to draw.
  - Students use the knowledge they gained from your oral explanation and write in their own words that seaweed converts energy from the sun into food and oxygen in the process known as photosynthesis.
- Station 2: Build a Kelp Ecosystem
  - Students take the series of photos and place them in proper order to represent the flow of energy in a food web. Students use arrows between the photos to show the direction in which energy is transferred.
- Station 3: An Ecosystem out of Balance
  - Students view multimedia to explore a kelp forest ecosystem and what happens when a predator/prey balance is upset. (Alternate activity: Students will read about the history of the sea otter fur trade and how it impacted local kelp forest ecosystems.)
- Station 4: People and Seaweed
  - Students write down which of the products pictured contain some amount of seaweed (all of them do). They try some edible seaweed, describing how it smells, feels, and tastes and guessing how it might provide nutrition for people

PROGRAM OUTLINE CONTINUED:

consuming it.

- Station 5: National Marine Sanctuaries in California
  - Students read about the threats facing California's kelp forests and how National Marine Sanctuaries help protect these important habitats.
  - After the groups have explored their final station, have each group present by reading the

TEACHER BACKGROUND:

Seaweeds are multicellular algae that are separated into three classifications: red, brown, and green. They are not actually plants, although they do share many characteristics with them. They are not grouped with true plants because they lack a specialized vascular system, roots, stems, leaves, and enclosed reproductive structures (flowers, cones, etc.). They do not need an internal conducting system because all parts of the seaweed are in constant contact with the surrounding water and are thus able to absorb nutrients and carbon dioxide. Terrestrial plants absorb nutrients and water from soil through their roots, and the nutrients and water are carried throughout the plant by specialized vascular tissue. Both plants and seaweeds get most of the materials they need for growth from carbon dioxide and photosynthesis.

Habitat

Seaweeds are typically found in the shallow, rocky intertidal and subtidal zones, where they are able to photosynthesize. Sunlight is captured by chlorophyll and other light-absorbing pigments within their cells, which are responsible for the various colors of seaweeds. Photosynthesis is a biochemical process that uses water, carbon dioxide, and sunlight to produce sugars and oxygen. The sugars are used for food and the oxygen is released into the water.

Role in the Food Web and Human Consumption

Just as vascular plants produce energy at the base of the terrestrial food web, seaweeds are the producers for the ocean food web. Seaweeds are a major food source for numerous invertebrates and fish. Some types of seaweeds are consumed by humans. Edible seaweed is rich in vitamins, iodine, calcium, potassium, and antioxidants. People use seaweed derivatives, such as alginates from brown algae, carrageenan from red algae, and beta carotene from green algae, as stabilizers, thickeners, and colorants. These derivatives play an important role in the manufacturing of food and other products.

Kelp Forests

Seaweeds can form extensive ecosystems known as kelp forests, which serve as important habitat, shelter, and food for a diversity of marine organisms. Each organism—whether producer or consumer—plays a vital role within a kelp ecosystem. If a species were to diminish or completely disappear from this ecosystem due to disease or human activities, it can greatly impact the balance of the entire system.

National Marine Sanctuaries

National Marine Sanctuaries are federally designated areas within U.S. waters that protect areas of the marine or Great Lakes environments that have special conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or aesthetic qualities. There are 14 such protected areas: 13 National Marine Sanctuaries and one National Monument. Sanctuary education programs teach the public about stewardship and helping to protect the environment. Community advisory groups provide input, and nonprofit partners help build support for effective ocean management.

GLOSSARY:

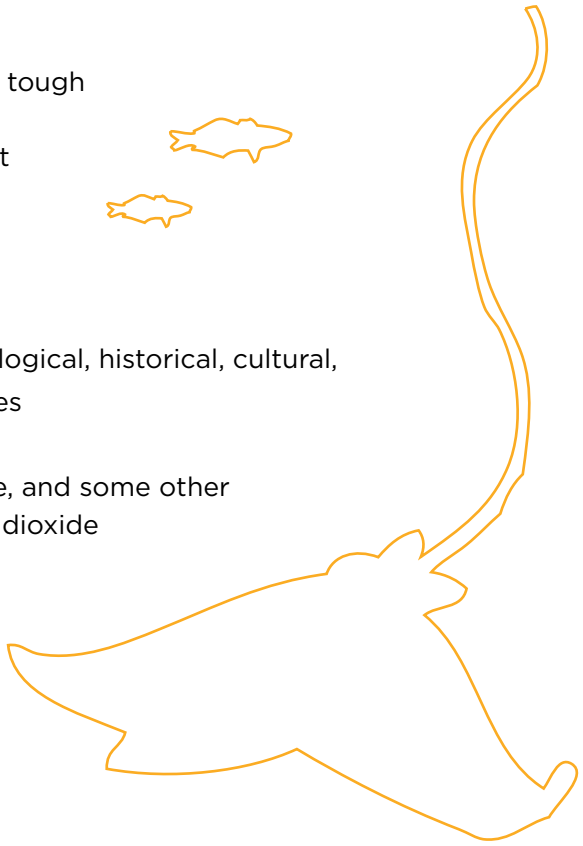
Algae: Any of numerous groups of photosynthetic aquatic organisms that range from single-celled forms to multicellular forms more than 100 feet long; distinguished from plants by the absence of true roots, stems, leaves, and vascular tissue

Climate Change: Change in global or regional climate patterns attributed largely to the increased levels of atmospheric carbon dioxide produced by the use of fossil fuels

Ecosystem: Biological community of interacting organisms and their physical environment

Seaweeds: Macroscopic, multicellular, benthic algae that grow beneath the high-tide mark

Kelp: Large brown seaweeds that typically have a long, tough stalk with a broad frond divided into strips; some kinds grow to be very large and form underwater "forests" that support a large population of animals.



National Marine Sanctuary: Federally designated area within U.S. waters that protects areas of the marine environment with special conservation, recreational, ecological, historical, cultural, archeological, scientific, educational, or aesthetic qualities

Photosynthesis: Process by which green plants, algae, and some other organisms use sunlight to synthesize foods from carbon dioxide and water

Rocky Intertidal Zone: Rocky shores that lie at the edge of the ocean and land between high tide and low tide that support a tremendous amount of biodiversity

Turkish Towel: Type of red algae with large, broad blades with a towel-like appearance and texture; grows in low intertidal zone; found along the Pacific coast from Alaska to Mexico

5TH GRADE STANDARDS:

California Common Core Standards

ELA/Literacy

- W.5.7. Conduct short research projects that use several sources to build knowledge through investigation of different aspects of a topic.
- RI.5.7. Draw on information from multiple print or digital sources, demonstrating the ability to locate an answer to a question quickly or to solve a problem efficiently.
- SL.5.2. Summarize a written text read aloud or information presented in diverse media and formats, including visually, quantitatively, and orally.

California Science Content Standards

- 2.f. Students know how plants use carbon dioxide (CO2) and energy from sunlight to build molecules of sugar and release oxygen.
- 2.g. Students know plant and animal cells break down sugar to obtain energy, a process resulting in carbon dioxide (CO2) and water (respiration).

California Next Generation Science Standards

- 5-LS2-1. Develop a model to describe the movement of matter among plants, animals, decomposers, and the environment.
- LS2.A. Interdependent Relationships in Ecosystems: The food of almost any kind of animal can be traced back to plants. Organisms are related in food webs in which some animals eat plants for food and other animals eat the animals that eat plants. Some organisms, such as fungi and bacteria, break down dead organisms (both plants or plant parts and animals) and therefore operate as "decomposers." Decomposition eventually restores (recycles) some materials back to the soil. Organisms can survive only in environments in which their particular needs are met. A healthy ecosystem is one in which multiple species of different types are each able to meet their needs in a relatively stable web of life. New introduced species can damage the balance of an ecosystem.

PROGRAM MATERIALS:

- "Seaweed Discovery Lab" worksheet
- "An Ecosystem out of Balance" information sheet
- "National Marine Sanctuaries in California" handout
- Printable photos of the sun, giant kelp, sea urchins, sea otter, Turkish towel seaweed, abalone, fish, shark, seabird, seal, bacteria
- Set of printable arrows
- Photos of magnified seaweed
- Photos of ice cream and sushi roll

Name: _____

Date: _____

SEAWEED DISCOVERY LAB

Station 1: Seaweed Up Close

Examine the magnified seaweed tissue and draw what you see.

What are the structures you are looking at? Why are they green?

_____

_____

_____

_____

How does seaweed make its own food? What is the name for this process? (Hint: It's the same process that grass and trees use to make food!)

_____

_____

_____

_____

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

Station 2: Build a Kelp Ecosystem

What is an ecosystem?

_____

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_____

Place the photos in the correct order of what consumes what. Place an arrow showing the transfer of energy. The arrows should point in the direction of the flow of energy. For example, an arrow would point toward a plant and away from the sun, toward a deer and away from grass. (Hint: One picture can have more than one arrow pointing toward or away from it.)

Describe what you've created. How does energy flow through this system? Where does the energy come from to begin with? Where does it end?

_____

_____

_____

_____

_____

_____

Take away the photo of the giant kelp. What happens to the animals in the ecosystem if the kelp disappears?

_____

_____

_____

_____

Other than food, what do seaweeds provide for animals in an ecosystem?

_____

_____

_____

_____

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

Station 3: Kelp Forests out of Balance

How much can kelp grow in one day?

_____

_____

_____

_____

What is the difference between a producer and a consumer? What is one example of each?

_____

_____

_____

_____

What happens when sea otters disappear from a kelp forest ecosystem?

_____

_____

_____

_____

Why is it important for a kelp forest ecosystem to stay balanced?

_____

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_____

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

Station 4: People and Seaweed

Look at these photos. Which items contain seaweed?

_____

_____

_____

_____

Why do you think they contain seaweed?

_____

_____

_____

_____

Pick up a piece of the edible seaweed. How does it smell? How does it feel?

_____

_____

_____

_____

Taste one small piece of seaweed. What does it taste like? Why do people eat seaweed? Does it have any nutrients that we benefit from?

_____

_____

_____

_____

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

Station 5: National Marine Sanctuaries in California

After reading about the threats facing California's kelp forests, fill in the table below with the threats and possible solutions to help protect them.

Threats to Kelp Forests	Solutions to Protect Kelp Forests

Why is it so important to have protected places like National Marine Sanctuaries in our oceans?

_____

_____

_____

_____

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

National Marine Sanctuaries in California

The California coastline is home to some of the greatest biodiversity in the world. Much of this life is found within our kelp forests. Unfortunately, kelp forests face many threats. Many of these threats come from humans.

- People harvest seaweed from the ocean. They use it to use to make food and many other products, such as frozen foods, cakes, puddings, shampoos, toothpastes, and salad dressings. Without rules for **harvesting**, people could take too much seaweed. This wouldn't leave enough seaweed for animals to use for food and habitat.
- **Pollution** is a major threat to kelp forests.
  - Runoff is water that moves from the land to the ocean, usually from rainfall. It can carry pesticides, herbicides, and fertilizers that are used to control pests on crops. These are toxic to both animals and seaweeds!
  - **Sewage** and pollution from cities can harm seaweeds and the animals that live in the ocean. This can upset the balance of ecosystems.
- Sometimes fish, invertebrates, and even seaweeds from other countries or regions are accidentally brought to the California coast. These are called **invasive species**. They compete with our native species for food and habitat. They can upset the balance of our ecosystems.
- **Big storms** create strong winds that cause lots of water to move in the form of waves and currents. This water movement can break apart kelp forests. Scientists believe that climate change is causing bigger and stronger storms to occur more often.
- **Overfishing** can hurt kelp forest communities. Taking too many fish from one part of the ocean upsets the balance of predators and prey. This harms the health of the whole ecosystem.

Fortunately, we have ways to protect our kelp forests! The National Marine Sanctuaries were established to help protect the special places in America's oceans and Great Lakes. There are only 14 of these protected areas. Four of them are found in California. Our four National Marine Sanctuaries are Cordell Bank, Monterey Bay, Gulf of the Farallones, and Channel Islands. They help protect and restore our beautiful coastline.

Scientists monitor the ecosystems within our sanctuaries. They gather data about ocean health and how the kelp forest communities are doing. This allows them to see and respond quickly to any problems. The sanctuaries have rules and laws that help protect them against pollution, overfishing, and harvesting. Scientists and volunteers help clean up pollution on beaches and remove invasive species. All of the sanctuaries have educators who teach people about climate change and other threats facing kelp forests.

Name: _____

Date: _____

SEAWEED DISCOVERY LAB CONTINUED

An Ecosystem out of Balance

Kelp is a type of seaweed that can grow more than one foot in length per day. It forms immense underwater forests where many animals take shelter and find food. These kelp forests are intricate ecosystems. Every organism in them has a role to play, whether as a producer (like seaweed) or consumer. If even one part of this delicate balance is disrupted, the health of the entire ecosystem is threatened.

The California coastline is home to many large kelp forests. In Monterey Bay there is a small population of southern sea otters. These marine mammals live in kelp forests. Sea otters are top predators. They feed on invertebrates—animals without a backbone—such as clams, oysters, mussels, crabs, sea stars, and sea urchins. In a healthy kelp forest, sea urchins consume pieces of kelp that fall to the sea floor. They are herbivores.

During the 19th century, this important balance among kelp, sea otters, and sea urchins was upset. Fur traders hunted sea otters for their luxurious fur. With up to one million hairs per square inch, sea otter fur was prized for its softness and warmth. (By comparison, a human head has only 100,000 hairs!) The fur hunters nearly wiped out all of the sea otters.

The disappearance of sea otters had a devastating effect on the kelp forest ecosystem. Since the sea otters weren't there to eat the sea urchins, the sea urchin population grew unchecked. They began eating kelp faster than it could grow back. Eventually, some ecosystems had no more kelp. This meant that there was no more food or habitat for the sea urchins—or any other animals.

By 1911, a conservation movement formed to protect sea otters. Since then the balance has slowly been restored. The population of sea otters has increased. As the otters ate more sea urchins, they controlled the sea urchin population. In turn, the kelp forests began to grow healthy once more.

LESSON 3

DISAPPEARING EELGRASS COMMUNITIES

Enduring Understanding: Eelgrass beds provide food and habitat for many organisms within San Francisco Bay, but they face various human-caused threats, and conservation is needed to protect them.

Materials

- 4 to 6 hula hoops (or similar structures) for "boundaries" of eelgrass beds
- 4 cones to set playing area
- Data sheet and sample graph (attached)
- Clipboard
- Blackboard or whiteboard
- Writing materials

SETUP:

1. Reserve a large playing space (at least 20 feet by 20 feet).
2. Place the cones in a rectangle to designate the playing field.
3. Place hula hoops randomly inside the four cones.
4. Print the data sheet and place it and a pencil on a clipboard.

PROGRAM OUTLINE:

What is eelgrass?

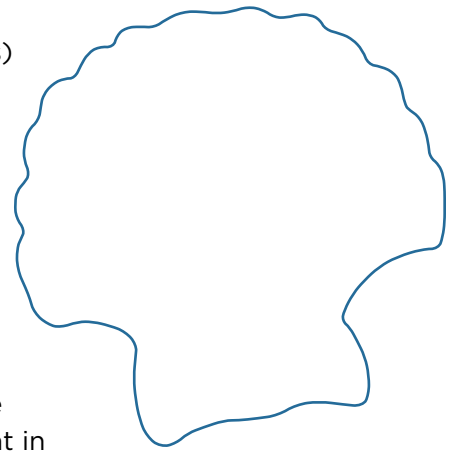
- Eelgrass is a true plant that grows submerged in the coastal marine environment.
- Eelgrass communities provide vital habitat for creatures that live in or migrate through San Francisco Bay, such as fish, invertebrates, and birds.
- Eelgrass beds also provide crucial nursery grounds for fish, such as salmon.
- Eelgrass is different from seaweed in that it has specialized roots, stems, leaves, and vascular tissue.

"Disappearing Eelgrass Habitat" Game

- Explain that the playing field is the San Francisco Bay estuary. The hula-hoops represent eelgrass communities and can be considered "safe eelgrass habitat zones."
- Pick three students to act as "predators" (birds or larger fish); have them stand inside the playing field.
  - You may choose to give these students open access to the entire playing field or limit them to just one area by designating lines within the field.
- Pick one or two students to be conservation biologists recording data on the number of eelgrass habitat zones for

each round and the number of salmon that survive each round. (You may choose to rotate different students through this role so everyone gets a chance to play the game and a few can experience taking data.)

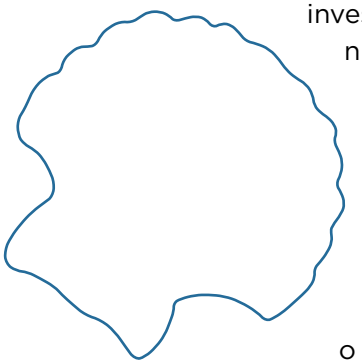
- Line up the rest of the class on one side of the playing field and designate them as juvenile "salmon."
  - The salmon need to make it from one side of the playing field to the other without getting eaten (tagged by predators).
  - The salmon can hide inside the hula hoops (safe eelgrass habitats) where the predators can't tag them; however, the salmon can only hide inside the eelgrass beds for a specified amount of time (up to 10 seconds) before they must step back out and try to make it to the next eelgrass bed.



- Once the round is over and all surviving baby salmon are on the other side of the playing field, introduce one threat that removes a hula hoop (see Threats in Instructor Background); play another round.
- Continue introducing threats in each round until there are no more hula hoops and the juvenile salmon no longer have any safe habitat in which to hide.

Graph survival data (return to the classroom for this activity)

- Write the data gathered from the game on the board. You will be using the data from the last column, "Total Surviving Salmon/Number of Salmon at the Beginning of the Round," on the x-axis and the "Number of Eelgrass Communities" on the y-axis. You may choose to work with fractions or convert them to percentages.
- Break students into three or four groups.
  - Explain the difference among the types of variables in a scientific study and ask them to identify each one.
    - Independent Variable: The part of the study that the experimenter purposely changes over the course of the investigation. Our independent variable is the number of eelgrass communities.
    - Dependent Variable: The part of the study that is observed and likely changes in response to the independent variable. Our dependent variable is the number of salmon that survive each round.
    - Controlled Variable: The parts of a study that are kept the same throughout the investigation. Our controlled variables are the number of "predators," as their number stayed the same, and the playing space inside the cones.



  - Ask students how they would graph the data (a simple line graph is clear and straightforward).
  - Have them graph the data from the game. You may either give them a copy of the x- and y-axis graph provided or have them draw their own graph after providing them with an example written on the board.
  - Have students interpret the data they graphed. Ask them the following questions:
    - Was it easier or harder to survive (avoid being tagged) as the eelgrass

communities disappeared?
  - Did the number of surviving salmon increase or decrease as the eelgrass communities disappeared? Why?
  - What would have happened to the surviving salmon over time if there had continued to be no more eelgrass communities?
  - What are the limitations of this study? (It was a game rather than actual scientific monitoring, only one variable was considered, etc.)

- If we were making an argument to protect eelgrass communities, how could the data be improved to support our argument?
  - More studies would be needed; have the students brainstorm additional variables that they could change or add to the game or other ways they could test the data to support this argument. A strong argument would include showing how solutions solve the problem. For example, introducing eelgrass communities rather than taking them away to see if more salmon survive.
  - Have students work together to determine solutions to the threats given during the game. Help them to discover solutions; you may choose to write out some of the solutions (found in the Instructor Background) on the board. Discuss any limitations to further studies (time constraints, limited space, and materials, limited number of students, etc.).
  - If time allows, carry out additional rounds of the game based on their ideas to gather and graph further data to demonstrate how these solutions may help protect eelgrass communities.

- Alternate game or additional round: Have the students be migrating birds, such as surf scoters, western grebes, or cormorants; the tagging students portray “hunger” or “exhaustion” that can kill the birds from lack of suitable habitat on which they can rest and hunt for food. Threats and solutions remain the same.

TEACHER BACKGROUND:

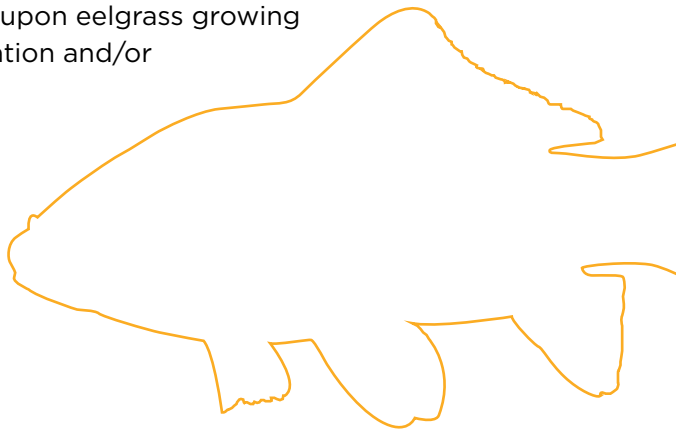
Eelgrass (Zostera marina) is a species of seagrass found submerged on sandy substrates or in estuaries. It is a type of flowering plant specially adapted to the marine environment. It is sometimes confused with seaweeds. However, eelgrass has roots, leaves, conducting tissues, flowers, and seeds, designating it as a true plant. Eelgrass can photosynthesize only through its leaves, and the roots are designed to take up nutrients and minerals from the soil. But all cells in seaweeds and other algae can photosynthesize and take up nutrients.

Ecological Importance

Eelgrass communities support tremendous biodiversity and provide food, habitat, and nursery areas for juvenile and adult fish, invertebrates, and birds. Their networks of roots and leaves can hide fish and invertebrates from predators, as well as protect them from strong currents. Some fish, including herring, lay their eggs on eelgrass leaves to shelter them while they mature. During low tide, eelgrass beds hold moisture and offer a safe, wet habitat for small creatures. Their extensive root mats preserve the productive bacteria in the sediment and nourish many invertebrates by holding the sediment in place and providing oxygen beneath the mud. Eelgrass and other species of seagrass have been recognized as important indicator species that reflect the overall health of coastal ecosystems. They provide valuable benefits for humans as well as marine life. They improve water quality by filtering polluted runoff and absorbing nutrients, such as nitrogen and phosphorus. Eelgrass beds also protect our shorelines from erosion by absorbing wave energy.

Threats

Eelgrass communities are vulnerable to a number of human-induced threats that take away growing space for eelgrass and increase sediment load in the water.



- Urban development is a major threat, as it may infringe upon eelgrass growing space and create poor water quality through sedimentation and/or pollution.
- Dredging is extremely destructive to eelgrass beds by either physically tearing up eelgrass roots or increasing sedimentation, which blocks sunlight from reaching the photosynthetic leaves.
- Invasive species, such as algae and invertebrates, can compete with eelgrass for habitat, light, and nutrients.
- Climate change from carbon emissions is thought to be increasing the intensity and frequency of extreme weather patterns, such as storms and droughts.
  - Storms can increase mechanical wave action, stirring up sediment that can block sunlight and physically damage eelgrass communities.
  - Droughts decrease freshwater flow, causing poor water quality and higher temperatures. (California is currently experiencing the worst drought in its recorded history.)
- Boats can damage eelgrass communities through the physical use of anchors, propellers, and mooring lines. They can also kick up waves that can harm eelgrass beds.

TEACHER BACKGROUND CONTINUED:

Solutions

There are many solutions to counteract these threats. Some of them are already in place.

- Limit the amount of urban development and construction that occur near sensitive habitats of San Francisco Bay.
- Protect river and stream banks from human activity; this can prevent erosion upstream.
- Better regulate boating activity.
- Designate certain eelgrass communities as protected habitat.
- Pass laws dedicated to reducing carbon emissions.
- Reduce water usage to curb drought.
- Reduce carbon footprints by using less electricity and fuel.
- Restore eelgrass habitats by "planting" eelgrass in mudflats during low tide.
- Better manage potential agricultural runoff through proper irrigation, managed pesticide usage, and better livestock confinement and management.

GLOSSARY:

Conservation: Preservation, protection, or restoration of the natural environment, natural ecosystems, vegetation, and wildlife

Controlled Variables: Parts of a study that are kept the same throughout the investigation

Dependent Variables: Parts of a study that are observed and likely to change in response to the independent variables

Dredging: Excavation activity or operation usually carried out at least partly underwater, in shallow seas, or freshwater areas with the purpose of gathering up bottom sediments and disposing of them at a different location

Drought: Prolonged period of abnormally low rainfall; shortage of water resulting from this

Eelgrass: Type of submerged aquatic vegetation evolved from terrestrial plants that has become specially adapted to the marine environment; grows submerged or partially submerged in shallow and sheltered coastal waters, undergoing its entire life cycle underwater; like terrestrial plants, it has leaves, roots, conducting tissues, flowers, and seeds and can produce food through photosynthesis.

Eelgrass Community: Ecosystem where eelgrass grows; supports a high diversity of fish and invertebrates, as well as provides food for migrating birds

Erosion: Process that removes soil and rock from one location and transports it to another; natural process that has been increased 10 to 40 times its natural rate by human activity

Estuary: Tidal mouth of one or more large rivers where the tide meets the stream; serves as nursery for young fish and invertebrates

Habitat Degradation: Process by which natural habitat is rendered functionally less able or unable to support the species present

Habitat Restoration: Practice of renewing degraded, damaged, or destroyed ecosystems and habitats in the environment by human intervention and action

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Pollution: Presence or introduction into the environment of a substance or thing that has harmful or poisonous effects

Urban Development: Social, cultural, economic, and physical development of cities, as well as the underlying causes of these processes

5TH GRADE STANDARDS:

California Common Core Standards

Mathematics

- 5.MD2. Make a line plot to display a data set of measurements in fractions of a unit. Use operations on fractions for this grade to solve problems involving information presented in line plots.

California Science Content Standards

- 6.g. Record data by using appropriate graphic representations (including charts, graphs, and labeled diagrams) and make inferences based on those data.
- 6.d. Identify the dependent and controlled variables in an investigation.

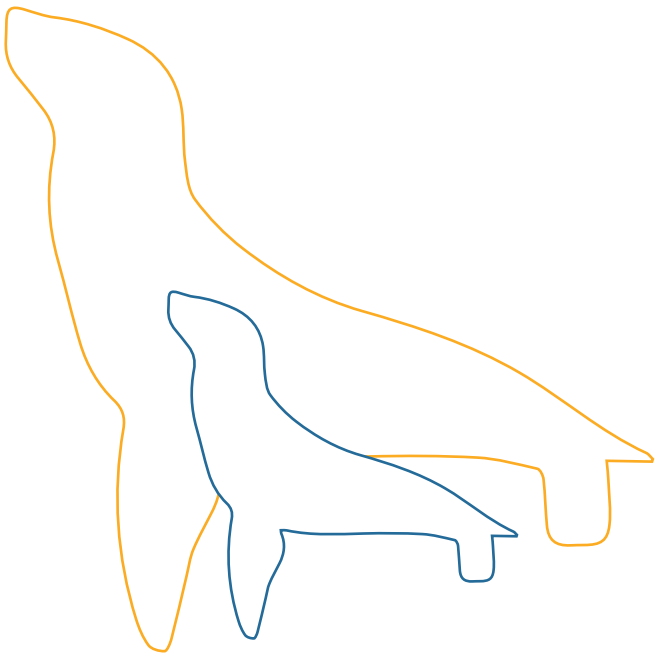
California Next Generation Science Standards

Engineering Design

- 3-5-ETS1-2. Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
  - Generate and compare multiple solutions to a problem based on how well they meet the

PROGRAM MATERIALS:

- “Disappearing Eelgrass Communities” data sheet



Name: _____

Date: _____

DISAPPEARING EELGRASS COMMUNITIES

Data Sheet

Round	Number of eelgrass communities (hula hoops)	Number of salmon to survive	Total surviving salmon/ number of salmon at the beginning of the round (x)

LESSON 4

WHY PROTECT EELGRASS COMMUNITIES IN SAN FRANCISCO BAY?

Enduring Understanding: Students should be able to create a persuasive argument, state a position on a conservation issue, and logically use evidence, data, and clear organization to support the position.

Materials

- "Disappearing Eelgrass Communities" data graphs (from Lesson 3)
- Whiteboard or blackboard
- Resource list
- Writing materials

SETUP:

1. Prepare writing materials.

PROGRAM OUTLINE:

Develop a persuasive argument to protect eelgrass.

- Have student volunteers come up to the board and write the threats that face eelgrass communities (learned in Lesson 3).
- Break your students into groups.
  - Have each group choose a threat.
  - Ask each group to brainstorm quietly and come up with solutions to their threat. Assist them with discovering possible solutions (see Solutions in Instructor Background) or remind them of solutions from Lesson 3.
- Review the data.
  - Referring back to the evidence and data gathered in Lesson 3, have your students choose a solution or solutions that they believe would be most effective in addressing the threat they chose. Assist them, but allow them to draw their own conclusions from the evidence.
  - Have the groups of students discuss whether or not they need more data or information to support their solution, and identify what additional resources could offer them the information (from Internet or texts).
- Explain that each person will write a practice persuasive argument letter to California's legislators. Their argument needs to include the following:
  - Clearly outline why eelgrass communities are important to both animals in the San Francisco Bay estuary and humans
  - Threat to eelgrass (that they chose), how it damages eelgrass

PROGRAM OUTLINE CONTINUED:

and threatens the animals that live there
- Viable solution they believe will address the threat
- Supporting evidence and data from Lesson 3, as well as additional information gathered from resources
- Clear conclusion with a call to action
- Developmentally appropriate scientific language; encourage students to use appropriate terminology to link their opinion and reasons, such as consequently and specifically.

- Explain that persuasive writing can influence the opinions and actions of others if their argument is expressed in a meaningful and respectful way.
  - Supporting an argument with details, evidence, and data can be convincing, especially in the conservation field.
  - Every voice matters; a well-written argument can gain the attention of leaders, which can lead to consideration of new regulations and laws.
- The argument should be given as a two- to three-day homework assignment and be written out with clear organization and logical structure that includes an introduction, body, and conclusion.
- They may use any available additional resources, such as texts or websites, to support their position. You may choose to require a certain number of reputable resources.
- Assist them with revising and rewriting the letter.

TEACHER BACKGROUND:

Persuasive Arguments

Writing a persuasive argument relies on having a solid foundation of facts, details, and evidence to support the writer's position. The general characteristics of writing a persuasive argument include a stated position or belief, supporting facts and evidence, persuasive language using proper terminology to link opinions and reasons, and a conclusion with a call to action.

Physiology

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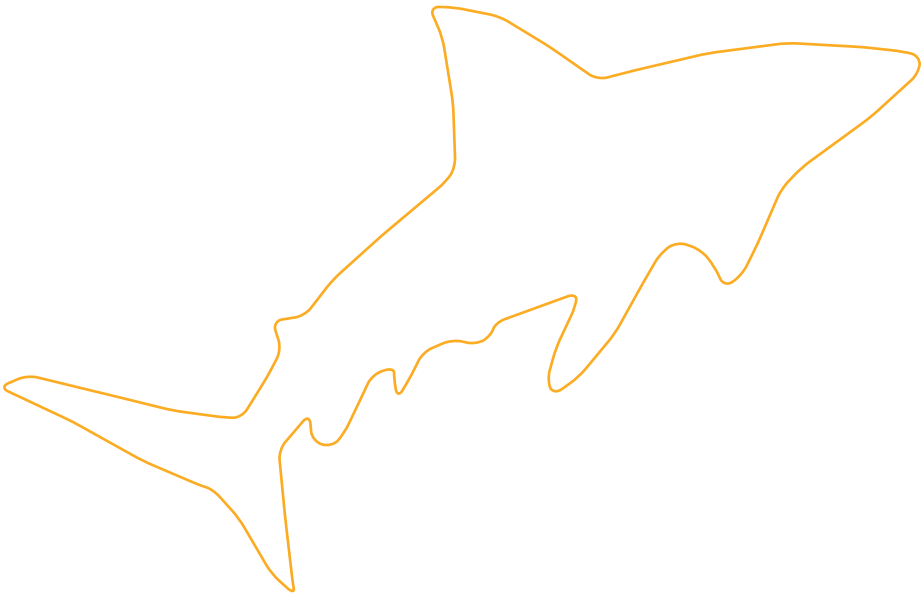

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5TH GRADE STANDARDS:

California Common Core Standards

Writing

- W.5.1. Write opinion pieces on topics or texts, supporting a point of view with reasons and information.
  - a. Introduce a topic or text clearly, state an opinion, and create an organizational structure in which ideas are logically grouped to support the writer's purpose.
  - b. Provide logically ordered reasons that are supported by facts and details.
  - c. Link opinion and reasons using words, phrases, and clauses (e.g., consequently, specifically).
  - d. Provide a concluding statement or section related to the opinion presented.

California Science Content Standards

- 6.h. Draw conclusions from scientific evidence and indicate whether further information is needed to support a specific conclusion.

California Next Generation Science Standards

- 5-ESS3-1. Obtain and combine information about ways individual communities use science ideas to protect Earth's resources and environment.
- ESS3.C. Human Impacts on Earth Systems: Human activities in agriculture, industry, and everyday life have had major effects on the land, vegetation, streams, ocean, air, and even outer space. But individuals and communities are doing things to help protect Earth's resources and environments.

5TH GRADE

RESOURCES

Books

- Hemminga, Marten A. and Carlos Duarte. Seagrass Ecology. Cambridge: Cambridge University Press, 2008.
- Iselin, Josie. An Ocean Garden: The Secret Life of Seaweed. New York: Harry N. Abrams, 2014.
- Larkum, Anthony W.D., Robert J. Orth, and Carlos Duarte, Seagrasses: Biology, Ecology and Conservation. Springer, 2010.
- Mondragon, Jennifer and Jeff Mondragon. Seaweeds of the Pacific Coast: Common Marine Algae from Alaska to Baja. Sea Challengers, 2003.
- Mouritsen, Ole G. Seaweed: Edible, Available, and Sustainable. Chicago: University of Chicago Press, 2013.

Websites

- California Coastkeeper Alliance, "Southern California Giant Kelp Restoration Project"

  http://www.cacoastkeeper.org/document/final-kelp-project-report.pdf
- NOAA, "What is seaweed?"

  http://oceanservice.noaa.gov/facts/seaweed.html
- National Marine Sanctuaries, "Ecosystems: Kelp Forests"

  http://sanctuaries.noaa.gov/about/ecosystems/kelpdesc.html
- NOAA, "What lives in a kelp forest?"

  http://oceanservice.noaa.gov/facts/kelplives.html
- PBS, Jean-Michel Cousteau: Ocean Adventures: "Kelp Forest"

  http://www.pbs.org/kqed/oceanadventures/video/kelp
- San Francisco Bay Subtidal Habitat Goals Project

  http://www.sfbaysubtidal.org
- The Seaweed Site

  http://www.seaweed.ie
- Richardson Bay Audubon Center & Sanctuary, "All about Eelgrass"

  http://richardsonbay.audubon.org/all-about-eelgrass