Tidal Tales: Monitoring Marine Life

Grade Level

5–8 or higher

Timeframe

45 minutes or more

Materials

- Computer, projector and screen
- Visual materials and text documents (all available to download)

Key Words

Abiotic factors, abundance, algae, environmental monitoring, invertebrates, rocky intertidal and subtidal zones, marine organisms, quadrat, transect line

Standards

NGSS: MS-LS2-4.
CCSS: W.6.10. SL.6.4.
Ocean Literacy Principles: 5.
Details at end of lesson

Students monitor a rocky intertidal community with a quadrat at a national marine sanctuary in California. Your students can do a similar monitoring activity in the classroom. Photo: Jessie Altstatt

Activity Summary

Students will learn techniques scientists use to measure species abundance in rocky intertidal and subtidal zones in national marine sanctuaries. They will examine photos taken in the two different habitats and identify species, assess organism abundance and compare the depths (zones) from which the photos were taken. Then they will consider the environmental conditions that influence species occurrence and abundance and why it is important to monitor these sensitive habitats.

Learning Objectives

Students will:

- Visually identify rocky intertidal organisms (primarily mollusks and algae) and subtidal organisms (primarily corals and sponges)
- Practice data collection methods and complete data sheets using photo quadrats of organisms in rocky intertidal and subtidal zones
- Argue from evidence and reflect on the environmental factors that influence species occurrence and abundance in different coastal zones

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National Geographic Society

&

National Marine Sanctuary Foundation

Background Information

National marine sanctuaries are a network of underwater areas in the ocean and Great Lakes that protect America's most iconic natural and cultural marine resources. Greater Farallones National Marine Sanctuary, in California, protects the waters surrounding Point Reyes and the Farallon Islands and the near shore waters of Bolinas Lagoon and Tomales Bay. Duxbury Reef, at the southern end of the Point Reyes peninsula, is one rocky area where students and scientists have been monitoring the reef's health for many years.

Sea stars in rocky intertidal habitat near Greater Farallones National Marine Sanctuary. Photo: NOAA

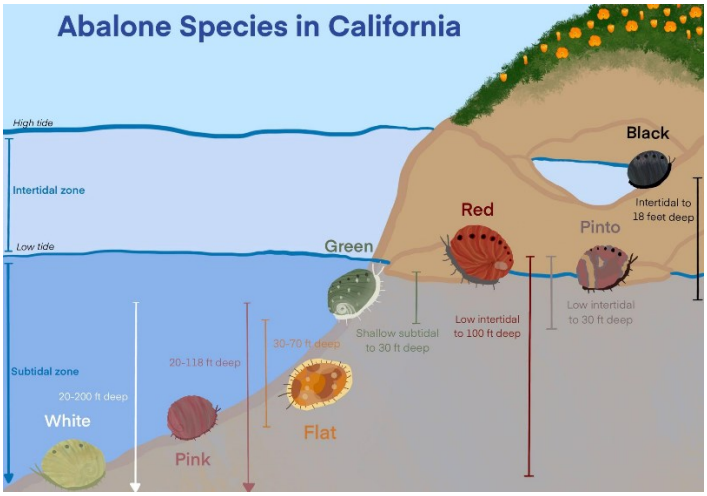
Cordell Bank National Marine Sanctuary, west of central California, is entirely offshore. Within its 1,286 square miles (3,331 sq. km), the sanctuary protects soft seafloor habitat, a rocky bank, deep sea canyons and communities of wildlife throughout.

Cordell Bank, teeming with fish and other marine life Photo: NOAA

Cordell Bank is an underwater rocky reef about 20 miles (52 km) west of Point Reyes and Bodega Head. Most of the Bank sits on the continental shelf at 400 feet (122 m), while some of it rises to peaks of 115 feet (35 m) below the surface of the water. Students will examine photos taken of organisms found in this area and Duxbury Reef.

Zones of Life

Ocean ecosystems are defined by environmental factors and the community of organisms living there. Many factors determine the distribution, species composition and abundance of invertebrate fauna. Tides, waves, predation, substrate and/or other factors cause vertical zonation patterns along the coast; density, pressure and light levels cause vertical zonation patterns in the open ocean.



Abalone are one of many organisms with different species adapted to various vertical zonation patterns in the intertidal and subtidal zones. Some species are endangered or threatened. Learn more: https://www.nps.gov/articles/000/sfanblog_why-black-abalone.htm
Illustration: Theodora Mautz / National Park Service / Point Reyes National Seashore

Zonation patterns influence organisms' distribution and diversity. Seafloor geology, types of rocky substrate or sediments, offshore currents and circulation patterns, exposure to waves and water depth also determine where organisms live. Bottom dwellers, like corals and

sponges, live in a stable environment of relative darkness, pressure and cold.

The rocky intertidal habitat supports a diverse array of invertebrate species. Intertidal invertebrates like sea stars must live in two worlds, submerged by high tide and exposed at low tide. Sea creatures arrange themselves vertically in the intertidal zone depending on their abilities to compete for space, avoid predators from above and below and resist drying out. Residents of the higher intertidal zones can either close themselves up in their shells to remain moist and ward off predators, or are mobile enough to retreat to a submerged zone when the tide goes out.

Monitoring Techniques

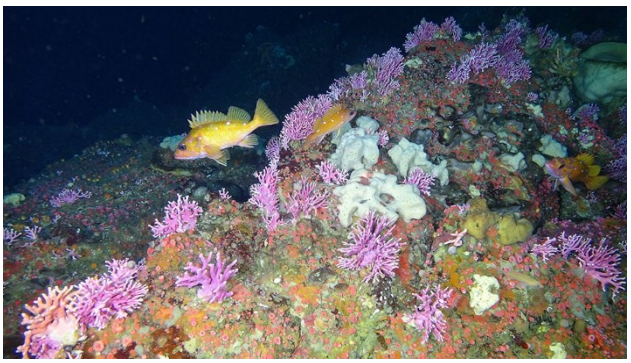
Measuring relative abundance of organisms is a way to determine the health of an area. Biologists use these techniques to track changes in the environment over time. Intertidal monitoring in the field is done along a transect line, which runs from the low tide zone to the high tide zone. Scientists collect data along this line and observe differences between the different tidal zones. Every five meters, scientists place a 0.25 m^2 quadrat and record the organisms in the area. For larger invertebrates, they count individuals found within the quadrat. In addition, they count the relative abundance of algae and invertebrates that are more common.

Monitoring is important to determine how these communities are affected by climate change, pollution, coastal development and human trampling and harvesting. Large numbers of people frequently visit rocky intertidal areas, which can adversely affect the health of the environment. Specific sites are monitored over time so action can be taken if they are negatively impacted.

Monitors on South Farallon Island with a quadrat used for systematically counting organisms.
Image: NOAA.

The subtidal environment of Cordell Bank is too deep to study by SCUBA divers and to use quadrats to estimate relative abundance. The sanctuary uses video cameras and an observer in a deep-sea submersible to learn about the invertebrate cover on this deep rocky reef.

This activity provides students with the opportunity to compare the subtidal environment of Cordell Bank and the intertidal habitats in Gulf of the Farallones through photos.



A deep-sea coral community on a rocky substrate at Cordell Bank National Marine Sanctuary
Photo: NOAA

Learn more:

"Cordell Bank Overview." NOAA: https://sanctuarysimon.org/cordell-bank-nms

"Cordell Bank National Marine Sanctuary celebrates 30 years of ocean protection." NOAA National Marine Sanctuaries: https://sanctuaries.noaa.gov/news/may19/30th-anniversary-cordell-bank-national-marine-sanctuary.html

Denka, S. "From the Beach to the Deep Sea: Exploring Ecosystems of the Gulf of the Farallones." NOAA National Marine Sanctuaries: https://sanctuaries.noaa.gov/news/sep14/exploring-gulf-farallones.html

"Greater Farallones Overview." NOAA: https://sanctuarysimon.org/greater-farallones-nms

"Intertidal Zone." National Geographic Society: https://education.nationalgeographic.org/resource/intertidal-zone

"Rocky Intertidal Monitoring at the South Farallon Islands." NOAA: https://farallones.noaa.gov/science/intertidal.html

Vocabulary	
Abundance	The number of individuals of a species found within a specific area
Algae	Chlorophyll-containing non-vascular organisms (plant or plant-like)
Invertebrate	Animal without a backbone, such as snails, sea anemones and sea stars
Monitoring	Tracking changes in an environment over time
Quadrat	A square or rectangular plot of land, often one square meter or 0.25 m^2, used to quantify the distribution of species over a wider local area
Rocky intertidal zone	Area where the ocean meets the land between high and low tides, characterized by rocks
Subtidal zone	Area where the seafloor is below the lowest tide and is generally submerged
Transect line	A measurement along a line with known intervals, measuring physical and/or biological conditions

Preparation

- Prepare to use the "Tidal Tales: Monitoring Marine Life" presentation with the class.
- Make one or more copies of these for students to share:
    - "Rocky Intertidal Photo Quadrats" (PowerPoint file with 6 slides) printed in landscape format on standard 8.5" x 11" paper
    - "Subtidal Photo Quadrats" (PowerPoint file with 4 slides) printed in portrait format on standard 8.5" x 11" paper
    - **Note**: To simplify the activity, use just the rocky intertidal images with student groups.

  The intertidal photos were taken at Duxbury Reef in Bolinas, California. The subtidal photos were taken through the porthole of a submersible on Cordell Bank off the coast of California.
- Copies of these for each student or group of 3–4 students
    - Photo Quadrat Data Sheet

- Photo Quadrat Answer Sheet
- Animal and Algae ID Card

- Prepare to conduct a simulated intertidal line transect with a measuring tape at least 6 meters long. Another tape that is at least 6 meters long would also be helpful for a subtidal line transect. You can create your own with a marker and rope or string, marking each meter with a marker or tape.
- Ask students to get science notebooks ready.

Procedure

Engage

- Begin by opening the "Tidal Tales: Monitoring Marine Life" presentation. Advance to slide two, which shows two habitats side-by-side: one that is healthy and teeming with life and the other with little life and a shoe in the corner. Share this mystery with them:
  - Scientists have observed that some parts of ocean shoreline appear healthier than other areas. They want to investigate what might be causing the differences.
- Ask students to think about the questions below and discuss them with a neighbor, recording ideas in science notebooks:
  - Which of these communities looks healthier? How do you know? What factors could be causing the difference?
  - What kind of habitats are these? What are the environmental conditions like in these areas? For example, what kind of wave action might there be? What temperature(s), salinity (amount of dissolved salt), weather conditions and exposure to direct sunlight might there be, etc.?
- Circulate to observe student discussions and answer questions. After a couple minutes, discuss student ideas and how the habitats are rocky intertidal reef, also known as the intertidal zone or tide pools.
- Discuss their ideas for why one area could be less healthy. It could be too much foot traffic in one part of the reef, or maybe it's a matter of different environmental conditions. Tell them the photo on the left is at Olympic Coast National Marine Sanctuary in Washington state. The photo on the right is a non-sanctuary beach in California, so it is difficult to compare the two, especially with just photos and no other data.
- Advance to the next slide with the map of the National Marine Sanctuary System. Tell them that today they will be exploring habitats that are common in West Coast sanctuaries, like Greater Farallones National Marine Sanctuary and Cordell Bank National Marine Sanctuary in California, northwest of San Francisco. Point these out on the map.
- Advance to the next slide showing Duxbury Reef and tell students that this is a site near San Francisco that students help to monitor for habitat health.

- Advance to the next slides and show students photos of rocky intertidal and subtidal habitats and animals. Ask students if they have ever seen these types of environments and animals before. Ask them:
    - Why is monitoring the abundance of organisms in these zones important?
- Explain to students that they will learn the same procedure that marine biologists use to monitor populations of key species in the intertidal zone.
- Share the slides that help students identify different species and explain how to count species.

Explore

- Ask students to form science teams of 3–4 and move furniture to create a large open area on the ground. Tell them they should imagine they are at the rocky shore in a California marine sanctuary and conducting scientific line transect monitoring of the organisms found there.
    - Lay out a measuring tape or rope at least 6 meters long and tell students they will be conducting a simulated line transect of a rocky intertidal area there. Lay down each of the 6 intertidal photos at the one-meter increments.
    - Lay out a second measuring tape or rope (if available) in another area of the room. Tell students this is an area where they can imagine they are in a submersible going offshore to conduct a long line transect down to ocean depths between 110 meters (over 360 feet) and 42 meters (138 feet) below the surface. Spread out the 4 intertidal photos at regular intervals along the line as much as possible, preferably every 2 meters or more.
    - Distribute the organism ID guides and data sheets to each student or group of students.
    - **Note:** To simplify the activity, do just the rocky intertidal transect with student groups.
- Explain that for each photo, students will quantify the abundance of algae and animals in each quadrat using two methods:
    - For the larger invertebrates, a total count of the number of individuals is recorded (under “individuals” on the data sheet).
    - For algae and the more abundant animals, the number of squares out of 6 with any portion of the algae or animal is recorded under “count and record” on the datasheet. (Point out how there are 6 equally-sized boxes with thin black lines on each photo.) Tell student that this can be a challenging method to use, yet it provides a relative abundance measurement and is good practice if they have the opportunity to participate in a field study.
- Ask the groups to choose one of the photos in either the intertidal or subtidal areas where they can start recording data.
    - Students should fill out the photo quadrat data sheet by looking to see if each species listed on the data sheet is present in the quadrat.

- After they finish doing so, they can move on to the next photo in order on the transect line. If multiple groups arrive at the same photo, you can lay out another copy of it nearby where the group will have enough space to observe it carefully.
- Tell the groups that they should observe at least 1–2 photo quadrats from both subtidal and rocky intertidal habitats. Ask them to also record their ideas for the questions on the handouts (in the space provided or in science notebooks).

Explain

- Ask the groups to share their results with the class and discuss them. Show the "Rocky Intertidal Photo Quadrats" presentation and then the "Subtidal Photo Quadrats" presentation on the screen to aid in discussion. Use the data sheet answer key to help students find organisms they may have missed.
- Discuss with the class which organisms were hard to identify and how doing line transects would be different in the field.
    - Ask students to explain some of the limitations of measuring abundance of species using this technique. Ask students to explain the benefits of measuring abundance using this technique.
    - Ask students how they might design a technique to measure abundance that still gains the advantages they have identified, but solves some of the limitations they have identified.
    - Ask students how scientists can measure abundance in the subtidal from a submersible. Discuss how a different kind of transect can be done with the submersible navigating over an area in a straight line. Two lasers that are 10 cm apart are often used to aid in measuring the different species that are found.
    - What sorts of decisions might resource managers make using data collected by these methods?
    - Ask students to compare the rocky intertidal organisms to the subtidal organisms.
        - How do the physical conditions in each environment impact which species are found there?
        - Why are some more abundant at one depth rather than another?
        - What types of adaptations do organisms have that allow them to live in each environment?
- Discuss the defining characteristics of each of these environments and how scientists define zonation patterns.
    - How might humans impact these environments?
    - How can information that community scientists and professional scientists gather through monitoring be used and shared?
    - How can negative human impacts be minimized and possibly reversed?

Enrich/Extend

- Play a California beach-themed song to help create the mood for your simulated trip to the beach. You could ask students for song ideas or choose one like "Big Sur" by Jack Johnson: https://youtu.be/edBw271tXyk.
    - Tell students that the cover of Johnson's album "All the Light Above It Too" shown in the video linked above features plastic that was picked up on a beach in Hawai'i in just one hour. The video for "You Can't Control It" shows how the plastic trash art was created in collaboration with Kokua Hawai'i Foundation and other partners: https://youtu.be/4grt0BtSa2E.
    - Ask students to think about what story Johnson and partners want to tell with the video and album cover. Ask them to brainstorm ways they might take action to improve the health of our global ocean and local areas. With your students' help, you could organize a service-learning event to clean up litter and/or marine debris.
        - You can use National Geographic Society's Marine Debris Tracker app to record the type of debris students collect: https://debristracker.org. Debris Tracker is designed to help citizen scientists make a difference by contributing data on plastic pollution in their communities.
        - Using information and data from Debris Tracker, ask students to argue from evidence how local efforts can have a big impact on marine pollution.
        - Students can compare the number of different types of items they collect with other organizations and/or areas using the filter on Marine Debris Tracker's website: https://debristracker.org.
        - Free "Learning Through Citizen Science" online training modules that feature the Marine Debris Tracker app and iNaturalist can be accessed at https://account.nationalgeographic.org/courses/cit-sci-home.
- Invite students to explore the "Fantastic Ocean Places You Can Bank On" StoryMap from NOAA with a partner: https://storymaps.arcgis.com/stories/bd5be93dcd214d64872de7e535425477
    - Ask students to discuss what ocean banks are, some places in the National Marine Sanctuary System where they can be found, and why they are important, recording ideas in science notebooks.
    - Then they can choose a bank in a sanctuary and create an art/writing project that encourages others to care about it, such as a poster, video, skit, creative story, poem or labeled diorama.
- Ask students to reflect on why it is important to have marine sanctuaries. Discuss how the future might look if these ecosystems are both protected and conversely unprotected from human-caused threats. Incorporate threats from climate change and ocean acidification in the discussion. Invite students to brainstorm actions that

people can take to mitigate these threats and how fragile intertidal and subtidal communities might thrive from special protection.

- If you live near a national marine sanctuary, give your students a hands-on experience collecting valuable coastal ecosystem data. Contact your local sanctuary education office to conduct an engaging field study. One program at Greater Farallones National Marine Sanctuary is LiMPETS (Long-Term Monitoring Program and Experiential Training for Students): https://farallones.org/limpets.

Evaluate

- Ask students to construct an argument supported by evidence that changes to physical or biological components of intertidal and subtidal ecosystems would affect populations and biodiversity of organisms.
- Ask groups to summarize their findings in the data collection/analysis activities in short class presentations, using their graphs as visual aids.
- Ask students to summarize what they learned in the activity and class discussions. These can be recorded in science notebooks or on separate paper. Students also might choose to add illustrations with labels to their written accounts.
- Review science notebooks and completed student data sheets.

Education Standards	
Next Generation Science Standards	Ecosystems: Interactions, Energy, and Dynamics • MS-LS2-4: Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations. Science and Engineering Practices: • Engaging in Argument from Evidence Crosscutting Concepts: • Cause and Effect • Systems and System Models
Common Core State Standards	Writing: W.6.10 Write routinely over extended time frames (time for research, reflection, and revision) and shorter time frames (a single sitting or a day or two) for a range of discipline-specific tasks, purposes, and audiences. Speaking and Listening: SL.6.4 Present claims and findings, sequencing ideas logically and using pertinent descriptions, facts, and details to accentuate main ideas or themes.
Ocean Literacy Principles	5. The ocean supports a great diversity of life and ecosystems. (e, f, h)
Climate Literacy Principles	3. Life on Earth depends on, is shaped by, and affects climate. (a, c) (If the Enrich/Extend activity is completed.)

Additional Resources

"Exploring Our Fluid Earth: Teaching Science as Inquiry." Curriculum from University of Hawai'i, NOAA and other partners: http://manoa.hawaii.edu/exploringourfluidearth

"Intertidal Zone." National Geographic Society: https://education.nationalgeographic.org/resource/intertidal-zone

"Marine Animals of the Rocky Intertidal Zone." Olympic Coast National Marine Sanctuary: https://marinedebris.noaa.gov/sites/default/files/Intertidal%20Zone%20Animals%20Field%20Guide%201.pdf

"Ocean Acidification: Rocky Intertidal Habitats." Greater Farallones National Marine Sanctuary: https://nmssanctuaries.blob.core.windows.net/sanctuaries-prod/media/archive/science/assessment/pdfs/gfnms_ocean_acidification.pdf

"Shoreline Habitats" lesson from NOAA targeted to elementary student grades; includes good background about Hawai'i habitats: https://coast.noaa.gov/data/SEAMedia/Lessons/G3U1%20Overview%20Shoreline%20Habitats.pdf

This lesson builds on an activity from Cordell Bank National Marine Sanctuary: https://cordellbank.noaa.gov/education/curriculumactivities.html

For More Information

This lesson was developed by NOAA's Office of National Marine Sanctuaries. The transect activity was adapted from the LiMPETS Rocky Intertidal classroom kit developed by Dr. John Pearse and Dawn Osborn of the University of California Santa Cruz. Subtidal comparison was added and adapted by Cordell Bank National Marine Sanctuary. For more information visit http://limpets.noaa.gov or http://www.cordellbank.noaa.gov/education/teachers.html. You can also email cordellbank@noaa.gov.

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