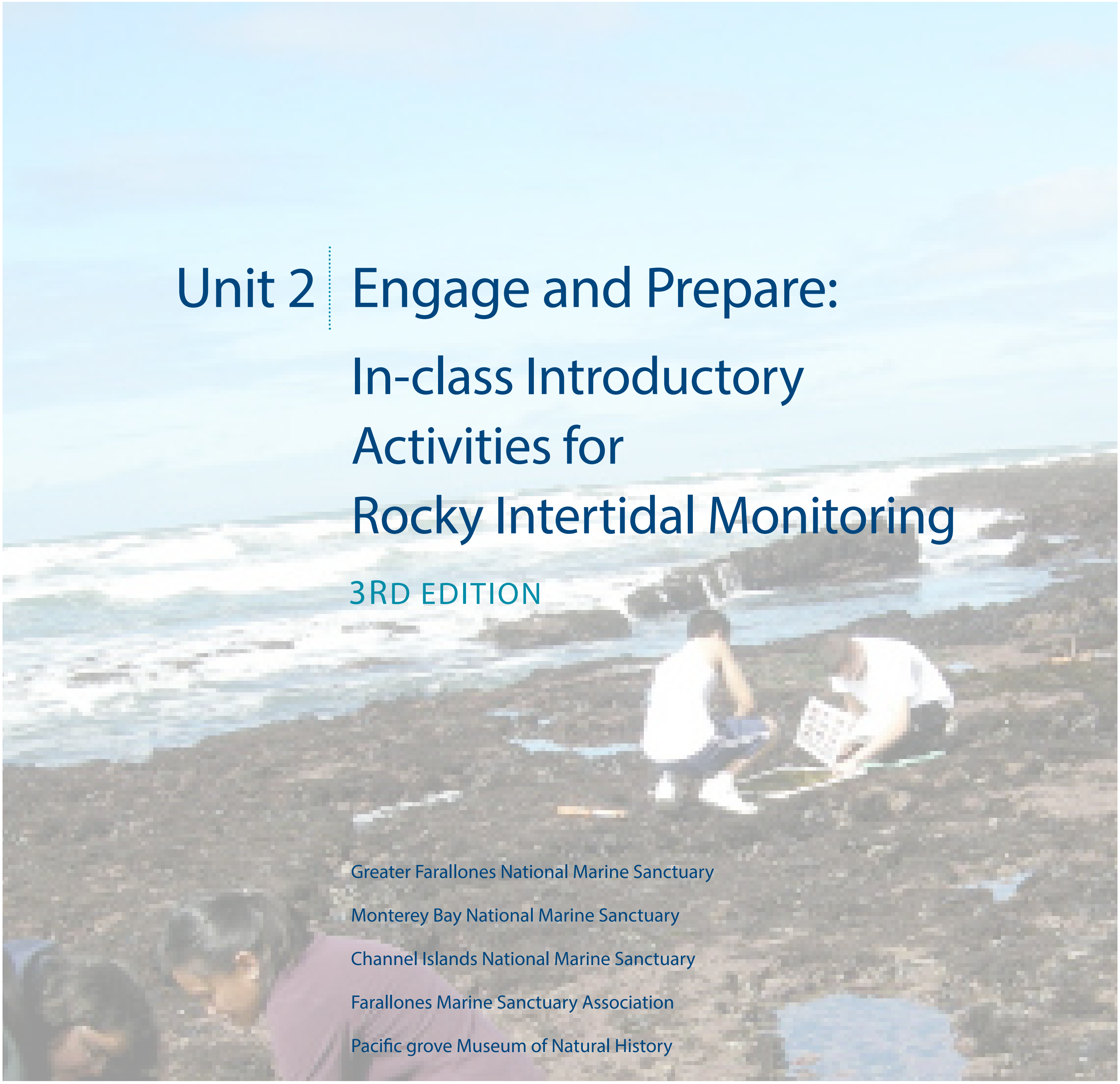
National Marine Sanctuaries



Unit 2 | Engage and Prepare:
In-class Introductory Activities for Rocky Intertidal Monitoring

3RD EDITION

Greater Farallones National Marine Sanctuary

Monterey Bay National Marine Sanctuary

Channel Islands National Marine Sanctuary

Farallones Marine Sanctuary Association

Pacific grove Museum of Natural History

LiMPETS Long-term Monitoring Program and Experiential Training for Students

LiMPETS Curriculum

The LiMPETS curriculum was created by the Farallones Marine Sanctuary Association and updated by the Pacific Grove Museum of Natural History in partnership with many generous individuals and organizations. We would like to thank everyone for their countless and valuable contributions to this project.

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Unit 2 | Engage and Prepare: In-class Introductory Activities for Rocky Intertidal Monitoring

Using the LiMPETS Curriculum

The LiMPETS curriculum was designed for a broad range of participants; middle school and high school students, college undergraduates, environmental education organizations, and community groups. We encourage you to adapt and customize this curriculum to suit the needs of your unique class or group. However, there are some essential elements that are required in order to participate. At minimum, teachers or group leaders should set aside three days to conduct the essential elements of the program: one day for classroom preparation, one day for monitoring, and one day for data entry and assessment.

The following outlines both the required and optional elements of this curriculum:

Unit 1: Getting Started (required reading for teachers and group leaders)

Unit 2: Engage and Prepare: In-class Introductory Activities for Rocky Intertidal Monitoring

- ACTIVITY: The Essentials of LiMPETS In-class Preparation (required)
- ACTIVITY: Monitoring with Life-Sized Photo Quadrats (suggested)
- ACTIVITY: Monitoring Sea Stars Using the Total Count Method (optional)
- ACTIVITY: LiMPETS Claymation Identification Game (optional)
- ASSESSMENT: Student Pre- and Post-Monitoring Reflection (optional)

Unit 3: Investigate and Archive: LiMPETS Rocky Intertidal Monitoring and Data Entry

- ACTIVITY: LiMPETS Rocky Intertidal Monitoring (required)
- ACTIVITY: Data Entry (required)

Unit 4: Analyze and Interpret: Data Analysis Activities for the Classroom (optional)

- ACTIVITY: Using Vertical Transect Data to Visualize Zonation at the Rocky Intertidal
- ACTIVITY: Tracking a Keystone Species Over Time
- ACTIVITY: Global Climate Change Exploration – Impact on Intertidal Species

Unit 5: Communicate: Effectively communicating science and taking action in your community (optional)

- ACTIVITY: Student Pre- and Post-Monitoring Reflection
- ACTIVITY: Communicating Science Through Posters, Scientific Papers, and Oral Presentations
- ACTIVITY: Taking Personal Action to Protect the Ocean — Us Vs Them

The LiMPETS curriculum is aligned with the Next Generation Science Standards and Common Core Standards for grades 6–12. It is also aligned with the Ocean Literacy Principles and Concepts, which identifies the content knowledge that an ocean literate person should know by the end of 12th grade, www.oceanliteracy.org.

Middle School Curriculum Alignment

Activity	Next Generation Science Standards	Common Core Standards	Ocean Literacy Principle
The essentials of LiMPETS In-Class Preparation	Practices obtaining, evaluating, and communicating information Core Ideas LS2.A: interdependent relationships in ecosystems LS2.C: ecosystem dynamics, functioning, and resilience LS4.B: natural selection LS4.C: adaptation LS4.D: biodiversity and humans ESS3.A: natural resources ESS3.C: human impacts on earth systems ESS3.D: global climate change Crosscutting Concepts stability and change	RST 2: determine the central ideal or conclusions of a text RST 4: determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context	1.H: although the ocean is large, it is finite and resources are limited 5.C,D,F,H: the ocean supports a great diversity of life and ecosystems 6.B,C,E,F: the oceans and humans are inextricably connected
Monitoring with Life-Sized Photo Quadrats	Practices planning and carrying out investigations Core Ideas LS2.A: interdependent relationships in ecosystems Crosscutting Concepts systems and systems modeling		5.H: tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms
Monitoring Sea Stars Using the "Total Count" Method	Practices planning and carrying out investigations Core Ideas LS2.A: interdependent relationships in ecosystems Crosscutting Concepts systems and systems modeling		5.D: ocean biology provides unique examples of relationships among organisms
LiMPETS Claymation Identification Game	Practices obtaining, evaluating, and communicating information Core Ideas LS4.B: natural selection LS4.C: adaptation Crosscutting Concepts structure and function		5.D: ocean biology provides unique examples of relationships among organisms
Student Reflection		W 3: write narrative to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sentences	6.G. individuals and collective actions are needed to manage ocean resources for all

High School Curriculum Alignment

Activity	Next Generation Science Standards	Common Core Standards	Ocean Literacy Principle
The essentials of LiMPETS In Class Preparation	Practices obtaining, evaluating, and communicating information Core Ideas LS2.A: interdependent relationships in ecosystems LS2.C: ecosystem dynamics, functioning, and resilience LS4.B: natural selection LS4.C: adaptation LS4.D: biodiversity and humans ESS3.C: human impacts on earth systems ESS3.D: global climate change Crosscutting Concepts stability and change	RST 2: determine the central ideal or conclusions of a text RST 4: determine the meaning of symbols, key terms, and other domain-specific words and phrases as they are used in a specific scientific or technical context	1.H: although the ocean is large, it is finite and resources are limited 5.C,D,F,H: the ocean supports a great diversity of life and ecosystems 6.B,C,E,F: the oceans and humans are inextricably connected
Monitoring with Life-Sized Photo Quadrats	Practices planning and carrying out investigations Core Ideas LS2.A: interdependent relationships in ecosystems Crosscutting Concepts systems and systems modeling		5.H: tides, waves and predation cause vertical zonation patterns along the shore, influencing the distribution and diversity of organisms
Monitoring Sea Stars Using the "Total Count" Method	Practices planning and carrying out investigations Core Ideas LS2.A: interdependent relationships in ecosystems Crosscutting Concepts systems and systems modeling		5.D: ocean biology provides unique examples of relationships among organisms
LiMPETS Claymation Identification game	Practices obtaining, evaluating, and communicating information Core Ideas LS4.B: natural selection LS4.C: adaptation Crosscutting Concepts structure and function		5.D: ocean biology provides unique examples of relationships among organisms
Student Reflection		W 3: write narrative to develop real or imagined experiences or events using effective technique, relevant descriptive details, and well-structured event sentences	6.G. individuals and collective actions are needed to manage ocean resources for all

The Essentials of LiMPETS In-Class Preparation

OBJECTIVE: Students will learn about tools and methods used to monitor the rocky intertidal and will understand why long-term cumulative data are important. Students will learn scientific classification, adaptations, ecological interactions and identifying characteristics of rocky intertidal invertebrates and algae monitored by the LiMPETS program. Students will learn ways in which humans affect the rocky intertidal.

ACTIVITY TIME: 45–90 minutes

GRADE LEVEL: 6–college

LIMPETS WEB RESOURCES:

- Species Monitored Pages, http://limpets.org/ri_species.php
- Student Resources Pages, http://limpets.org/student_resources.php

MATERIALS: Note that the fact sheets are also available on the "Student Resources" page of the LiMPETS website.

- LiMPETS Introductory Prezi: Teachers and group leaders receive the passoword to the "Teacher Resource Portal" during the LiMPETS Workshops. Prezis are updated annually.
- LCD projector, computer, and projection screen
- LiMPETS Rocky Intertidal ID Notes Pages
- Student Handout: Quiz Yourself
- The Rocky Intertidal: Fact Sheet (grades 6–college)
- Field Sampling Techniques: Fact Sheet (grades 9–college)

BACKGROUND: Students should be familiar with the how, what and why of monitoring before going to the rocky intertidal. Preparation is both key to quality data collection and to an exciting and meaningful student experience. This activity outlines, at minimum, the required elements of training that will help engage and prepare your students in-class for a successful day in the field. You may wish to review Unit 1, "Why Monitor" and "Rocky Intertidal Ecology", as well as the script embedded within the LiMPETS Introductory Prezi.

PROCEDURE:

- Assign students readings, The Rocky Intertidal: Fact Sheet and/or Field Sampling Techniques: Fact Sheet for homework (or in-class) prior to the Prezi.
- Make copies of Rocky Intertidal ID Notes (1 per student) for use during the Prezi.
- Review the Prezi. This is a long and detailed presentation that may not be appropriate in its entirety for your students. Decide how much of the presentation you plan to give to your students. Skip sections as needed.
- Before you begin the presentation, hand out the Rocky Intertidal ID Notes to each student in your class. Students should complete this handout during the "Species Identification" portion of the presentation.
- Assign the Quiz Yourself handout for homework to reinforce learning.

EXTENSION ACTIVITIES:

- Conduct other activities in this unit.
- You may ask students to visit the LiMPETS website, http://limpets.org, to review the "Species Monitored" pages and conduct additional web research on rocky intertidal organisms.

ASSESSMENT: Ask students to complete the Student Reflection 'anticipation questions' on page 22.

Answer Key:

Quiz Yourself (pg 8): Inverts-turban snail, aggregating anemone, unidentified large anemone, purple sea urchin, limpet, chiton. Algae-scouring pad alge, tar spot algae, surfgrass, upright coralline algae.

LiMPETS Rocky Intertidal ID Notes

Name ______________________________

Instructions: Complete this handout during the LiMPETS introduction presentation.

Invertebrate	Identifying characteristics	Sketch or notes
1. Giant green anemone (Anthopleura xanthogrammica)	• Larger than 5 cm (2 in) in diameter, green. • No radiating lines on its ________ ________. • If closed: has a flared base and has texture of an avocado.	
2. Sunburst anemone (Anthopleura sola)	• Larger than 5 cm (2 in) in diameter, green. • Has __________ ________ on its oral disk. • If closed: the outside has big tubercules in rows and columns (texture of a pickle).	
3. Aggregating anemone (Anthopleura elegantissima)	• Smaller than 5 cm (2 inches) in diameter. • Can form dense aggregations. • Often covered in ______ and _______.	
4. Sea mussel (Mytilis californianus)	• Bivalve mollusks with ______ shells. • Shell blue and black in color. • Can form "beds."	
5. Chiton (Mopalia spp./Nuttalina californica/ Lepitochitona spp.)	• Oval in shape, with 8 overlapping ________. • Often well camouflaged with surroundings.	
6. Limpets (Lottia spp.)	• Snail-like mollusk with one shell. • Shell is ______________ or flat. • Shell is either smooth or ribbed (has ridges)	
7. Owl limpet (Lottia gigantea)	• Big limpet greater than 2.5 cm (1 in). • Shell is oval-shaped with an ________ apex. • Shell surface often rough with a darker rim.	
8. Whelk (Acanthinucella spp. & Nucella spp.)	• Shell is coiled or in a spiral; can be many different colors. • Both ends of shell are ___________.	
9. Turban Snails (Tegula spp.)	• Color deep purple, black, or brown with a copper-colored top. • Shell is smooth, with a __________-shaped top.	
10. Hermit Crab (Pagurus spp.)	• Crab that lives in the abandoned shells of snails.	
11. Common acorn barnacle (Balanus glandula/Chthamalus dalli/fissus)	• Can be as tiny as a sesame seed. • Shell white or brown-ish. • Often found in __________.	

12. Pink acorn barnacle (Tetraclita rubescens)	• Larger than common (greater than 2 cm in diameter). • Shell is ________ in color, appearing thatched. • Like pink volcanoes.	
13. Leaf barnacle (Pollicipes polymerus)	• Has a dark brown, fleshy stalk. • Top is covered with white ________. • Usually found in tight clusters mixed with mussels.	
14. Ochre sea star (Pisaster ochraceus)	• Can be orange, purple or brown in color. • Has white-tipped spines that resemble a ___________-shape in the center.	
15. Purple sea urchin (Strongylocentrotus purpuratus)	• Red to purple in color, juveniles are pale green. • Spherical body covered with _________.	
16. Honeycomb tube worm (Phragmatopoma californica)	• Worms that live in tubes of cemented _______ grains. • Tubes often found in large masses and looks like sand glued together.	

Algae	Identifying characteristics	Sketch or notes
1. Green pin-cushion alga (Cladophora columbina)	• Bright green and spongy. • Branched filaments that form densely matted tufts. • It resembles clumps of ___________.	
2. Sea lettuce (Ulva spp.)	• Bright green, oval-shaped blades. • Thin blades only _____ layers thick.	
3. Surfgrasses (Phyllospadix spp.)	• Leaves are narrow and long, bright green. • These are ___________, NOT algae.	
4. Flattened rockweeds (Fucus spp./Hesperophycus californicus)	• Olive green to tan in color. • Flattened body, WIDE blades with distinct midrib and _______________ branching.	
5. Slender rockweeds (Silvetia compressa/Pelvetiopsis limitata)	• Olive green to tan in color. • Becomes darker, shriveled when dried out. • Thin blades with NO midrib, and has _______________ branching.	
6. Stunted turkish towel (Mastocarpus papillatus/jardinii & Mazzaella affinis.)	• Small dark red to purplish-black blades that split near their ends (dichotomous divided blades). • Blades covered with little ___________ (reproductive structures called papillae).	
7. Iridescent algae (Mazzaella flaccida/splendens)	• Large, _________ blades that appears dark-purple, brown, green, sometime have a rainbow sheen. • Can have reproductive bumps on blades (seasonally). • Blades that stretch like __________ bands.	

8. Scouring pad alga (Endocladia muricata)	• Short, bushy clumps that are dark reddish-brown in color. • Branches covered with short ___________. • Feels rough and dry, not slimy or smooth.	
9. Encrusting coralline algae (many species)	• _________-colored crust on rock or shells. • Like someone spilled pink and/or white paint.	
10. Upright coralline algae (Bosiella, Corallina & Calliarthron spp.)	• White to dark ___________ in color. • Calcium carbonate in their cell walls make them stiff. • Many species are branched and have tiny jointed segments.	
11. Tar spot algae (Mastocarpus spp./Ralfsia spp. & others)	• Black crust on rock, looks like someone spilled black paint. • Feels like wet ____________. • Can grow in small or large patches.	

Notes:

Quiz Yourself

WHO AM I? INVERTEBRATES

1. I am a small, black snail about the width of your thumb. My shell is rounded at the top. I am a very common type of snail on the rocky shore.

2. I am a small, green anemone. I am closed up and look like a little blob. I am often found in large groups.

3. I am a closed, green anemone, larger than the size of your fist. I have the texture of an avocado. I am not found in groups or aggregations.

4. I have a round purple shell with long spines all over it. I live in the low intertidal zone.

5. You'd miss me if you weren't looking very closely. I am very small with one cone-shaped shell that is well camoflauged with the rocks.

6. Who am I?
   (Length=2cm)

WHO AM I: ALGAE

1. I am a short, bushy, dark-brown alga that often forms clumps on rocks or mussel beds. I feel rough, not slimy or smooth.

2. I do not look like algae at all – but like black oil (or tar) covering the rocks.

3. I am a flowering plant, not an alga. I have long, narrow, green leaves. I am sensitive to pollution.

4. I am pink, and some people mistake me for coral. I have calcium carbonate deposits in my cell walls, making the branches of my body relatively stiff, resistant to grazing and pollution.

The Rocky Intertidal: Fact Sheet

ALISON YOUNG

The rocky shores that lie at the edge of the ocean, between the high and low tides, are called the rocky intertidal. Rocky intertidal areas along the west coast of North America are some of the richest and most diverse places in the world. Over 1000 species of invertebrates and algae can be found in the rocky intertidal of central California, and this wide variety of life makes exploring the rocky shores fun and exciting. Does this diversity matter to the rocky intertidal? Many scientists agree that having diversity in a system may act like an insurance policy, providing a kind of buffer against storms, pollution, global warming and other environmental problems. Loss of diversity could therefore threaten rocky intertidal areas, making them more vulnerable to change.

Physical and Biotic Conditions

Changing tides, pounding waves, and competition for food and space are among many physical and biological factors that determine the nature of rocky intertidal communities. At the rocky intertidal, organisms live part of their days under water and part of their days exposed to the air. When the tide is in, wave action threatens to crush the animals and plants or tear them away from their homes. When the tide is out, organisms are more visible to predators, more susceptible to desiccation (drying out), and can be exposed to rainfall or direct sunlight. Sea stars, snails, seaweeds, and other intertidal life have adapted to these conditions in many ways and can thrive in these harsh and changing environments.

Tides are one major factor that determine the diversity of organisms living within the rocky intertidal. Tides can be defined as the regular rise and fall of water along the ocean's shores. Most places on earth expereince two high tides and two low tides each day. The rise and fall of the ocean is a result of the combined effects of the gravitational forces from the moon and the sun.

As the tide goes out, water loss becomes a problem for residents of the intertidal zone. Mobile animals prevent desiccation by hiding under wet algae and rocks or in crevices or tidepools. Less mobile organisms close up, like a mussel pulling together its valves or a limpet tightening down its shell onto the rock. Seaweed can lose up to 90% of its moisture and survive until the tide rises again.

As the tide rises, organisms must deal with the physical pounding of waves. Many rocky intertidal inhabitants anchor firmly and hold tight to the rocks. Limpets hold on with their muscular foot, mussels with their byssal threads, and seaweed with their holdfasts. Body design, such as being flexible or very flat and close to the rocks, can minimize the impact of waves. Behavior, such as hiding in cracks and under ledges, can also help animals survive and stay put.

Competition for food and space are other important features that structure communities. The rocky intertidal has a limited amount of surface area for algae and animals to live on. Organisms cope with limited space either by growing on each other, bulldozing others out of their territory, or growing quickly to out-compete their neighbors.

Zonation

Rocky shores are divided into a series of zones that are defined by the amount of time the rocks are exposed to air and water. Zones range from the splash zone, closest to the terrestrial environment, to the low zone, closest to the ocean.

SPLASH ZONE: As the name implies, this zone gets merely splashed by waves on most days, and organisms are rarely submerged. Few organisms can survive here. The major producers in the splash zone are the cyanobacteria that form the thin, black coating on many of the rocks. Tiny periwinkle snails feed on the cyanobacteria and prevent dessication by attaching tightly to rocks using their muscular foot, keeping moisture inside. Barnacles and a type of green algae, Ulva intestinalis, also live in the splash zone.

THE HIGH TIDE ZONE: Organisms that inhabit this zone are exposed to air more than 70 percent of the time and have unique adaptations to survive the long dry periods. Limpets, chitons, and black turban snails form a watertight seal on the rocks with their shell to protect themselves from drying out. The highly branched, bushy nature of scouring pad alga enables it to survive here, hanging onto water like a wet mop.

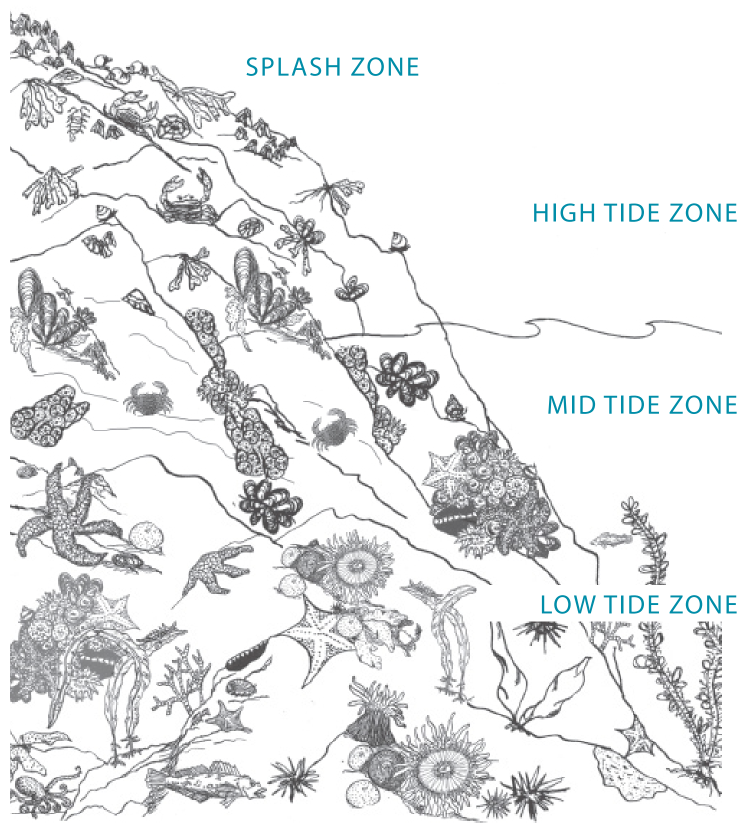
THE MID TIDE ZONE: This zone is densely populated. California mussels often form large beds that provide important refuge and habitat for a variety of other invertebrates and algae. When the tide ebbs, mussels tightly close their two shells to avoid drying out. They also form byssal threads that anchor themselves to other mussels and to the substrate, so they do not wash away with the crashing waves. Ochre sea stars live in the mid and low zone. They have tube feet that work like suction cups and are uniquely adapted to pull apart the shells of their prey.

THE LOW TIDE ZONE: In this zone, organisms may only be exposed to air during extreme low tides, or spring tides, which occur approximately twice per month. They are therefore well adapted to withstand the forces of waves and less resilient to air exposure. It is in this zone that most life exists within the rocky intertidal. The giant green anemone and the purple sea urchin are two types of larger invertebrates that frequent the lower zone. Anemones firmly attach themselves to the substrate with a pedal disk and have stinging tentacles that catch and paralyze prey that drift by in the water. Sea urchins rely on their tube feet to survive in the low zone. Similar to sea stars, urchins use tube feet for movement and attachment.

Human Impact

The rocky intertidal is vulnerable to many types of human activities. As coastal populations continue to grow, more people visit, use and exploit our rocky shores. As a result, threats to California's rocky shores are increasing. The following briefly describes some of the major threats to California's rocky intertidal.

- Harvesting: Sea urchins, mussels, abalone and algae are all exploited by humans for food. On rocky shores throughout California, overharvesting has severely depleted stocks of some species (e.g. abalone) and has compromised biodiversity in these areas. As a



Intertidal life and zones.

result, overharvested areas have become extremely vulnerable. California has recently established a system of Marine Protected Areas (MPAs) where, in some cases, no collecting is permitted.

- Oil spills: Oil spills pose a significant threat to the health and balance of life on rocky shores. Past spills, such as the 2007 Cosco Busan oil spill in San Francisco Bay, have deposited oil on coastal rocky shores, including Duxbury Reef. Oil can smother mussel beds and kill acorn barnacles, limpets and other species.
- Invasive species: Non-native species have made their way to California's rocky shores and can be especially prevalent near areas with high volumes of shipping traffic, like the San Francisco Bay. One recent invasion, the algae Sargassum horneri, native to Asia, was first discovered in the intertidal zone in 2009 and is thought to be rapidly increasing off Orange County, California. Invasive species threaten the abundance and/or diversity of native species, disrupt ecosystem balance and threaten local marine-based economies.
- Pollution: Water from streams and culverts that drains onto rocky shores often bring contaminants that can have a variety of biological effects.
- Climate change: Because rocky intertidal environments lie at the land and sea interface, they are expected to be strongly influenced by climate change. In response to rising air and sea temperatures, we may expect the distribution of species along our coast to change. Indeed, that was what was seen when species abundance was compared between the early 1930s and the mid 1990s at one site in Monterey Bay: several common southern California species that were rare or absent in the 1930s are now abundant in the Monterey Bay area. Moreover, climate change will likely cause a rise in sea level. As sea levels rise along the rocky intertidal, the different zones may begin to shift higher onto the shore.
- Human activites such as burning fossil fuels and deforestation, have lead to a rapid increase in atmospheric carbon dioxide levels. The ocean absorbs approximately 1/3 of the atmospheric carbon dioxide from human activities, or anthropogenic carbon dioxide. Carbon dioxide acts as a weak acid when it dissolves in seawater. The dissolution of anthropogenic carbon dioxide into the ocean is changing ocean chemistry and making it difficult for some calcifying organisms to live. The intertidal in California is particluary vulnerable to changes in ocean chemsitry because of upwelling, cold, nutrient rich water from the deep ocean that comes to the surface along the coast.

Monitoring programs like LiMPETS are important because they can identify changes over the short term, like discovering the spread of an invasive species. But even more valuable is the ability for long-term data to help reveal the natural variability, or the ups and downs, in a system. If we understand what is 'normal' in a system, we can then begin to identify trends that could be a result of destructive human activities. Long-term data therefore lead to better conservation and protection of our oceans. The data help us understand what species need protection (like abalone) and what places are most vulnerable to human activities.

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Field Sampling Techniques: Fact Sheet


AMY DEAN

What do field scientists do — and why do they do it? Scientists have specialized methods or techniques that they use to gather data in the field about individuals, populations or communities. Good scientific technique is essential and must produce results that are both unbiased and representive of what is happening in the entire study area. This fact sheet serves as an overview of some of the common sampling techniques used by scientists to monitor rocky shores.

1. SUBSAMPLING: Is it possible to determine abundance of mussels, snails or limpets by counting all of the individuals on an entire rocky reef? In almost all cases, the answer is no. So subsampling (taking smaller samples as a subset of a larger potential sampling area) is performed to provide an estimate of abundance.

a) Tools Used: Scientists use different tools such as transects and quadrats to subsample an area.

b) Purpose of Tools: Different tools all serve a slightly different purpose with the common goal of providing a standardized way to conduct field sampling. Transects are simply lines of a known length (e.g. a measuring tape) laid out across the sampling area. Transects serve as a baseline for placement of other types of sampling tools such as quadrats. Each of these tools is of a known size so that scientists can determine how much of an area was sampled.

c) Application for LiMPETS Rocky Intertidal Monitoring: Think of how challenging it would be to identify and count all of the different species at the rocky shore! To avoid this time consuming (and nearly impossible) task, you will subsample a smaller part of the rocky intertidal using transects, quadrats, and permanent plots.

2. REPLICATION: taking more than one sample in a given sampling area. Scientists take more than one subsample in a given location in order to make sure that their samples represent the actual number of organisms in a given area and that the number they got didn't happen just by chance.

a) Representative Sample: By using the tools and techniques described above, scientists collect data from multiple samples in one location. Together these samples constitute a representative sample, in that it accurately represents what is happening in a given area. When a representative sample is obtained, this information can then be applied to the rest of the sampling area.

b) Application for LiMPETS Rocky Intertidal Monitoring: Let's say that your class is sampling at the rocky intertidal. You want to know how many purple sea urchins are in the area. You count urchins within one quadrat, randomly placed in a permanent area, and find 15 urchins total. You count urchins in 4 more quadrats, and this is what you find: Quadrat 2 = 0 urchins, Quadrat 3 = 1 urchin, Quadrat 4 = 0 urchins, Quadrat 5 = 2 urchins. You can now determine that Quadrat 1 with 15 urchins is not consistent with what you found in other quadrats. This doesn't mean that you shouldn't use this sample, by all means it should be included; however, in order to get a representative sample, you need to sample enough times in one location to address the variability that is characteristic of most rocky intertidal communities.

3. STANDARDIZING DATA: a calculation made with data that takes into account the size of the area where the samples were collected and provides a way for scientists to compare samples across locations and research projects. For example, if you counted 20 ochre sea stars in a given

area, it is important to note the size of the area you sampled. Did you find 20 sea stars in an area 10m^2, 50m^2, 100m^2? The size of your study area can make a big difference when trying to determine the population sizes of a particular organism.

a) Calculating Abundance: In order to be able to compare samples of the same type of organism from research projects conducted by different groups of scientists, there needs to be a common way to standardize data — or calculate how many organisms there are in a particular location. We call this calculating abundance. Abundance can be calculated in many ways. A common abundance calculation (e.g. for sea stars) = # of stars/area sampled.

b Application for LiMPETS Rocky Intertial Monitoring: In the case of sea stars and other relatively large invertebrates at the rocky shore, scientists often report findings:

Abundance = # of stars / square meter (m^2)

4. DATA ANALYSIS: The goal of data analysis is to organize your data into tables and graphs and look for patterns. Your analysis revolves around the questions you are asking and the independent and dependent variables you are testing. By analyzing your data, you are looking for ways that independent variables (e.g. water temperature) affect the dependent variables (e.g. mussel abundance) that you are interested in researching.

a) Baseline Data: Analyzing data and looking for patterns allow scientists to find evidence to support or refute their hypotheses. This evidence is not conclusive (in other words, it's not the final answer) but adds to the knowledge base that scientists have about a particular organism. An accumulation of evidence and information about an organism (e.g. life history patterns, population dynamics) allows scientists to establish baseline data about a population of organisms.

b) Application for LiMPETS Rocky Intertidal Monitoring: Baseline data concerning the abundance and zonation of algae, sea stars, mussels and other organisms allow scientists to know what is normal for the organism under natural conditions. If scientists understand the natural ups and downs (the variability) in a system, they can then determine if something about the organism has changed over time. Gathering baseline data requires repeated samples in a variety of locations where the organism lives over the course of many years. The data you collected as a class contribute to what we know about the 'the baseline' for many organisms living along rocky shores throughout California.

5. POPULATION SAMPLING TECHNIQUES: There are many ways that scientists can estimate the abundance of organisms. In our case, transect lines, quadrats and permanent areas are used to estimate abundance in standardized ways. For large invertebrates that can be easily counted, abundance is calculated as the # of individuals/m^2. These data can then be used to estimate abundance at a particular location and compared over time at the same location and between different locations.

Scientists use different methods to estimate abundance for organisms living in different environments, like the open ocean. Think about scientists trying to estimate the abundance of tuna in the Pacific Ocean. Using quadrats would obviously not work very well. Different types of environments present unique challenges for estimating populations sizes. How might you sample organisms that live in a marsh, deep in the mud, or in dark caves? Additionally different types of organisms present challenges based on their lifestyle characteristics. For example, think about the different methods required to research the population sizes of particular species of birds, fish, insects, and mammals with large ranges (e.g. wolves). Both different environments and different lifestyle characteristics of organisms create the need for various sampling methods. These challenges allow scientists to be innovative and creative in their work as they design new ways to estimate population sizes or modify existing methods that will work in their particular sampling environment.

Monitoring With Life-Sized Photo Quadrats

OBJECTIVE: Students will learn rocky intertidal monitoring techniques used in LiMPETS by practicing with life-sized photos. Students learn to identify intertidal algae and invertebrates and will determine vertical zonation of select species using data generated by the class.

ACTIVITY TIME: 20–40 minutes

GRADE LEVEL: 9–college (may be adapted for middle school)

LIMPETS WEB RESOURCES:

- Rocky Intertidal Methods, http://limpets.org/ri_methods.php
- Species Monitored pages, http://limpets.org/ri_species.php

MATERIALS: The following materials are available for loan within a 50-mile radius of a California national marine sanctuary office. Offices are located in San Francisco, Santa Cruz, Monterey, and Santa Barbara. Contact your local LiMPETS coordinator for more information. Unable to borrow materials? An alternate activity that does not require quadrats or life-sized photos can by found on the Teacher Resources pages of the LiMPETS website.

- One set of photo quadrats (laminated life-sized photos of the intertidal). Photos are taken at regular intervals from high to low intertidal.
- Quadrats (0.5m x 0.5m)
- Vertical transect data sheets from your monitoring site, http://limpets.org/ri_data.php.
- Invertebrate and Algae Photo ID Guide, http://limpets.org/ri_data.php.

BACKGROUND: Scientific method taught in the classroom takes on new meaning when students see (and experience) “real science.” Monitoring the environment means taking repeated samples in the same way at the same locations over time. At the rocky intertidal, long-term monitoring takes the pulse of the system and helps to determine what actions need to be taken to protect these special places.

One common monitoring unit that is used in rocky intertidal ecosystem studies is the quadrat. Quadrats are square or rectangular frames within which algae or animals are counted. Scientists can place quadrats at intervals along a transect line. Quadrats are used because it is impossible to count every living and non-living thing in an ecosystem.

In this activity, students use quadrats to monitor the distribution of key organisms along an imaginary transect line that streches from the high intertidal to low intertidal zone. Collecting data along a vertical transect can demonstrate classic zonation patterns and is an instructive, hands-on lesson in intertidal ecology. This is good practice for students who plan to participate in LiMPETS or other monitoring studies at the rocky intertidal. By repeartedly collecting data along a transect line that reaches from the high to the low intertidal zone, scientists can detect changes in the ecosystem over time. A major concern over the next several decades will be the effects of rising sea levels, as a consequence of climate change, on the biota of the rocky intertidal. A rise in sea level could shift the different zones higher on the shore. Will this really happen? Monitoring can help provide the answer.

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PROCEDURE:

- Present the LiMPETS Introductory Prezi prior to conducting this activity.
- Before you begin: Download and print the data sheets and Photo ID Guide from the LiMPETS website.
- Review how species are monitored using transects and quadrats. Review elements of intertidal ecology and zonation, if desired.
- Divide class into groups of 2–4 students each.
- Give each group one set of the materials: photo, quadrat, data sheet and Photo ID Guide. Students can work at their desks or you may wish to set up a mock transect by stretching a meter tape along the floor and placing photos over the transect location (in meters, written on the upper corner of the photos).
- Review the two ways to conduct counts. The algae and invertebrates listed in the first box on the data sheet are discrete and easy to count; students should therefore count the total number of individuals that they can find within the quadrat. The organisms listed in the lower box on the data sheet are more difficult to count. They may grow in continuous sheets or may be clumped closely together (e.g. most algae, aggregating anemones, etc.). Students will count the number of small squares within the large quadrat that contain any ATTACHED portion of the alga or animal (total # possible = 25).
- Each group should choose one person to record the data on the data sheet. The other students in the group will be counting organisms within the quadrat.
- Students should place the quadrat directly over the photo. The center of the quadrat should be directly over the red dot on the photo. Once in place, the quadrat should not be moved.
- The student recording the data should fill out the top of the data sheet. This student also directs the others in the group by telling them what to count.
- You may wish to have students skip over 'hermit crabs' and 'loose sand' since these are difficult to count in photos.
- Bare rock is the last item on the data sheet. Students should count squares that have any visible amount of bare rock.
- When students have completed their data sheets, they can use the data from the entire class to make conclusions about the vertical zonation of species. Which algae and invertebrates appear to show no zonation pattern? Which appear in primarily the high, mid or low intertidal? Does their data support the classic zonation patterns described in The Rocky Intertidal: Fact Sheet, page 9?

EXTENSION ACTIVITIES:

- Ask students to visit the LiMPETS website, http://limpetsmonitoring.org, to review the "Species Monitored" pages and conduct additional web research on some species of interest.
- If you are interested in conducting a more thorough analysis of the data collected in this activity, you may use part of an activity in Unit 4 – Using Vertical Transect Data to Visualize Zonation at the Rocky Intertidal.
- If you plan to have your students complete a scientific paper, poster or oral presentation, you may decide to give students a 'question' or a choice of 'questions' to focus on that you have pre-determined. Sample questions are listed in Unit 5 – Communicating Science Through Posters and Oral Presentations.

ASSESSMENT:

- Ask students to determine the accuracy of their counts by comparing their data to the answer key. Evaluate sources of error using photos and potential sources of error in the field.
- Ask students to complete the Student Reflection 'anticipation questions' on page 21.
- If students will be required to write up a lab report for their LiMPETS investigations at the rocky shore, ask students to write a draft of their "Methods" section prior to monitoring.

Monitoring Sea Stars Using the 'Total Count' Method

OBJECTIVE: To engage students in an activity that will introduce them to one of the rocky intertidal monitoring techniques used in LiMPETS. Students will understand the role that "keystone species" play in an ecological community and will learn how and why ochre sea stars are monitored.

ACTIVITY TIME: 10–20 minutes

GRADE LEVEL: 6–8

LIMPETS WEB RESOURCES:

- Species Monitored Pages, http://limpets.org/ri_species.php
- Rocky Intertidal Methods Pages, http://limpets.org/ri_methods.php

MATERIALS:

- Student handout: Monitoring ochre sea stars
- Data sheets from LiMPETS website titled, "Total organism count - sea stars." Go to http://limpets.org/ri_data.php.

BACKGROUND: Some large invertebrates, such as sea stars, can have a major impact on community organization of the rocky intertidal. The ochre sea star is the "keystone" species influencing biological diversity in the entire area.

Ochre sea stars are colorful, conspicuous members of the rocky intertidal showing color variation ranging from yellowish orange to brownish purple. Though causes of this polymorphism remain a mystery, we know that approximately 20% of stars in a population are orange. Ochre sea stars are predators, typically preferring to eat mussels, Mytilus californianus. Human activities like collecting can decrease the abundance of stars which in turn can result in an increase in the abundance and distribution of mussels. When mussel beds grow and expand, other intertidal species such as aggregating anemones get crowded out. Predation by the sea star can determine how many species may thrive in a rocky intertidal area. By counting ochre sea stars in a large, permanent area, we can detect long-term changes their abundance that may result in changes throughout the entire rocky intertidal community.

PROCEDURE:

- In preparation for the activity, make color copies of the student handouts and the corresponding data sheets. Alternatively, you can project the handout and data sheet onto a screen in the classroom and conduct this activity as a group.
- Present the LiMPETS Introductory PowerPoint before completing this activity.
- Introduce the term "keystone species" and "polymorphism."
- Review methods for conducting total counts of sea stars. Students should know that they will systematically search for ochre sea stars (both purple/brown and orange color morphs) in a defined area, moving back and forth in successive swaths about the width of their outstretched arms. One student is responsible for completing the data sheet while the others search—and should tell the recorder what they see as they see it. If any portion of the animal is inside the permanent area, it should be counted.
- Students complete the handout and data sheet.

ASSESSMENT:

- Compare student results.
- Discuss: Challenges to finding Ochre stars in the field (i.e. small, partially hidden, camoflouged, etc.)
- Discuss: Ensuring accuracy of counts in the field (i.e. how to avoid double counting, where to look, etc.)

EXTENSION ACTIVITIES:

- After monitoring sea stars in the field and entering data online, complete the data analysis activity in Unit 4, Tracking a Keystone Species Over Time.

Answer Key: purple/brown ochre stars-6; orange ochre stars-2

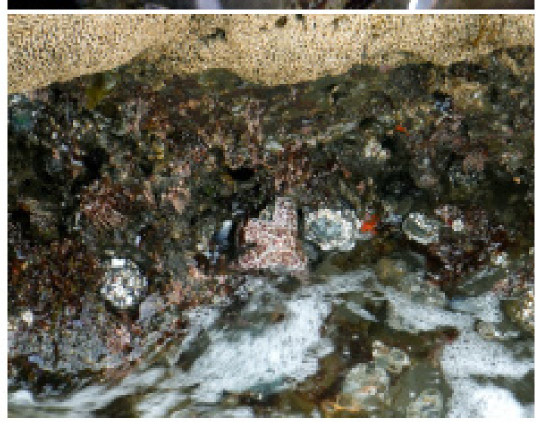
Monitoring Ochre Sea Stars

Name_________________

Directions: Find the Ochre Sea Stars in the pictures. Fill out the Total Organism Count datasheet

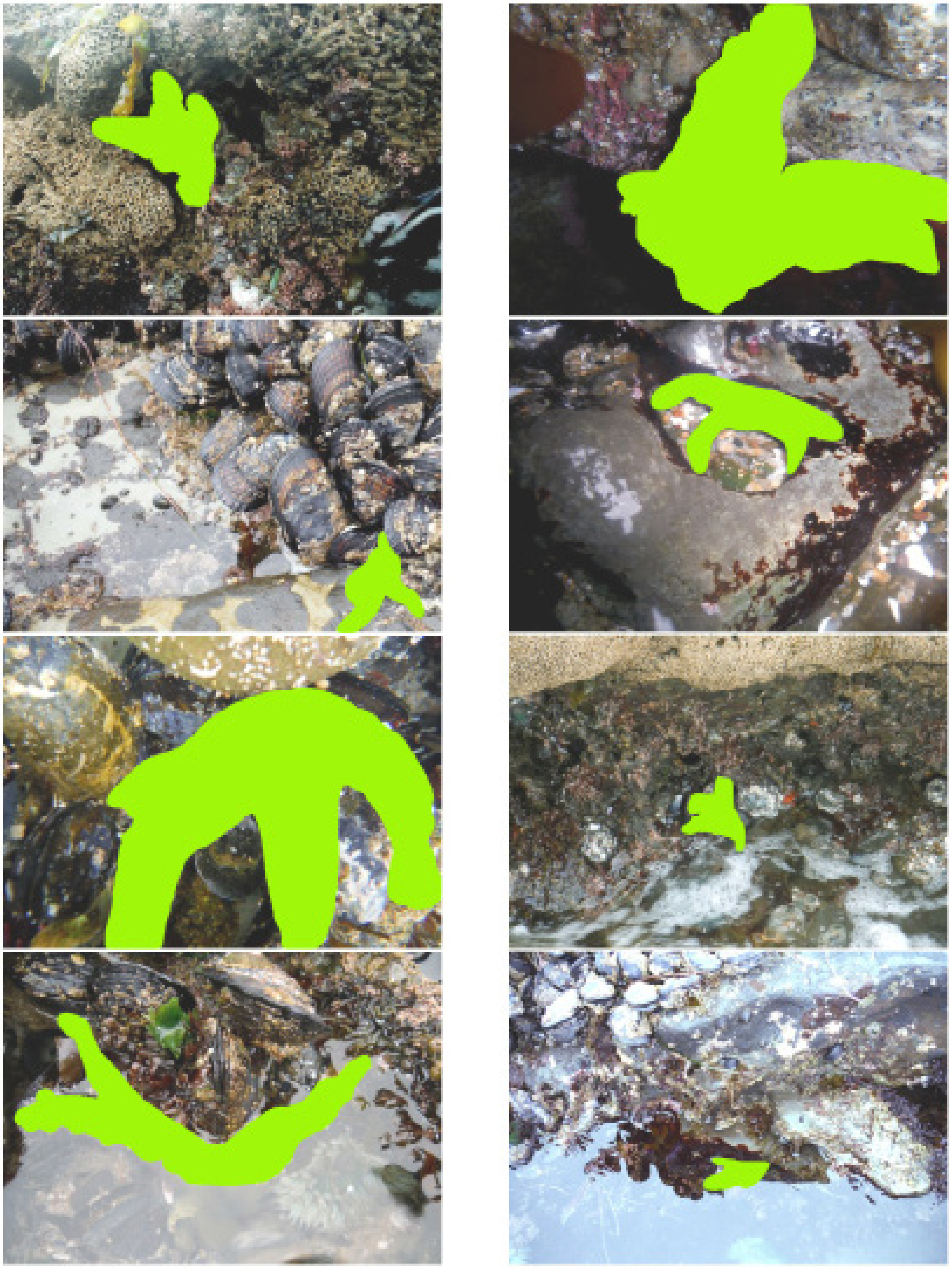




Monitoring Ochre Sea Stars

Answer Key



LiMPETS Claymation Identification Game

Author: Gillian Ashenfelter

OBJECTIVE: Students will reinforce knowledge of the characteristics used to identify rocky intertidal algae and invertebrates in the field. Students will understand how body shape complements function and survival in this unque environment.

ACTIVITY LENGTH: 20 minutes

GRADE LEVEL: 7–12

LIMPETS WEB RESOURCES:

- LiMPETS Species Monitored Pages, http://limpets.org/ri_species.php

BACKGROUND: Learning to correctly identify over 29 taxa+ of invertebrates and algae can be challenging. This activity prepares students for a successful monitoring experience by enabling them to hone their identification skills through fun, hands-on play. This is a good activity for all learners, and especially can help ELL students become familiar with the study organisms.

MATERIALS:

- Invertebrate and Algae Photo ID Guide, http://limpets.org/ri_data.php.
- Organism Name Card Page
- Cup or opaque container
- Modeling clay (several different colors)
- Plates or shallow dishes to hold clay
- Scissors (optional)

PROCEDURE:

- Complete the LiMPETS Introductory Prezi prior to conducting this activity.
- Before you begin: Download and print the Invertebrate and Algae Photo ID Guide. Print copies of Organism Name Card Page. Cut apart columns.
- Divide class into groups of 3–5 students each.
- Give each group one set of the materials: Photo ID Guide, one column from Organism Name Page, one cup, modeling clay (various colors) on a plate, scissors (optional).
- Each group should cut apart the Organism Name Page, fold up each slip of paper, and place in their cup.
- One student in each group will remove a piece of paper from the cup, read it silently without showing it to the other students, and place the paper face down next to them so that it cannot be read by other students.
- That student will then begin to make a model of the organism using the clay and will continue without speaking until the other students guess what is being represented by the clay.
- When the students figure out the organism, the cup gets passed to the next student who will pull out a slip of paper and begin modeling their organism.
- This continues until the group has gone through all of the slips of paper and each student has modeled various organisms.
- If you want to create a competition and add a bit of fun, the groups can compete with one another to see who can model and guess all of the organisms correctly first.

ASSESSMENT:

- Play as a post trip activity. Have students compete in groups without the aid of a Photo ID Guide.
- At the end of the game, ask each student (or group) to create a detailed clay model of the orgamism of their choice and describe how body shape complements function and survival in the rocky intertidal.

Aggregating anemone	Aggregating anemone	Aggregating anemone
Giant Green Anemone	Giant Green Anemone	Giant Green Anemone
Sunburst Anemone	Sunburst Anemone	Sunburst Anemone
Chiton	Chiton	Chiton
Limpet	Limpet	Limpet
Turban snail	Turban snail	Turban snail
Whelk	Whelk	Whelk
Sea mussel	Sea mussel	Sea mussel
Ochre sea star	Ochre sea star	Ochre sea star
Purple sea urchin	Purple sea urchin	Purple sea urchin
Hermit crab	Hermit crab	Hermit crab
Pink acorn barnacle	Pink acorn barnacle	Pink acorn barnacle
Stunted turkish towel	Stunted turkish towel	Stunted turkish towel
Tar spot algae	Tar spot algae	Tar spot algae
Encrusting coralline algae	Encrusting coralline algae	Encrusting coralline algae
Flattened rockweed	Flattened rockweed	Flattened rockweed
Green pin cushion algae	Green pin cushion algae	Green pin cushion algae

LiMPETS Rocky Intertidal Monitoring Student Pre- and Post-Activity Reflection

Author: Gillian Ashenfelter

OBJECTIVE: Students will take time to reflect about the value of collecting baseline data through a monitoring program such as LiMPETS. Students will understand that they are learning and providing a service.

ACTIVITY TIME: 15–20 minutes

GRADE LEVEL: 8–12

BACKGROUND:

The values of reflecting on service learning experiences are widely recognized, and literature abounds on the benefits to student learning (Learn and Serve Clearinghouse).

> "Reflection in service-learning provides students and teachers with a way to look back at their experiences, evaluate them, and apply what is learned to future experiences.
>
> Reflection is an important means by which students integrate prior knowledge and experiences with new experiences to develop critical thinking and problem solving skills."

If you have an interest in learning more about the value of reflection in service learning, the organization referenced in this activity has a large number of studies revealing the gains achieved through reflection.

PROCEDURE:

- After introducing students to the LiMPETS program and protocols, give them independent time to work on the pre-trip anticipation questions. This can be a homework assignment. Give students an opportunity to share their thoughts in class with other students if time allows.

KAREN PROEHL

- After the trip, assign students the post-trip reflection questions to be done independently. Again, this can be a homework assignment. Give students an opportunity to discuss their thoughts with other students and facilitate a class discussion. In your discussion, be sure to point out the messy nature of field work and the importance of following protocols to the best of your ability in order to get reliable data.

REFERENCES:

- Learn and Serve America's National Service Learning Clearinghouse. Web. 27 July 2011. http://servicelearning.org.

Reflections on Rocky Intertidal Monitoring

ANTICIPATION QUESTIONS:

1. What are you expecting this experience to be like? Do you think you will enjoy it?

2. What is the value of monitoring algae and invertebrates in the rocky intertidal?

3. Why are California's national marine sanctuaries asking students to help gather data?

4. What value will these data have for future scientists?

5. Why is it going to be important for us to follow the procedures carefully when we go monitoring?

6. Do you think you might be interested in a career in the sciences or the environment? Why or why not?

POST-TRIP REFLECTION QUESTIONS:

1. How did this experience compare to your expectations?

2. How is gathering reliable and accurate data in the field (at the rocky shore in this case) different from gathering reliable and accurate data in a classroom?

3. Student monitoring programs like LiMPETS can be called 'service learning.' What do you think that means? Can you explain how monitoring organisms at the rocky shore is a service learning experience?

4. If you were a teacher, would you take your students rocky intertidal monitoring? Explain.

5. After participating in 'real field research' through the LiMPETS program, are you more or less interested in science as a career? Why?