MARINE SCIENCE INSTITUTE
OCEAN LAB PROGRAM EDUCATORS' GUIDE

Revised Summer 2012

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INTRODUCTION

THE MARINE SCIENCE INSTITUTE

Founded in 1970, Marine Science Institute is a private, non-profit organization dedicated to providing interdisciplinary science education programs that cultivate a responsibility for the natural environment. Over the years, MSI has developed a variety of different programs for students and adults of all ages, which take place at the Institute, onboard our research vessel, at local schools, at the tide pools and at the beach. We are continuing to grow and develop by striving to make each program a science learning experience that will be enjoyed and remembered for many years.

Our goal is to actively involve students through problem-solving field analysis, role-playing, debates, and games. Through these activities, students develop a deeper understanding and appreciation of our marine environment, simultaneously defining their own role within it. The California State Science Framework themes of energy, stability, evolution, patterns of change, scale and structure, and systems and interactions can be readily presented through this program. Given the flexibility of our programs, instructors can vary particular themes and apply them to different grade levels, thereby supporting this new approach to science education.

MARINE SCIENCE INSTITUTE'S MISSION

The Institute's mission is to cultivate a responsibility for the natural environment and our human communities through **interdisciplinary science education**. We achieve this goal through innovative marine science education programs that:

- Place students of all ages in direct contact with the natural environment;
- Emphasize the interdependence of all living things, their connection to the physical environment, and the special responsibilities of humans to the environment;
- Facilitate active learning through the use of observation, critical thinking, and problem solving skills in a cooperative setting, and
- Instill confidence, encourage involvement, and inspire accomplishment by providing positive role models.

EDUCATORS' GUIDE to the OCEAN LAB PROGRAM

This guide is meant to further understanding of the Marine Science Institute's Ocean Lab program curricula and program logistics. Through the use of this guide, teachers will know what to expect from our program and will gain a better understanding of rocky shore ecology and organisms.

PROGRAM DESCRIPTION

The Marine Science Institute's Discovery Classroom and Lab offers students a chance to experience real marine science, using live animals, habitat exhibits, microscopes, identification keys and demonstrations. The students work through a series of exercises with the help of marine science instructors, and your chaperones.

Our self-guided exercise sheets are designed to encourage the students to rely on their own observation for discovering the answers. They will explore the characteristics of mollusks, arthropods, cnidarians and echinoderms and use an identification key. They will also be introduced to intertidal ecology and explore the interdependence of the animals and their environment.

PROGRAM OBJECTIVES

1) To provide an exciting educational experience that shows students what marine biologists do on a daily basis.

2) To compare and contrast the characteristics of marine invertebrates within four major invertebrate phyla: Cnidaria, Mollusca, Arthropoda and Echinodermata.

3) To relate physical and behavioral adaptations of marine invertebrates to their environment.

4) To identify the ecological zones found along the Pacific Coast, and list the organisms typical to each.

5) To gain an understanding, appreciation, and respect for marine invertebrates and the marine environment.

PROGRAM LOGISTICS

PROGRAM LENGTH, GROUP SIZE, AND GRADE

The program allows one class of up to 60 students to participate at a time and lasts two and a half hours in total length. The students should be in 4th grade and higher.

Please use the following chart to find information pertaining to your class size.

# OF GROUPS	CLASS SIZE	PROGRAM LENGTH	SIZE OF SMALL GROUPS
3	Up to 30 students	2.5 hours	3 groups of up to 10 students
4	31-45 students	2.5 hours	4 groups of 10-12 students
5	46-60 students	2.5 hours	5 groups of 10-12 students

ROLE OF ASSISTING ADULTS
In order to keep program costs at a minimum, we require the participation of at least one adult per instructor group. Each group of students will be working with one instructor and the available adult. After an introduction, the group will break into small study groups, and rotate through several learning stations. The assisting adults will each be placed with a group and will help the students to focus as they work through the self-guided exercise sheet. Assisting adults will also help with overall group organization.

CLOTHING AND GEAR
Students will be working as scientists "in the field." **Please have students wear clothing that they do not mind getting a little wet.** Although we do have some indoor space, some of our activities must take place outdoors. **Please make sure students dress appropriately for the weather. They will need warm clothes if it is a cold day and a rain jacket if it is raining.** Hats and sunscreen are also recommended for most of the year!

PRE/POST-VISIT ACTIVITIES
Our program is a guided exploration of marine science and environmental awareness; it is an excellent way to kick off or conclude a marine science unit, but can also stand alone. In all cases, our programs, and each student's educational experience, will be greatly enhanced by the use of our suggested pre- and post-visit activities. For this reason, we encourage you to read through the activities at the end of this guide, and choose those which you feel are appropriate for your students.

PROGRAM FORMAT & STATION DESCRIPTION

The lab program is set up in 5 stations. The students move through the stations as a team of up to 13 students. Each group will have about 20 minutes at a station before moving on to the next. Lab sheets will be provided to direct the student, and the instructors and chaperones will be there to provide guidance. The emphasis will be on observation. Your students will be encouraged to touch some of the animals as part of their observations.

Introduction: Once the class is settled in the Marine Science Center, the instructors will introduce the format and explain how to correctly and gently handle the animals. Topics including, tidal zonation, animal adaptations and scientific

classification will introduced and the class will be divided into 3-5 learning teams. Within each team, lab sheets will be distributed.

Learning stations: Each learning team will rotate through 5 hands-on stations. At each station students will explore one phylum and lead in a series of questions, experiments and animal identification exercises.

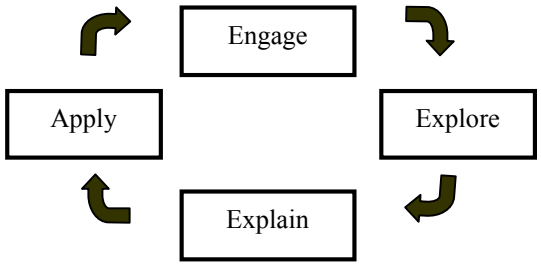
Closing: A demonstration of predator-prey response can used to wrap up the lab and explore some of the ways that sedentary animals can escape a very large and voracious predator. Or, we will review the zones and relate this ecosystem to one the students are familiar with in their own community. The students will apply what they have experienced at the stations.

STUDENT ASSESSMENT & LEARNING CYCLE

For 30 years, MSI has tailored science activities to meet the needs of teachers' curriculum. Students and teachers present themselves to our programs with a wide range of interdisciplinary science understandings and skills. Our marine science educators are specially trained to teach all ages with interesting and innovative methods that encourage interaction and problem solving. We encourage you to tailor your program by telling us about a particular theme that your class has been studying. Please fill out the "Shoreside Student Assessment" you received to let us know.

MSI has also recently modified our working educational philosophy to respond to this broad range and to help teachers and students get the most from our programs. What you do before, during, and after the day of the program will determine to a very large extent how strong a partner MSI will be in helping you meet your learning objectives. As you plan a visit to MSI, please consider how this opportunity fits within your overall instructional objective. What learning outcomes do you desire from this experience? How well is the class positioned to move your desired outcomes toward a reality? Please use the following description of the learning cycle to assess your students.

The Learning Cycle Model



Engage – Students are just beginning to generate interest in marine science.
"The MSI program will be the hook from which I launch my unit and introduce my class to the excitement of marine science. I'm willing to come into this trip a bit

cold…my main objective is to generate curiosity and get the students raising questions."

Explore – Students are ready to actively experience, form predictions, and make observations.
"My students are already hooked on marine science. I'm bringing them to the MSI program with basic understandings and tools… They know a bit about the Bay and are ready to actively explore it. My objectives are for my students to make observations and to collect and record data. I'd like to see them make informed predictions and to begin framing their own critical questions."

Explain – Students have been developing understanding for some time, and are now ready to speak the language of marine science.
"By the time we participate in our MSI program my students will have conducted serious investigations of topics related to the San Francisco Bay. My objective is to see them using the language of marine science… I'd like them to begin exploring important concepts and to comprehend and analyze other explanations."

Apply – Students have a mature understanding of marine science, perhaps including aspects that are far afield from the San Francisco Bay area, and now are ready to relate that knowledge to their own backyard.
"My group has a good handle on the major learning objectives I have set for marine science. MSI's program is going to provide new scenarios for them to consider and address. My objective is to see my students using and applying their new knowledge in a different context."

BACKGROUND INFORMATION

BASIC ECOLOGICAL CONCEPTS

Ecology is the study of the relationships between organisms and their environments. An ecologist asks questions like: Where does this organism live and what characteristics make it particularly suited for that location? How does this organism get its food? What other organisms eat it? By asking questions such as these some basic principles have emerged. Understanding the following basic ecological concepts help us appreciate the complexity of life residing in and around the Bay.

Everything is related to everything else

Perhaps the easiest place to see interdependence in the environment is to look at food. All food on this planet is essentially made by plants through the process of *photosynthesis*. *Herbivores* are animals, which depend directly on plants for food. *Carnivores* eat herbivores. Take away all of the plants and there would be no animals. Can a plant, then, exist independently of all other organisms? No. Although it doesn't eat, a plant needs *nutrients* and is dependent on *decomposers* (bacteria and fungi) to break down dead organisms, thereby releasing these nutrients for use by the living plant.

Everything depends on something else

All organisms are also dependent on factors in the physical environment. They must have a source of water. Animals must have oxygen to breathe. Plants must have sunlight to perform photosynthesis. You can probably think of many more examples of how organisms are dependent on their environments.

Everything must go somewhere

No object ever disappears completely from the face of the earth. It may be broken down into atoms and be used to build something else, but those atoms are still there. In this way, nature deals with waste by recycling. Any plant or animal that does not become food for some animal becomes food for decomposers, which free the nutrients to be used again. Anything that cannot be decomposed must remain in the environment as it is. What are some examples of this kind of waste? The next time you throw something away, you might remember that there really is no "away" to throw it to.

Earth's resources are limited

How often do you run out of time to do what you want or need to do? Everyone knows that each day only has so much time in it, and that we have to be careful how we use it if we are going to accomplish everything we need to. The earth's available resources are like time in that we have to be careful how we use them, or they might run out. There is only so much gold, so much petroleum, so much fresh water, so much food, and so much space. All organisms are limited by the availability of resources, but humans have a special opportunity and a special responsibility. Although plants cannot make a decision to conserve clean water, humans can. To do this intelligently we must find out how much of each resource is available and then we must budget our use. We must also think about recycling. The earth can recycle

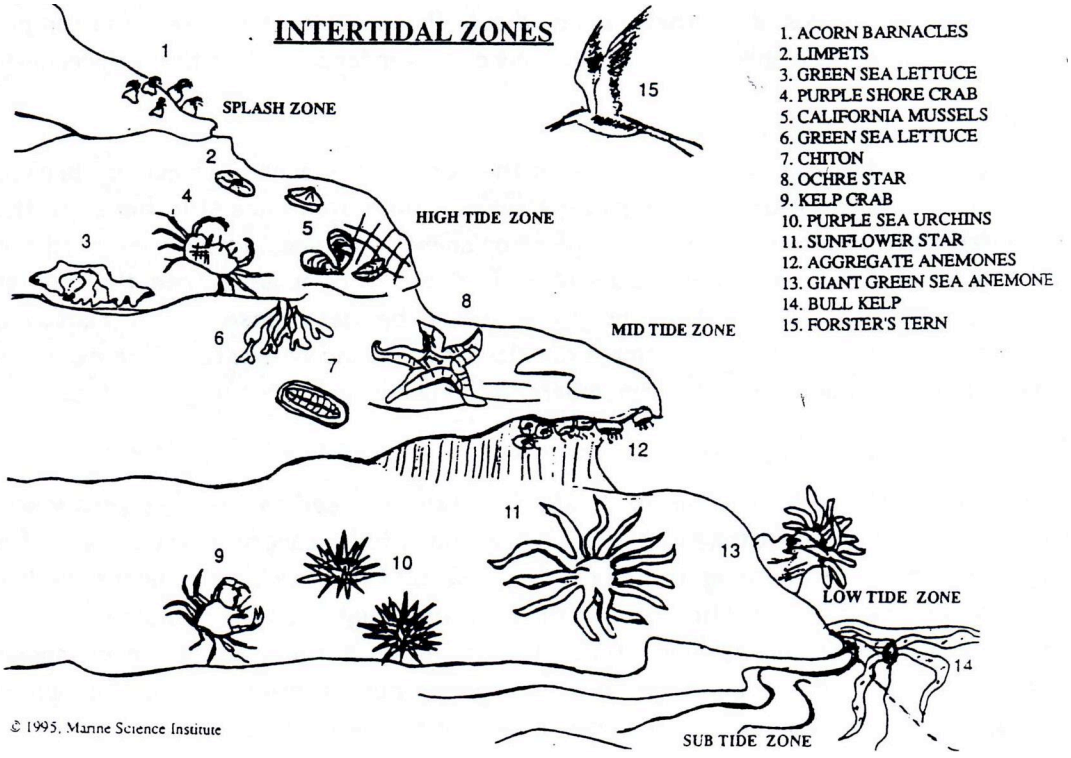
its components naturally but humans must make special efforts to preserve the natural resources.

THE ROCKY SHORE

The rocky shores along the Pacific Coast have some of the world's richest intertidal life. The animals brought to your classroom are found mostly between Santa Cruz and San Francisco. These rocky shores consist of layered shale leading up to steep cliffs. The changing tide levels often form tidepools, which are home to a huge diversity of marine invertebrates.

THE INTERTIDAL ZONES

Intertidal animals, by definition, live between the high and low tide zones. These are regions of constant and radical change. During high tide the animals and plants are underwater, but during low tide they are exposed to pounding waves, drying wind, rain that dilutes salinity, and air, which can be very hot or extremely cold. In addition to these problems, intertidal animals are also exposed to predation from the land animals such as sea gulls, sandpipers, and humans. It's a tough life, and in order to survive, intertidal dwellers have gradually adapted to these kinds of adversities. The intertidal zones extend from the highest wave-splashed rocks down to levels that are only uncovered by extreme low tides. There are five basic zones: the splash zone, high tide zone, middle tide zone, low tide zone, and subtidal zone.



The splash zone is the uppermost zone that is closest to the cliff area, and is only partially covered during very high tides. It receives wind blown spray, which

moistens animals such as blue-green algae, periwinkles, limpets and acorn barnacles.

The high tide zone, bordering the splash zone, may be exposed for 12 hours at a time. This area may have large rocks and boulders, which during winter storms can pound the animals at this level. Animals found here include lined shore crabs, California mussels, hermit crabs, and turban snails.

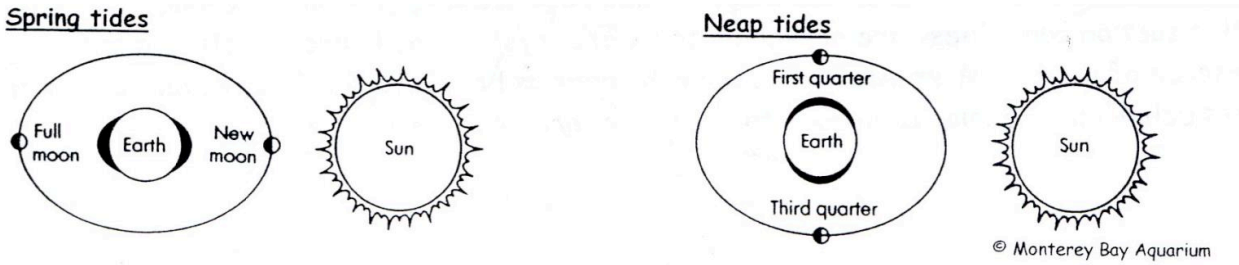
The middle tide zone covers the area between the high tide zone and the "zero" tide line. This zone is less physically stressful, as exposure may last for 12 hours or less. The animals found in this zone are adapted to the daily tidal rhythms and may actually require it to survive. Ochre sea stars, mussels, gooseneck barnacles, and purple sea urchins are a few of the species found here.

The next level is the low tide zone, and is often only exposed during times of the new or full moon. It is during this period of the lunar cycle that the tides are most extreme. Consequently, the low tide zone is exposed during only the lowest tides. This zone is often the largest and has a complex diversity of animals competing for food and room to grow. Here, clinging animals are again apparent. Anemones resist drying at low tide by contracting their delicate feeding tentacles. Sea stars can be found in clumps under rocks, using their tube feet to hold on. Mussels attach themselves to rocks by secreting tough byssal threads.

The subtidal zone, as the name implies, is almost never uncovered by water; therefore animals that are unable to tolerate air exposure for any length of time live in this area. The space is crowded with animals and competition for food and space is fierce.

ABOUT TIDES

What can be found along the shoreline, and even what the shore looks like will depend a great deal on the tides. The rhythmic rise and fall of the ocean and other large bodies of water are due mostly, but not exclusively, to the pull exerted on the water by the moon's gravity. Tides are influenced by additional forces including the sun's gravity, the earth's centrifugal force, the shape of the coast, and the ocean bottom. The highest and lowest tides, called spring tides, occur every two weeks near the times of either full or new moon. These extreme tides occur because the moon and sun are in line with the earth and the gravitational pull from each combine. Between periods of spring tides there are less extreme tides, called neap tides. During this time, the sun and the moon are at right angles to each other, and their pull tends to cancel each other. The low spring tides are the best for exploring the intertidal zone, since most of the area will be exposed.



GENERAL INTERTIDAL INVERTEBRATE CHARACTERISTICS

An invertebrate is an animal without an internal supporting structure, better known as a backbone. As a group, the invertebrates are highly successful in the natural world and well adapted. They are found everywhere: on land and in the soil, in freshwater, in saltwater, and in the bodies of other animals. In fact, invertebrates make up 97% of all the animals on the earth.

Rocky-intertidal animals are numerous, easy to find, and very spectacular with bright colors and strange shapes. They appear in such abundance in the intertidal zone that the main limiting factor is space or room for organisms to attach, cling, crawl, hide, and burrow. They are characterized by features that help them to do the above, and also ways to survive the cruel daily battles of living in a tidepool.

SCIENTIFIC CLASSIFICATION

Phylum Arthropoda

Arthropods possess an exoskeleton made of calcium carbonate, jointed appendages, and antennae. This is the largest single phylum, comprising eighty percent of all animal life, with over one million described species. Crabs, insects, shrimp, and spiders are examples of arthropods.

Class Crustacea

The crustacean body is divided into a head, thorax, and abdomen. The head has antennae, mouth-parts and eyes. The thorax is covered by a hard, plate-like carapace. Sometimes the head and thorax are fused into a single unit. Here are some examples of crustaceans: hermit crabs, purple shore crabs, lined shore crabs, yellow shore crabs, and acorn barnacles.

Phylum Mollusca

There are a variety of classes of mollusks represented in the intertidal zones. Mollusks are the second largest group of invertebrates. They have a soft body divided into a head, a foot, and a visceral hump, which contains the internal organs. The body is usually protected by a hard shell, which is secreted by the mantle.

Class Bivalvia

Clams, mussels, and scallops are examples of bivalves. They are filter feeders, and use their gills for both feeding and respiration. The shell is divided into two halves, of roughly equal sizes.

Class Gastropoda

Snails, limpets and nudibranchs (sea slugs) are examples of animals in the class Gastropoda. They have one shell or no shell, and they have a soft, muscular foot used to creep along or cling to the surface of rocks.

Phylum Cnidaria

This phylum includes sea anemones, jellyfish, corals, sea pens and hydroids. Cnidarians have a circular body plan, which is referred to as radial symmetry. They possess a crown of tentacles equipped with stinging cells that are arranged around the circular body. The main group found in the intertidal zone is the class Anthozoa (sea anemones).

Phylum Echinodermata

These animals have characteristic spines which are hard calcareous projections of their skeleton. The echinoderms posses an internal skeleton that is made of interlocking calcite plates. This is similar to our own skeletal structure. They usually have five-rayed symmetry, and move with their tube feet. Tube feet are long flexible appendages tipped with a suction cup. These are hooked up to a water system and hence, function in the presence of water. Most intertidal zone echinoderms belong to the Class Asteroidea or the Class Echinoidea. Examples include the sea stars and sea urchins.

Phylum Chordata

These animals all have a hollow nerve chord running though their bodies. The Class Chordata is divided into seven Classes, including the Mammal, Birds, Bony Fish, and Sharks and Rays. In this station we will look at the Class Osteichthyes, also known as bony fish.

GLOSSARY

ADAPTATION	Modification of an organism in order to survive within its habitat.
ALGAE	Primitive aquatic plants that lack true stems, roots and leaves. They are in their own kingdom
ALGINATE	A derivative of brown algae.
BEACH WRACK	Seaweed that has washed ashore.
BENTHOS	The substrate at the bottom of a body of water; the adjectival form of benthos is benthic.
BERM	A flat, terrace-like area of sand just above the high-tide zone on a beach.
BETA CAROTENE	A derivative of green algae.
BIODEGRADABLE	Something capable of being broken down to simple compounds, especially into harmless products, by the action of microorganisms.
BIODIVERSITY	The richness, abundance and variety of life across all trophic levels of which all ecological systems, including the planet earth, are comprised.
BIVALVE	A Mollusk having two shell hinged together. e.g. clam, oyster and mussel.
BLADE	The leaf-like part of a seaweed.
BRACKISH	Water that has more salt than fresh water but not as much as seawater.
BYSSAL THREAD	Tough threads of protein secreted by a gland in the foot of the mussel and used to attach it to rocks, piers etc.
CAMOUFLAGE	Method of hiding in which organisms blend in with their surroundings.
CANOPY	The top layer of the kelp forest where fronds float on the surface.
CARAGEENAN	A derivative of red algae.
CARAPACE	In crustaceans, a hard portion of the exoskeleton that covers the fused head arid thorax.
CARNIVORE	An animal that consumes other living animals.
CLAY	Small particles of sediment which cannot be individually felt or seen; particle diameters are smaller than 1/256 (.0039)mm.
COMMUNITY	A group of plants or animals living in the same area and depending on one another for survival.
CONSUMER	An organism that gets its nutrients by eating other organisms.
CRUSTACEAN	An animal with a hard outside shell, antennae, mandibles and compound eyes. e.g. crabs, shrimps and barnacles.
DECOMPOSER	An organism that breaks down organic material and releases simple substances usable by other living things. Examples of decomposers are bacteria and fungi.
DECOMPOSITION	The breakdown of substances into inorganic forms.
DEPOSIT FEEDER	An animal that feeds by ingesting substrate and filtering out the small organic particles on the substrate.
DETRITIVORE	An animal that eats detritus.
DETRITUS	Dead plant and animal material.
DIATOM	A type of microscopic, one-celled photosynthetic organism. All diatoms are surrounded by a silica shell and most are a golden brown in color.
DICHOTOMOUS KEY	A tool used to identify organisms based on their physical features.
DISSOLVED OXYGEN	Oxygen that has dissolved in water and can be used for respiration.
ECHOLOCATION	The use of echoes to navigate or locate prey; sonar used by toothed whales.
ECOLOGY	The study of relationships between organisms and their environment.
EDGE COMMUNITY	A productive area where land and sea interface. This community, because of its proximity to land, receives huge inputs of sediment, nutrients and freshwater, which in turn supports a diversity of plants and animals.
ENDANGERED	An organism that is threatened with extinction.

ENVIRONMENT	The sum of all physical and biological factors that affect an organism.
ESTUARY	A semi-enclosed body of water where salt water and fresh water meet and mix.
EXOSKELETON	A hard encasement deposited on the surface of an animal, such as the outer covering of arthropods that provides protection from abrasion, predation, desiccation, etc.
FILTER FEEDER	An animal which extracts food particles by straining the water. Examples of filter feeders are clams, oysters, sponges and some fish.
FOOD CHAIN	A sequence of living organisms in an ecosystem in which members of one level feed on those in the level below and in turn are eaten by those in the level above them.
FOOD WEB	An assemblage of organisms in an ecosystem, including plants, herbivores and carnivores, which shows the relationship of "who eats whom."
FOOT	The wide, flat or wedge-shaped muscle of mollusks used for crawling, adhering and/or digging.
GEOLOGY	The study of the composition and structure of the earth.
GILL	An organ used for underwater breathing or respiration by fishes and some invertebrates.
HABITAT	The particular area in which an organism normally lives.
HERBIVORE	An animal that eats plants.
HOLDFAST	The root-like part of a seaweed that anchors it to the seafloor.
ICHTHYOLOGY	The study of fish.
INVERTEBRATE	An animal without a backbone.
MANTLE	An outer sheet of fleshy tissue (in mollusks) secreting the shell and forming the chamber to enclose the internal organs.
MOLLUSK	The second largest Phylum of animals. Mollusks have soft bodies, a foot, visceral mass, and a mantle. Most also have a shell made of calcium carbonate. Snails, clams, slugs, squid and octopus are examples of mollusks.
MUDFLAT	The salty soil area of land between the lowest low and highest low tide that is flooded with sea water daily and upon which very few plants grow.
NEAP TIDES	Low amplitude tides that occur during quarter moons, when the moon's pull is at a right angle in relation to the pull of the sun.
NEKTON	Swimming animals of open water, the adjectival form of nekton is nektonic.
NEMATOCYST	In cnidarians, stinging capsules used in defense and gathering food.
NERITIC ZONE	The area of the open water that lies over the continental shelf and where there are commonly interactions with seafloor organisms.
NUTRIENTS	The raw materials necessary for continuing life processes.
OCEANIC ZONE	The area that encompasses the open water that lies beyond the continental shelf.
OMNIVORE	An organism that eats both plant and animal material.
OVOVIVIPAROUS	Reproductive strategy where mother bear young that develop internally but are unattached to a placenta inside the mother (born live from an egg).
PELAGIC	Living or occurring in the open ocean.
PHOTIC ZONE	Upper sunlight portion of the water column. The depth of the photic zone in the ocean ranges from 30 to 200 meters.
PHOTOSYNTHESIS	The process used by plants to make food; in this process light energy is used to combine carbon dioxide and water to make carbohydrates (sugar and starch); oxygen gas is given off as a by-product.
PHYTOPLANKTON	Algae, usually microscopic, which freely drift in the sunlit portions of the water column.
PLANKTON	Drifting aquatic plants and animals; the adjectival form of plankton is planktonic, and a planktonic organism is called a plankter.
POLLUTION	Harmful impact on the environment resulting from human activities.
PREDATOR	An animal that captures other animals for food.

PREY	An animal caught for food.
PRODUCER	An organism that makes its own food; an example of a producer is a green plant.
RESPIRATION	Process used by animals and plants to release energy from food; this process requires oxygen and releases carbon dioxide and water.
SALINITY	The amount of salt in the water. Measured in parts per thousand.
SALT MARSH	Salt-water wetland between terrestrial and marine ecosystems; salt marshes can also be seasonal or tidal wetlands.
SAND	Sediment particle which can be distinguished with the naked eye; particle diameters range from 1/16 (.0625) mm.
SCAVENGER	An organism that is an opportunistic feeder; scavengers usually include dead and decaying animal flesh in their diets.
SIPHONOPHORES	A siphonophore is a relative of jellies. It is a translucent chain of specialized parts, each of which carries out a unique function. Siphonophores can reach lengths of up to 95 feet or more !
SIPHONS	The feeding tubes used by some bivalves (clams and oysters) to filter plankton.
SPECIES	A population of plants or animals that are able to produce viable of with with each other and not with other species.
SPRING TIDES	Occurs every two weeks near the times of either the full or new moon. These are high amplitude tides that occur when the sun, moon, and the earth are lined up.
STIPE	The stem-like part of a kelp plant.
SYMMETRY	Correspondence in size, form, and arrangement of parts.
TENTACLE	A slender, flexible appendage.
TIDES	The daily rise and fall of the sea level along a shore, occurs twice a day on our local shores.
TUBE FEET	In echinoderms, hollow appendages filled with water and operated by the water-vascular system. Used for attachment, movement and the capture of water.
TUBERCLE	Small, round bumps that increase the surface area of the skin.
UPLAND	Ground that is elevated above the lowlands, marshlands, or rivers.
VERTEBRATE	An animal with a backbone. The back bone can be made of bone or of cartilage like in some fish (sharks and rays).
VIVIPAROUS	Reproductive strategy where mothers bear young that are nourished through a placental attachment (live birth).
WATER-VASCULAR	A system of canals, bulbs and appendages filled with sea water. This system is involved in locomotion in echinoderms.
WETLANDS	Areas that periodically have waterlogged soils, support plants adapted to wet soil, and are covered or occasionally submerged by water.
ZOOPLANKTON	Animal plankton

SAN FRANCISCO ESTUARY RESOURCES

AQUARIUM OF THE BAY
Pier 39, Embarcadero at Beach Street, San Francisco, CA 94133 · (415) 623-5300 http://www.aquariumofthebay.com
Classroom programs and guided tours.

AUDUBON SOCIETY OF SANTA CLARA COUNTY
22221 McClellan Rd., Cupertino, CA 95014 · (408) 252-3747
http://www.scvas.org
Classroom education kits, classroom visits, and Wetlands Discovery Program.

BAY AREA ENVIRONMENTAL EDUCATIONAL RESOURCE GUIDE
http://www.ecologycenter.org/baeerg/
An online guide for environmental resources.

THE BAY INSTITUTE
500 Palm Drive, Suite 200, Novato, CA 94949 · (415) 506-0150
http://www.bay.org
STRAW Project (Students and Teachers Restoring a Wetland) in Marin, Sonoma, and Napa counties.

CALIFORNIA STATE COASTAL COMMISSION
45 Fremont Street, Suite 2000, San Francisco, CA 94105-2219 · (415) 904-5260 http://www.coastal.ca.gov
Adopt-a-Beach, Boating Clean & Green Campaign, Coastal Stewardship Pledge, Coastal Art and Poetry Contest, Whale Tail Grants.

COYOTE POINT MUSEUM.
1651 Coyote Point Drive, San Mateo, CA 94401 · (650) 342-7755
http://www.coyoteptmuseum.org
Museum tours, on-site classes, outreach programs, and assemblies.

COYOTE HILLS REGIONAL PARK
8000 Patterson Ranch Road, Fremont, CA 94555 · (510) 795-9385
http://www.ebpark.org/parks/coyote.htm
Visitor center and naturalist-led programs.

DON EDWARDS SAN FRANCISCO BAY NATIONAL WILDLIFE REFUGE
P.O. Box 524, Newark, CA 94560 · (510) 792-0222
http://desfbay.fws.gov
Field trips, classroom presentations.

ENVIRONMENTAL VOLUNTEERS
3921 East Bayshore Rd., Palo Alto, CA 94303 · (650) 961-0545
http://www.evols.org
Classroom presentations, field trips, environmental education certificate for K-6 teachers, classroom lesson plans.

GOLDEN GATE NATIONAL RECREATION AREA

Fort Mason, Building 201, San Francisco, 94123 · (415) 561-4700
http://www.nps.gov/goga
Programs for K-high school at parks and Crissy Field Center.

HEADLANDS INSTITUTE

GGNRA, Building 1003, Sausalito, CA 94965 · (415) 332-5771
http://www.yni.org/hi
Residential Field Science Program offers 1-5 day programs to groups of K-12 students throughout the school year.

THE MARINE MAMMAL CENTER

Marine Headlands, 1065 Fort Cronkhite, Sausalito, CA 94965 · (415) 289-7330 http://www.marinemammalcenter.org
Education programs on marine mammal natural history and conservation.

MOUNTAIN VIEW SHORELINE PARK

Mountain View, CA · (650) 903-6392
http://www.ci.mtnview.ca.us/citydepts/cs/shoreline.htm
Pathways and trails with self-guided interpretive signs, wetlands.

PALO ALTO JUNIOR MUSEUM

1451 Middlefield Rd., Palo Alto, CA 94301 · (650) 329-2111
http://www.city.palo-alto.ca.us/ross/museum/
On-site programs, field trips, outreach programs, after-school programs, and workshops.

SAN FRANCISCO BAY MODEL VISITOR CENTER and BAY MODEL ASSOCIATION

2100 Bridgeway, Sausalito, CA 94965 · (415) 332-3871 · (415) 332-1851 (BMA)
http://www.spn.usace.army.mil/bmvc/
http://www.baymodel.org
Tour of the 1.5-acre model of the San Francisco Bay, JASON Project, Project Transquest.

SAVE THE BAY

350 Frank H. Ogawa Plaza, Suite 900, Oakland, CA 94612 · (510) 452-9261
http://www.savesfbay.org
Restoration programs, teacher training and workshops.

YOUTH SCIENCE INSTITUTE

16260 Alum Rock Avenue, San Jose, CA 95127 · (408) 258-4322
http://www.ysi-ca.org/
Science education programs for children at three sites: Alum Rock Park, Sanborn Park, and Vasona Park.

PRE-VISIT ACTIVITIES

Here are some activities to prepare your students for their MSI program. In addition you may want to ask your librarian to set aside ecology or marine science books for your class, or ask students to bring books and magazines from home to share.

SCIENCE

ANIMAL ADAPTATIONS
Have your class research and discuss how estuarine animals protect themselves from their predators or what adaptations they have to become better predators. Have the class team up in small groups and be responsible for researching one phylum. Within each group, each student can choose one animal from this phylum. They can begin with the background information in this preparation guide, and then use books, tapes or any other resource to put together a report

SCIENTIFIC CLASSIFICATION
Demonstrate the meaning of scientific classification by having students categorize inanimate objects according to their own framework. You could use fruit, or something ordinary such as different kinds of nails (wood, standard, aluminum, galvanized, ringed, headless), to each small group. Have them categorize and then share their results with each other to start a general discussion on classification. Do we need it? Is any one type of classification better than another? Is there a benefit to sticking to one standardized system of classification?

DICHOTOMOUS KEYS
To demonstrate how a dichotomous key works, play a "20 Questions" style game. Pick one student without disclosing his/her identity, then have the rest of the class discover who you've picked by asking yes-or-no questions. During this process, you can construct a key based on their questions. Tell them to go from the most general to the most specific. For example:

1a. Is the student male.....Go to question 2
1b. Is the student female.....Go to question 7
2a. Does the student have blond hair.....Go to question 3
2b. Does the student have dark hair.....Go to question 9
3a. Does the student have blue eyes.....Go to question 4
3b. Does the student have brown eyes.....Go to question 11

NO GARBAGE LUNCH (Part 1)
Within a day or two of your class trip, hold a surprise "lunch raid" by making a collection of all the garbage (man-made materials only!) to be potentially thrown out after lunch is over.

- Sort the garbage into piles such as plastics, paper, aluminum, etc., and count the number of items in each pile. Make a colorful bar graph depicting your findings.
- Discuss the results and the importance of recycling.

- Discuss where the solid garbage goes. Much of it goes into landfills which are actually "bay fills." How long can this go on?
- Challenge your class to make “No Garbage” lunches. This means bringing a lunch box or a bag that can be used again. Reuse containers for sandwiches and snacks.
- Talk about the drawbacks of snack food that come in cute little packages but create lots of garbage. What could we do instead? (Buy bulk size).
- Encourage the three "R’s": Reuse, Reduce (garbage) and Recycle.

ORGANISM REACTIONS

A. Varying salinity

Have students make wet mounts of a thin section of red onion bulb. Mount in 1% NaCl (salt)
solution and observe effects. Flush with fresh water and observe effects. Have students explain the reactions.

B. Varying temperature

Put equal numbers of fruit flies in jars and keep them at different temperatures for a few minutes. Observe relative activity rates. If a pond or other body of water is nearby, measure air and water temperatures at different times of the day to see which environment has more stable temperatures.

SOCIAL SCIENCE

GEOGRAPHY

Make a map of the Bay Area, or a 3-D model of the Bay Area. Emphasize the mountains, and the Hayward and San Andreas Faults. Clay, or a mixture of baker's dough works well.

PYRAMID OF LIFE (From Joseph Cornell's *Sharing Nature with Children*)

Give each student a slip of paper and have them secretly write on it the name of a plant or animal that lives in your area. Collect all slips of paper and begin to construct a "human pyramid" (performed in a flat position, rather than one child on top of another, if safety is a concern or the group is large).

Begin by asking, "From what source does the earth get its energy?"(Sun) "What form of life is the first to make use of that energy?" (Plants) Next, divide students into groups (from their secret slips) depending on whether they are plants, plant-eaters (herbivores), meat-eaters (carnivores), or omnivores (let the omnivores choose which group they'd like to be in). Try to construct a food pyramid beginning with all the plants on the bottom. Who is next? And next? Is it too top heavy to work? What will happen to all the animals on top with nothing to support them underneath? What needs to be done to correct it? Conclude by pretending to yank out a plant; what happens to the pyramid?

MAP GAME

The class is divided into two teams. One member of each team puts their back to a map of the Bay Area. The teacher calls out a city or landmark that is found on the map, and then says "Go". The students turn around to find the city or landmark,

trying to do so before the other one does. The first correct answer gets a point for their team, and the team that gets the most points wins. Emphasize the geography of the Bay Area, "Find and name the mountains forming the east side of the Bay." "Find and name a river that empties into the South Bay." Be careful with these; there are a few rivers. "Find the bridge that connects Oakland and San Francisco and name it."

ART

FISH PRINTING

Fish printing, or gyotaku (gyo=fish, taku=rubbing), was invented by the Japanese in the 1800's and has since evolved into an art form. Prints can be made on paper, cloth, or t-shirts.

- Obtain whole fish, octopus, or squid from market. It should be thawed out.
- Wipe the outside of the fish to remove moistness and mucous. Be careful not to damage the scales.
- Lay fish on a newspaper covered table.
- Using a wide stiff brush, paint the side of the fish with fabric paint or water-based printers' ink of any color. Don't use too much paint as it will smear.
- Paint the fins and the tail last.
- Slowly lower the paper or cloth onto the painted fish and gently pat the material all over the fish. Make sure you get the tail and fins. Lift the print straight up from the fish.
- Place print in a safe place to dry and admire!

CAMOUFLAGE CRITTERS

Discuss the concept of camouflage, its usefulness to an animal, and perhaps how it evolved
through natural selection. Have students draw an animal camouflaged for a particular environment (forest, meadow, stream bottom, etc.) Or, choose environments on the school grounds and create a critter (from paper, clay, pipe-cleaners, even raw vegetables!) that is camouflaged in those surroundings.

MATH

MEASURING

Using the metric system, we measure plankton in micrometers. Have the students make measuring sticks and send them out on a measuring hike. Tell them to find things of certain lengths. Let them figure out how many microns are in the items they measure.

GRAPHING

Make a tide table. Have the students check the newspaper each day for the tides. Then record each day on a graph. Watch how the tides go up and down each day and get higher and lower as the month progresses.

POST-VISIT ACTIVITIES

Here are some activities to help reinforce concepts learned during your MSI program. In addition you may want to ask your librarian to set aside ecology or marine science books for your class, or ask students to bring books and magazines from home to share.

SCIENCE

AQUARIUMS
Set up an aquarium in your classroom. All you need is a small aquarium, an undergravel filter system, an air pump connected to a bubbler, and fish or invertebrates. Most aquarium stores can direct you, or ask us at MSI. Students can watch the fish as they move their gill openings. How many times do they "breathe" per minute? Have your class figure out what the animals need to survive: food, water changes, oxygen, etc.

TIDES
Make a tide table. Have the students check the newspaper each day for the tides. Record each day on a graph. Watch how the tides go up and down each day and get bigger and smaller as the month progresses. Ask the students to check the moon each night and correlate the phases of the moon.

NO GARBAGE LUNCH (Part 2)
After our program, once again hold a lunch raid and compare how much garbage they have this time as opposed to the last time (there should be much less). Let the colorful bar graphs of the two days emphasize the dramatic difference the students themselves are making to the health of the planet!

WEB OF LIFE
Have the students stand in a circle. Ask the students about the habitat they just saw (this will work for any habitat). Ask them where in that habitat all energy begins, (sun).

- Hand the student who answered correctly a ball of yarn.
- Ask what uses the sun's energy to create food (plants). Have them name a plant they saw.
- Have the student with the ball of yarn (still hanging on to the end of the string) toss the ball itself over to the "plant" student.
- Ask, "Who uses plants for energy?" And continue this discussion using herbivores, carnivores, decomposers, and of course, humans,
- With each completed step, students continue to toss the yarn to each other around the circle, creating a complex and interrelated food web.
- Now pick a random student. Because of hunters, or pollution, or loss of habitat (several reasons apply), the component he or she represents has died and must sit down. As he does so, he inadvertently creates a tug on the yarn, thus affecting other aspects of the web of life. Every student, then, who feels a tug on the yarn they are holding is affected in some way by the death of that one individual, and must sit down and tug on their own yarn.
- Eventually, all students will be seated and you can discuss the results.

BEACH WALK
If time and funds permit, organize a visit to a rocky beach location at low tide. A visit to the tide pools drives home the idea that intertidal animals have a different set of adaptations and problems to deal with. Three good local tidepool areas to visit are Fitzgerald Marine Reserve, Pillar Point, and Pescadero Beach.

Equipment needed
- Rubber boots or hip waders
- Identification books or keys
- Magnifying glasses

Important rules to follow
- Study and observe the animals and plants where you find them. Do not pick up and move organisms to a different location.
- When searching for animals, replace any over-turned rocks as you found them. Turn them over gently, and replace them carefully so as not to leave the underside exposed to the sun or elements.
- Avoid disturbing unusual ecological areas that may be more sensitive to disturbances, or any other types of animals that you might see such as marine mammals and birds.
- Please teach and practice conservation!

ART

TURN YOUR CLASSROOM INTO A BAY
Put blue paper around the classroom and have the students draw in various plants and fish, or have them cut out pictures of marine creatures to put on the blue paper. Let them put some benthic invertebrates on the bottom and plankton on the top!

MOBILES
Let the kids make mobiles of the fish they saw. Take a hanger, some string, some cut-out drawings or pictures of fish and have fun! Attach the fish to the string. Then attach the string at varying lengths to the hanger. Be creative, use pictures of plankton and benthic critters. Possibly take two copies of the fish, glue the edges together, and stuff with some already used paper (recycle it!) and have a 3-D mobile. Older groups can make mobiles in the form of a food chain.

ENGLISH

WRITING
Write letters to the instructors and/or your class sponsor to tell them about the trip. When we receive letters and pictures back from the kids our instructors remember what a thrill it is to be teachers. The sponsors also enjoy getting direct feedback from the class and teacher to reinforce that they are making a difference for kids learning science. Please include the day, date and time of your trip so we can try to remember your group a little better.

ORAL PRESENTATION

Have the class team up in small groups and have each group do a short oral presentation on one of the animals they learned about in the program. If they have done the pre-visit activity of researching an animal, they can use that information, plus add what they have just learned. In the presentation they could include what phylum it belongs to and why, where it lives in the Bay, what it eats, what might eat it, and any special offensive or defensive adaptations it may have.

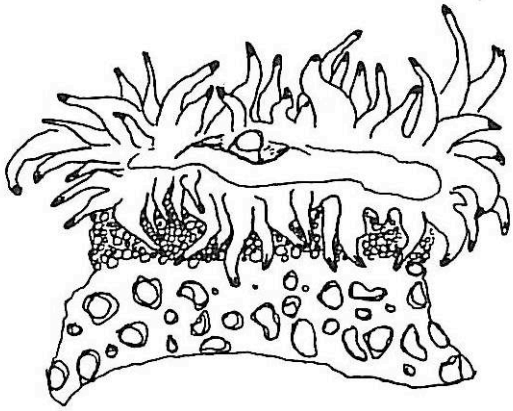
ACTIVITY #1: Creative Classification

Objective:
To create an animal by using physical characteristics to categorize that animal in a classification system.

You will need
- Clay
- Paper
- Markers
- Reference materials

Procedure:
1. Each student chooses a phylum, class, order, and family in the animal kingdom after which to model their animal. Write down main characteristics. You may want to limit choices.
2. Separate clay into medium sized balls.
3. Give time to design an imaginary animal following the main characteristics of the chosen phylum, class, order and family.
4. Name animal with an original genus species name. Genus is a larger group for similar species. Species category is for organisms with similar structures.
5. Compare "new critters" to the others in the same families.
6. Discuss differences between animal characteristics, habitats, and diets that create *biodiversity*.

NOTE: *You may change this lesson by asking the students to create an animal based on the physical parameters of a given habitat. They can use the same materials and assign their critter a genus & species name as before!*



Anthopleura
Elegantissima

ACTIVITY #2: Rocky Shores Creature Feature

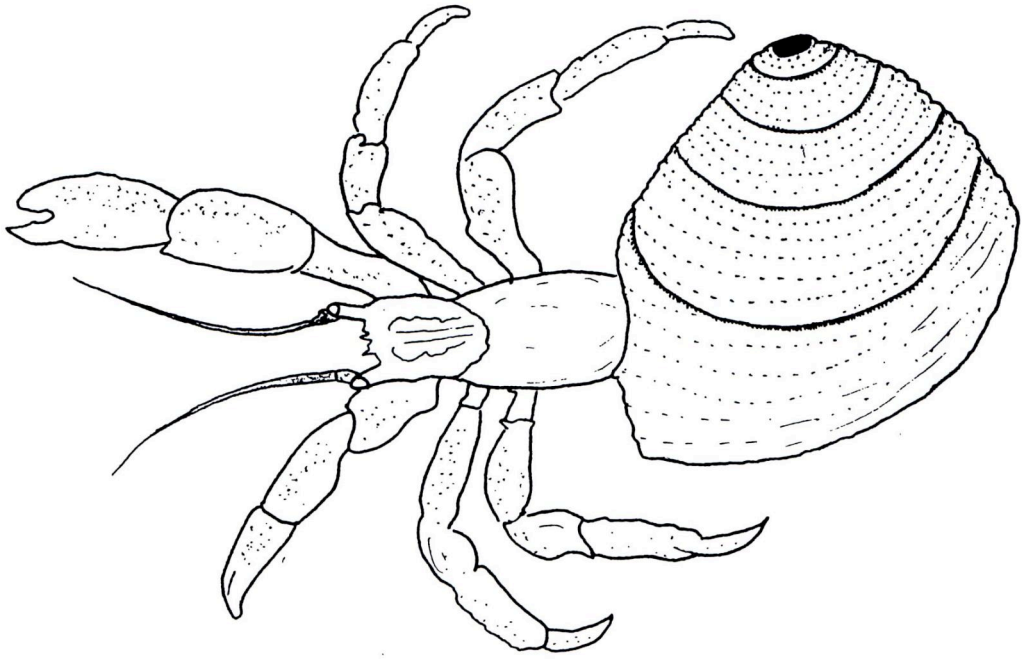
Objective:
The objective of this activity is to familiarize and excite students about the creatures that live at the rocky shores.

Procedure:
There are many possibilities for classroom activities using the "Creature Feature" information cards.

You may wish to conduct an "Each One – Teach One" with your students. Make enough copies of the creature information cards so that there is one featured animal per student when pages are cut apart. Let students choose a creature card randomly. Give students time to read the card or further research their chosen organism. Props and pictures are fun additions to this activity. Then, let the each one – teach one begin. Set up teaching "stations" around the room. Devise an organized way to have the students teach and learn from each other as they move between teaching stations.

Alternate activities could include :

a. The creation of a rocky intertidal food web using the creature information cards and poster boards.
b. Human Impact Activity: Have students pick a creature information card and research the impacts that humans have on that specific organism.



ROCKY SHORES CREATURE FEATURE

Turban Snail

Description: Their shell can be brown or black with a spiral coiling shell. The snail's soft, muscular foot is black on the sides.
Food: It scrapes algae off rocks with a texture tongue, called a radula.
Predators: Shore birds, fish, crabs, other snails, and humans.
Zone: Found in the middle to low intertidal zone.
Fun Facts: The black turban is one of the best known snails on the west coast and has served in many field and lab investigations. These snails may live 25 years.

Purple Sea Urchin

Description: Urchins have round shells with short spines. Its body is reddish to purple. Juveniles are pale green. They often burrow into rocks.
Food: They are herbivores that graze on algae.
Predators: Their predators include sea otters, fish and humans. Pollution is also a threat to urchins.
Zone: Urchins are found in the low tide zone.
Fun Facts: Giant kelp is the preferred food of the sea urchin. They have tube feet, which catch the blades of kelp and pass food to its mouth.

California Mussel

Description: The mussel is a black bivalve. It attaches to rocks by secreting a liquid that quickly hardens to form strong threads.
Food: Detritus, living plankton.
Predators: Ochre stars and humans
Zone: Found in dense colonies on wharf piles and surge exposed rocks in the middle to high intertidal zone.
Fun Facts: When the water exceeds a certain temperature, often from late May through October, mussels feed on microorganisms that make them poisonous for humans to eat.

Purple Shore Crab

Description: These are a dark wine color with purple spots on their claws.
Food: It is a scavenger and eats dead plants, detritus, or small animals.
Predators: Fish, sharks, and shorebirds.
Zone: It is found in the high intertidal zone.
Fun Facts: They use camouflage and their claws for defense. They also hide under rocks. Gently picking one up and examining its belly can determine this crab's sex. A male will have a "lighthouse" shaped abdominal flap and a female will have a "beehive" shaped abdominal flap.

Acorn Barnacle

Description: Barnacles are white and volcano shaped. They glue themselves to rocks, pier pilings, whales, and ships.
Food: Plankton and particles suspended in water.
Predators: Their enemies include worms, snails, sea stars, fish, shorebirds, and oil spills.
Zone: They live in colonies in the high and middle intertidal zones.
Fun Facts: When submerged, they stick out their feather feet, called cirri, to strain out plankton and absorb oxygen. This is probably the most common intertidal barnacle along our coast. shores.

Ochre Star

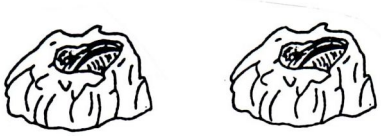
Description: These stars have rows of white tipped spines covering the back. They are rough to the touch. The color may be purple, brown, orange, red or yellow.
Food: Mussels, barnacles and certain snails.
Predators: Shorebirds and humans
Zone: They live in middle to low intertidal zones.
Fun Facts: This sea star needs only a 0.1 m.m. opening to insert its stomach into a mussel shell. This is one of the few stars that is capable of withstanding the direct force of large waves for extended periods.

Nudibranch

Description: Soft body - not protected by a shell. The color is orange on the back with bright light blue lines. They have their gills on their back.
Food: Small sea anemones, worms, small crustaceans, tiny clams and even dead animals.
Predators: Few animals eat slugs because of their brightly colored warnings. The exceptions are sea hares, inexperienced fish and people.
Zone: Found in the low to subtidal zone.
Fun Facts: Sea slugs eat sea anemones, and store the poison from the anemones stinging cell in projections on their back.

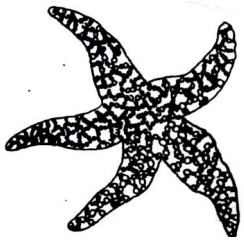
Giant Green Anemone

Description: The column is olive green and the tentacles and disc are emerald green. The column is covered with wart-like tubercles.
Food: These animals use their stinging tentacles to catch detached mussels, crabs, sea urchins and small fish.
Predators: Sea slugs, snails, fish and sea stars.
Zone: Commonly found in the middle intertidal zone.
Fun Facts: They have needle-like stinging cells on their tentacles that inject paralyzing compounds into prey.

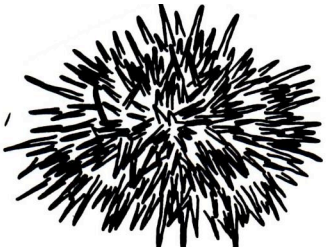


Acorn Barnacle
Balanus glandula

Turban Snail
Tegula spp.



Ochre Star
Pisaster ocraceous

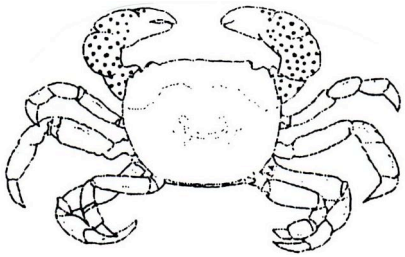


Purple Sea Urchin
Strongylocentus purpuratus

Sea Slug
Hermissenda crassicornis

California Mussel
Mytilus californicus

Giant Green Anemone
Anthopleura xanthogrammica



Purple Shore Crab
Hemigrapsus nudus

Directions to Marine Science Institute

Redwood City, California
(650) 364-2760 Fax (650) 364-0416
www.sfbaymsi.org

From 280

1. Take the Woodside Road exit towards Redwood City (east).
2. Continue on Woodside Road until it becomes Seaport (go under Hwy 101).
3. Follow Seaport, turn left onto Chesapeake Drive (second light).
4. Turn left on Saginaw.
5. Turn right on Cardinal Way (watch for Seaport Plaza).
6. At the end of the road veer right, pass the Stanford Boathouse, and continue on to the Institute.

From 101

1. Take the Seaport Blvd exit at Redwood City.
2. Follow Seaport, turn left at Chesapeake Drive (second light).
3. Turn left on Saginaw.
4. Turn right on Cardinal Way (watch for Seaport Plaza).
5. At the end of the road veer right, pass the Stanford Boathouse, and continue on to the Institute.