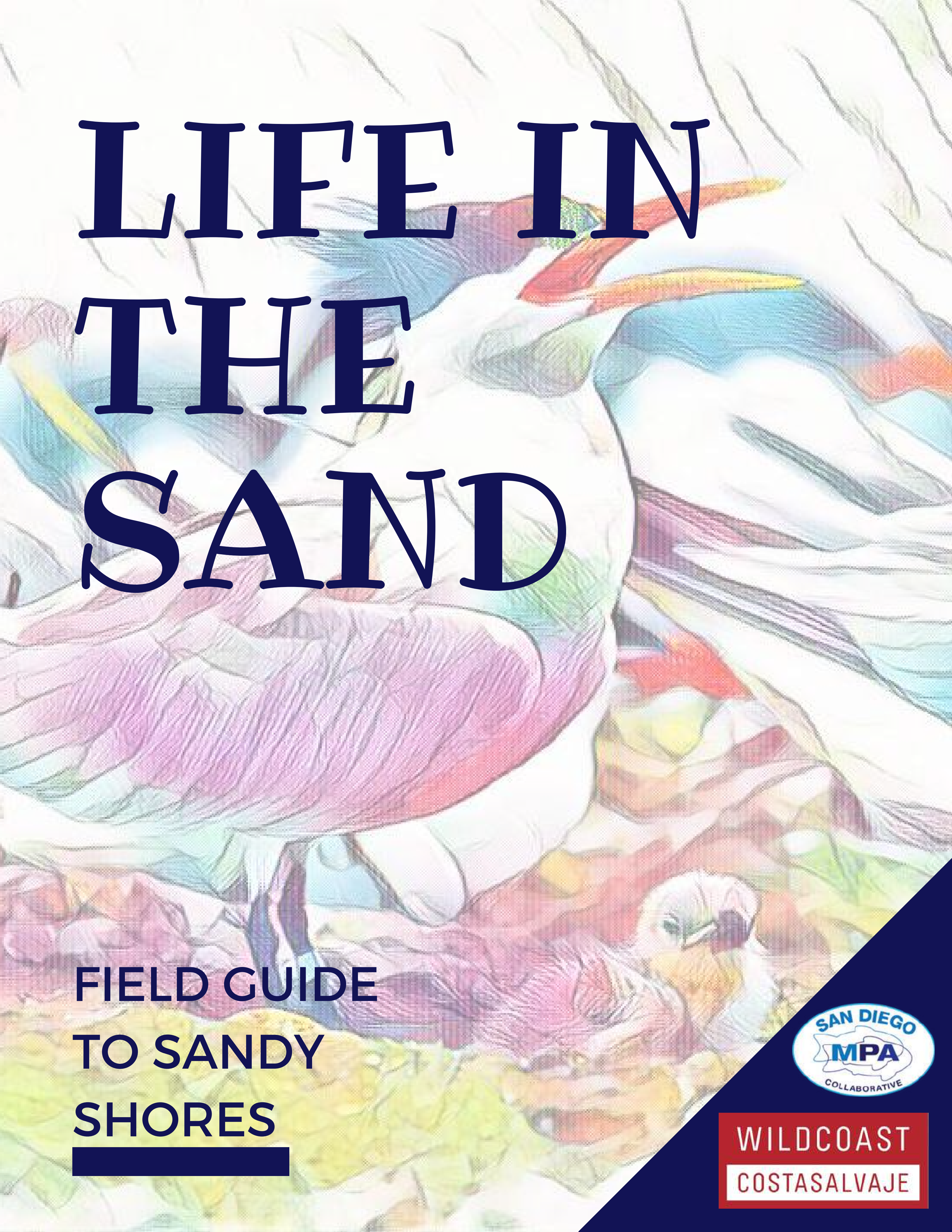

LIFE IN THE SAND

FIELD GUIDE TO SANDY SHORES

SAN DIEGO MPA COLLABORATIVE

WILDCOAST COSTASALVAJE

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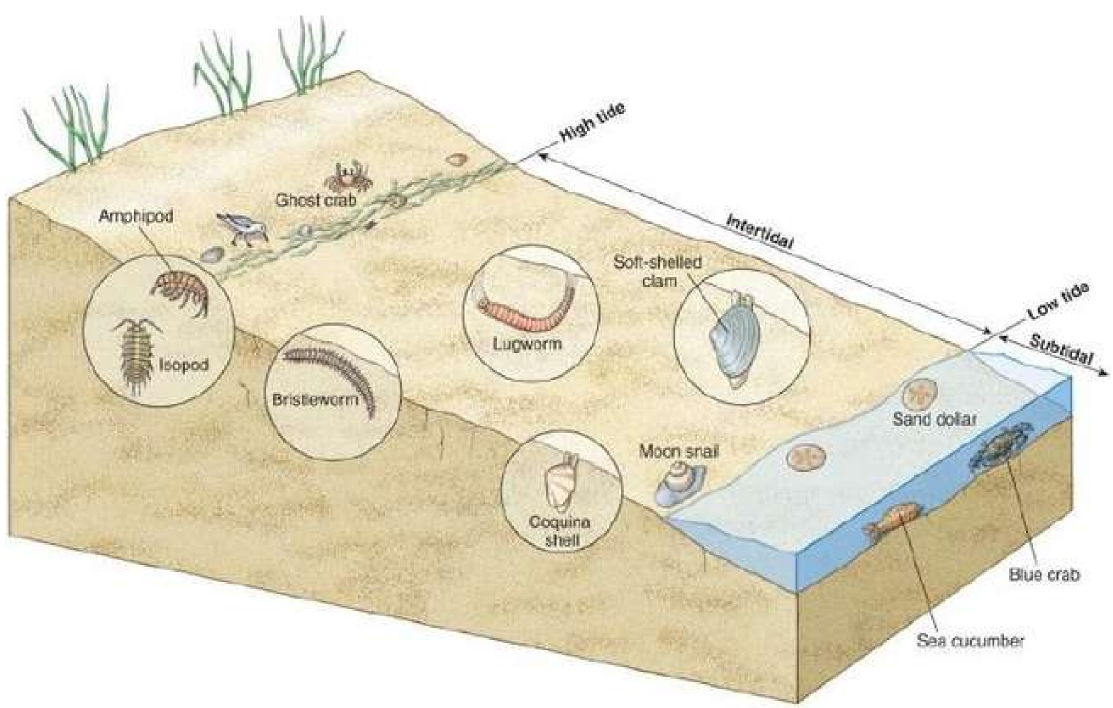
SANDY SHORES

IDENTIFICATION

ACTIVITIES

Sandy Shores

Sandy shores are areas where deposits of sand or other sediments cover the shoreline. To beachgoers, sandy shores often appear to be devoid of life, made up only of sand, shells, and the occasional piece of driftwood. But in reality, this dynamic habitat is home to a diversity of species, each specially adapted for life above or below the sand. These organisms must contend with pounding waves, changing tides, and constantly shifting sand particles - not to mention people who love to visit and develop beaches!



intro

Key Words

Shoreline: The line where a body of water and the shore meet.

Beach: A deposit of loose material on shores that is moved by waves, tides, currents, and wind.

Intertidal Zone: The area between high and low tides.

High Tide: The tide when the water is at its highest level.

Low Tide: The tide when the water is at its lowest level.

Adaptation: A physical or behavioral change that helps an organism survive in its environment.

Swash: The rush of water up the shore after the breaking of a wave.

Desiccation: A state of extreme dryness caused by prolonged periods of being out of the water.

There are many **advantages** of living on a sandy shore including:

- Swash and tides supply food, oxygen, and nutrients and carry away waste products.
- In contrast with rocky shore habitats, organisms living on sandy shores can retreat into the substratum in order to avoid desiccation during low tide.

However, there are also many **challenges** of living in the intertidal:

- Sediments are constantly shifting due to wave energy, tidal fluctuations, currents, and wind.
- Organisms living in the intertidal sections of a sandy shore must deal with marine predators at high tide and terrestrial predators at low tide.
- Oxygen availability quickly decreases with sediment depth.

In order to survive in this dynamic habitat, organisms that live in and on sandy shores have evolved a wide array of specialized adaptations.

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Sand

We all know what sand is...it is that stuff we play in and build sand castles with at the beach. It's the stuff that gets stuck between our toes and fills our car after a fun day in the sun!

Sand is actually rather complex. It is made up of abiotic things such as small, loose pieces of rock, soil, and minerals, as well as biotic things such as shells.

Sand is formed when these larger items are weathered by waves, wind, rain, or ice, thereby breaking them down into small grains.

Sand can be made up of many different compounds, such as quartz, calcium carbonate, or volcanic fragments. What the sand is made up of determines its color. Sand can be white, tan, black, green, or even pink!

Each beach is made up of more grains of sand than we can even imagine! For example, if you take a 30 second walk on the beach, you have already walked over trillions of grains of sand!

Key Words

Sand: Granular material made up of weathered rocks, minerals, and shells.

Abiotic: Non-living things.

Biotic: Living or once-living things.

Weathering: The process by which waves, wind, water, or gravity breaks things down into smaller pieces.

sand

Watch It: The Amazing Life of Sand - Deep Look by KPBS
https://youtu.be/VkrQ9QuKprE

Explore It: Bring a sample of sand to class. Have students look at the sample with a magnifying glass or under a microscope. Have them try to sort and/or identify what they see!

Adaptations

adaptations

To deal with the challenges of living on a sandy shore, organisms have developed a wide array of adaptations.



THREAT: Sand and water are in constant motion.

ADAPTATIONS: Many sandy shore creatures are expert burrowers and dig down into the sand to avoid being washed away by waves. When wave energy gets too high, clams use a powerful foot to quickly burrow to safety. They will wait until the tide changes and the sea is more calm, then come out to eat.

Ingrid Taylor

THREAT: Predation from terrestrial species (birds and mammals)

ADAPTATIONS: Burrowing into the sand can also help creatures avoid being eaten. Mole crabs like to feed on tiny plankton in the swash, then burrow down into the sand as the water recedes so that they won't be picked off by a sea bird.

THREAT: Oxygen levels are very low within the sand and sediment.

ADAPTATIONS: Many organisms that live in and on sandy shores are able to use oxygen very efficiently, meaning that a little bit of oxygen goes a long way. These creatures are able to use a small amount of oxygen to create enough energy to keep them alive.

Tides

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Key Words

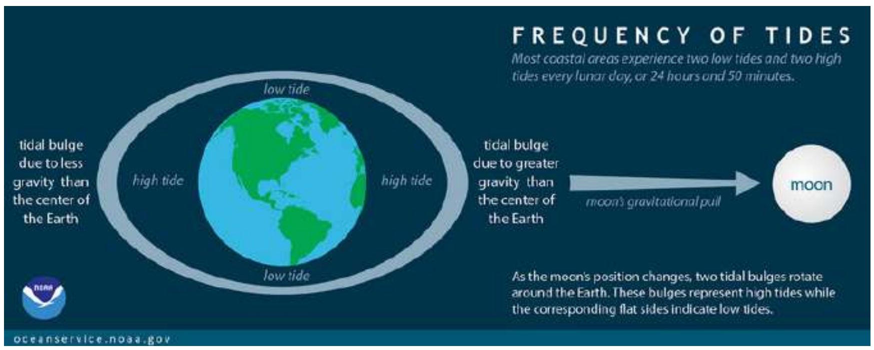
Tides: The periodic rising and falling of ocean water that results from the gravitational pulls of the sun and the moon.

Neap Tide: The weak tide created when the sun and moon are at a right angle with the Earth.

Spring Tide: The strong tide created when the sun and moon align with the Earth.

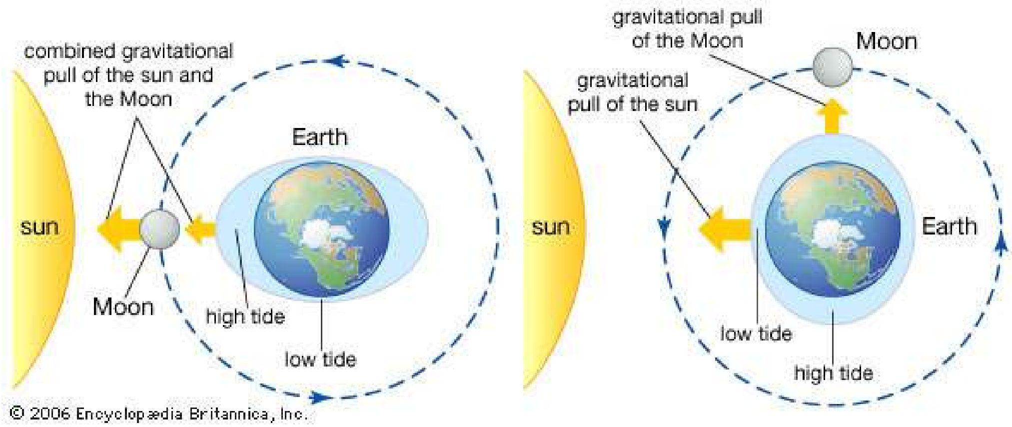
Tide Chart/Tide Table: A graph used to represent predicted high and low tides over a set period of time at a specific location.

Tides are the periodic rising and falling of ocean water that occur at regular intervals because of the gravitational pulls of the sun and the moon. Tides seem to make the water creep up the beach with each incoming wave for part of the day until it reaches a so-called "high tide line" and then retreat back down the beach in the same manner. The height of tides is determined by the positions of the Earth, sun, and moon. The gravitational pulls of the sun and the moon pull the ocean water toward them, so the Earth will experience high tides on the sides of the Earth closest to the sun and the moon. Since the moon revolves around the Earth, the Earth revolves around the sun, and Earth rotates on its own axis the distances and relative position of each of these are constantly changing. Depending on the distances of the sun, Earth, and moon the tides may be higher or lower and the currents stronger or weaker.



tides

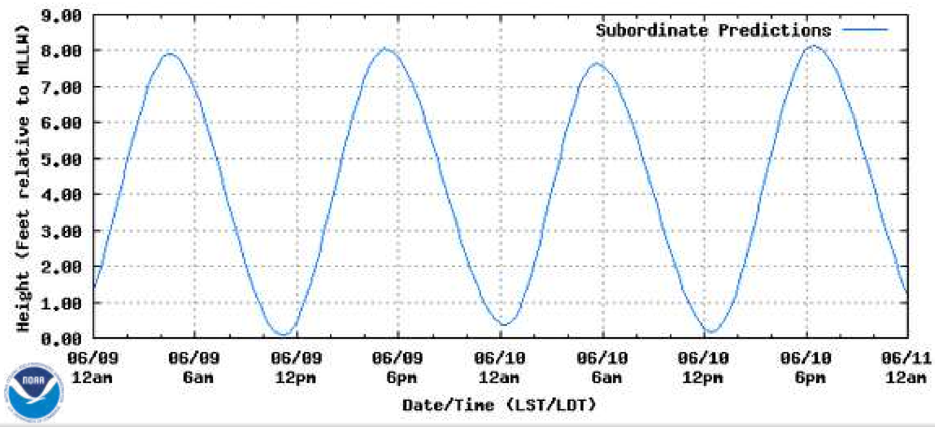
For example, when the sun and the moon are at a right angle with the earth, a phenomena known as a neap tide, their gravitational pulls partially cancel each other out creating weaker tides. When the sun and moon align with the Earth, called a spring tide, their gravitational pulls combine creating stronger tides. Since the sun is 360 times farther from the Earth than the moon, the gravitational pull of the moon is twice as powerful as the pull of the sun. The Earth and the moon revolve around a common point every 27.3 days creating a tidal cycle that repeats approximately every 27.3 days.



tides

There are two high tides and two low tides each day which, because of the angle of the moon to the Earth, may not be of equal height. Tide heights may also differ from day to day due to the changing distance between the Earth and the moon. The timing and height of each high and low tide are predictable and any fluctuations may be measured by scientists and used to track hurricanes and winter storms.

Tides are reported in a tide chart or tide table which shows the predicted water level at a specific location over a certain period of time. Water levels are portrayed as a wave with time and date on the x-axis and water level on the y-axis. The crests of the wave represent the high tides, while the troughs represent the low tides. To determine what the water level will be at a given time find the date and time on the bottom of the chart, trace up to the tide line, and then look to the left side of the chart. Tide charts are specific to a certain time period, so new tide charts are issued regularly.



Tide charts for the United States may be found through NOAA:
https://tidesandcurrents.noaa.gov/tide_predictions.html

Tide charts in Mexico may be found through UNAM:
http://www.mareografico.unam.mx/portal/index.php?page=Estaciones

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MPAs

Marine Protected Areas (MPAs)

California's coastal and marine ecosystems are some of the most iconic and treasured resources in the state and contribute greatly to the history, identity, and economy of the area. Unfortunately, these same ecosystems are also some of the most exploited and without proper care the long-term health of these resources is in jeopardy. Recognizing the need to safeguard California's coastal and marine ecosystems, the state legislature passed the Marine Life Protection Act in 1999. This act aimed to protect California's precious marine resources by creating a statewide network of marine protected areas (MPAs). Designed to protect the diversity and abundance of marine life while still maintaining recreational access for people, MPAs now protect over sixteen percent, or 850 miles, of the California coast.

Just as state parks protect resources on land, MPAs protect resources in the ocean by managing human activities within biologically important areas. The Marine Life Protection Act recognizes that a combination of MPAs with varied amounts of allowed activities and protections (marine reserves, marine conservation areas, and marine parks) can help conserve biological diversity, provide a sanctuary for marine life, and enhance recreational and educational opportunities.

There are 11 MPAs in San Diego County that fall under three categories:

Key Words

Marine Protected Area (MPA): MPAs are areas in or near the ocean made to protect or conserve marine life and habitat, safeguard cultural sites, and provide enhanced recreational opportunities

Natural Resource: Materials or substances such as minerals, forests, water, or animals that are found in nature and are valuable to humans.

Take: To hunt, pursue, catch, capture, or kill, or attempt to hunt, pursue, catch, capture, or kill.

State Marine Reserve (SMR)

Take, damage, injury, or possession of any marine resource (living, geological or cultural) is prohibited. Recreational activities are encouraged.

Matlahuayl
South La Jolla
Cabrillo

No-Take State Marine Conservation Area (SMCA)

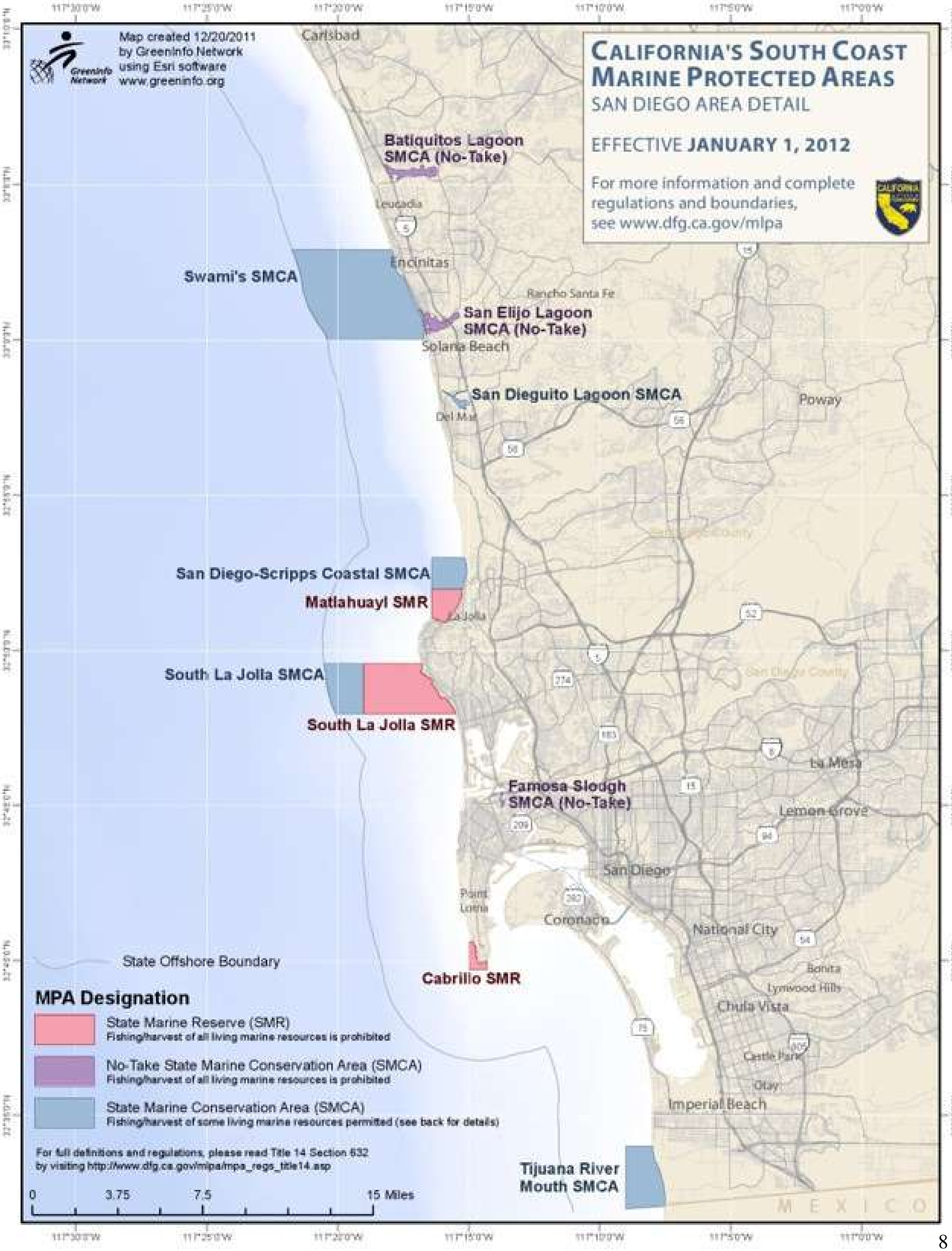
Take, damage, injury, or possession of any natural resource (living, geological or cultural) is prohibited.

Batiquitos Lagoon
San Elijo Lagoon
Famosa Slough

State Marine Conservation Area (SMCA)

Take, including fishing/harvest of some marine resources is permitted. Some consumptive recreational and commercial activities are allowed at specific locations.

Swami's
San Diego-Scripps Coastal
South La Jolla
San Dieguito Lagoon
Tijuana River Mouth


CALIFORNIA'S SOUTH COAST MARINE PROTECTED AREAS
SAN DIEGO AREA DETAIL
EFFECTIVE JANUARY 1, 2012
For more information and complete regulations and boundaries, see www.dfg.ca.gov/mlpa
Map created 12/20/2011 by GreenInfo Network using Esri software www.greeninfo.org
Batiquitos Lagoon SMCA (No-Take)
Swami's SMCA
San Elijo Lagoon SMCA (No-Take)
San Dieguito Lagoon SMCA
San Diego-Scripps Coastal SMCA
Matlahuayl SMR
South La Jolla SMCA
South La Jolla SMR
Famosa Slough SMCA (No-Take)
Cabrillo SMR
Tijuana River Mouth SMCA
Carlsbad
Leucadia
Encinitas
Rancho Santa Fe
Solana Beach
Del Mar
Poway
La Jolla
San Diego County
La Mesa
Lemon Grove
San Diego
Point Loma
Coronado
National City
Bonita
Lynwood Hills
Chula Vista
Castle Park
Otay
Imperial Beach
MEXICO
State Offshore Boundary
MPA Designation
State Marine Reserve (SMR)
Fishing/harvest of all living marine resources is prohibited
No-Take State Marine Conservation Area (SMCA)
Fishing/harvest of all living marine resources is prohibited
State Marine Conservation Area (SMCA)
Fishing/harvest of some living marine resources permitted (see back for details)
For full definitions and regulations, please read Title 14 Section 632 by visiting http://www.dfg.ca.gov/mlpa/mpa_regs_title14.asp
0 3.75 7.5 15 Miles

Although all of the animals found on this page can be seen in Southern California MPAs, those labeled with a star (*) are more likely to gain a direct benefit from MPAs. Animals marked with a star have smaller home ranges and/or spend significant portions of their lives within MPAs. As these animals grow larger, their offspring can help repopulate adjacent waters.

⚠ THE IMAGES OF ORGANISMS ARE NOT MADE TO SCALE

Mammals

*Sea lion
Otariinae

Blue whale
Balaenoptera musculus

Gray whale
AKA Pacific gray whale, California gray whale
Eschrichtius robustus

Mammals

Bottlenose dolphin
Tursiops

Pacific whiteside dolphin
Lagenorhynchus obliquidens

Mammals

*Harbor seal
Phoca

Short beaked common dolphin
Delphinus delphis

Reptiles

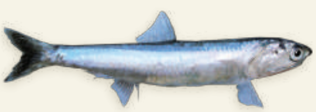
*Green sea turtle
AKA Green turtle,
Pacific green turtle
Chelonia mydas

Birds

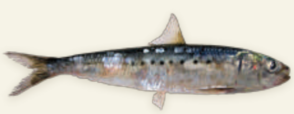
*Great blue heron
Ardea herodias

Fish

Topsmelt
Atherinops affinis Ayres



Californian anchovy
Engraulis mordax



Pacific sardine
Sardinops sagax

*Croaker spp.
Sciaenidae

*White sea bass
Atractoscion nobilis

California corbina
Menticirrhus undulatus

Fish

*Rockfish spp.
Sebastes

*Kelp bass
AKA Calico bass
Paralabrax clathratus

*Barred sand bass
Paralabrax nebulifer

*Spotted sand bass
Paralabrax maculatofasciatus

*Giant sea bass
Stereolepis gigas

California halibut
AKA California flounder
Paralichthys californicus

Fish

Pacific bonito
Sarda chiliensis lineolata

Sunfish
AKA Mola
Mola mola

*Shovelnose guitarfish
Rhinobatos productus

Bat ray
Myliobatis californica

Round stingray
AKA Haller's round ray
Urolophus halleri

*Leopard shark
Triakis semifasciata

Birds

*Tern spp.
Sternidae

*Gull spp.
Laridae

*California least tern
Sterna antillarum browni

Osprey
AKA Sea hawk, River hawk, Fish hawk
Pandion haliaetus

*Double-crested cormorant
Phalacrocorax auritus

*Brown pelican
Pelecanus occidentalis

Fish

Garibaldi
AKA Garibaldi damselfish
Hypsypops rubicundus

*Blacksmith
AKA Blacksmith chromis, Blacksmith damselfish
Chromis punctipinnis

Giant kelpfish
Heterostichus rostratus

*Male California sheephead
Semicossyphus pulcher

*Female California sheephead
Semicossyphus pulcher

Señorita
Oxyjulis californica

Fish

*California scorpionfish
AKA Spotted scorpionfish
Scorpaena guttata

Pacific seahorse
Hippocampus ingens

*Opaleye
Girella nigricans

Californian killifish
Fundulus parvipinnis

*Goby spp.
Gobiidae

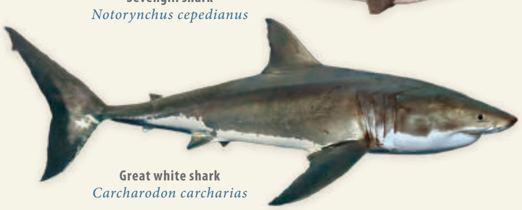
Pacific jack mackerel
AKA California jack mackerel
Trachurus symmetricus

Fish

*Horn shark
Heterodontus francisci

Spiny dogfish
AKA Spurdog, Mudshark, Piked dogfish
Squalus acanthias

Sevengill shark
Notorynchus cepedianus



Great white shark
Carcharodon carcharias

Invertebrates

*California Two-spot octopus
Octopus bimaculoides

Invertebrates

Bat star
Patiria miniata

*Purple sea star
AKA Ochre sea star, Ochre starfish
Pisaster ochraceus

Banded brittle star
Ophiolepis superba

*California sea cucumber
Parastichopus californicus

Sea anemone spp.
Actiniaria

*California sea hare
Aplysia californica

Invertebrates

*Wavy top turban
Megastraea undosa

*Abalone spp.
Haliotidae

*Sea snails
Gastrapoda

*California spiny lobster
Panulirus interruptus

*Sea urchin
Echinoidea

Western sand dollar
AKA Pacific sand dollar
Dendraster excentricus

Sea, Sand, Me!

Lesson by: Scholastic

This lesson plan is based on the book Sea, Sand, Me! by Patricia Hubbell

Book Summary

This delightful rhyming story captures the special moments a mother and daughter share when spending a day at the beach. Soft pastel illustrations help capture the beauty of a summer afternoon at the shore.

Objective

Activities will encourage children to hear and identify rhyming words and rhythmic text and recall events in the story.

Before Reading

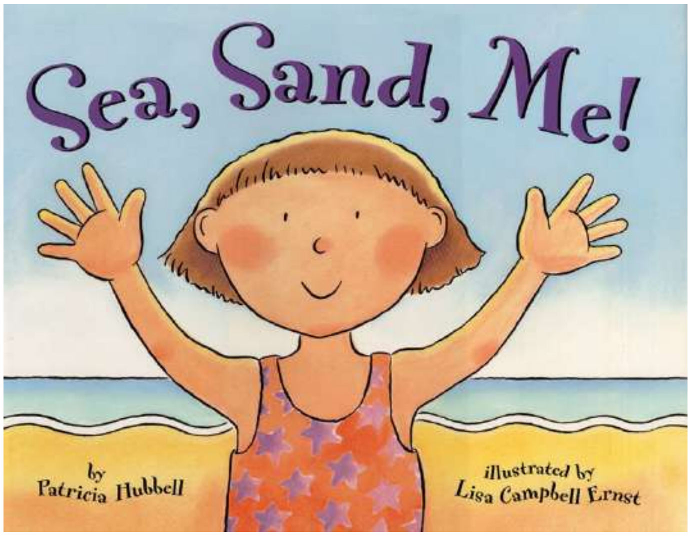
Show the children the book Sea, Sand, Me! by Patricia Hubbell. Ask them to predict what the story will be about. Record their predictions on chart paper. Read the story then compare their predictions with the story.

Teaching Plan

Materials

-Sentence strip paper
-Marker
-Pocket chart
In advance: Write the following sentences on individual strips of paper.

Pack up our beach bags and load up the car.
Put on my sun hat and put lotion on my nose.
Play in the sand.
Play with the birds.
Meet a friend and build a sand castle.
Play with seaweed and shells.
Dance in the water and jump in the waves.
Eat lunch.
Play beach ball and find shells.
Wave good-bye to my friend.



Sea, Sand, Me! cont.

1. Reread the story to a small group of children. Place the sentences into a pocket chart, mixing up the order of events. Or place them in the middle of the rug where they can read them. Read each sentence to the students.
2. Now ask the children to organize the sentences to match the sequences of the story. Encourage them to recall the events from the story. Invite them to refer to the book, if necessary.
3. Offer all the children an opportunity to engage in the activity. Keep the sentences and the book available so they can continue practicing this sequencing activity. Some students may even enjoy creating their own drawings to illustrate each sequence.

Read It With Rhythm

1. Read the book to the children with a lot of expression to emphasize the rhyme and rhythm of the text. Once they have become familiar with the story, invite them to join in as you read aloud. Students can clap along to the rhythm.
2. Now leave off the last rhyming word and encourage them to complete the sentence. Have fun reading this lively story as a group.

Rhyming Beach Words

1. Ask the class to create another list of words that describes the beach. Review the book's illustrations so they can identify different objects like the sun hat, beach bag, umbrella, and birds. They can also include additional words that are not included in the story, but relate to their own experiences at the beach.
2. Reread the new word list with the children. Now invite them to think of words that rhyme with these words. Add these to the list.

Rhyming Word Drawings

Materials

-Drawing paper
-Craypas, crayons, or watercolor paints
-Pencil
-Scissors
-Rhyming word lists
-Resealable plastic bags

1. Cut apart the rhyming-word lists the children developed in the previous activities. Put sets of rhyming words into individual resealable plastic bags.
2. Set up a table with art materials and invite several children at a time to do the activity. Tell them that they will each get a set of rhyming words and they will create a drawing about their words.
3. Then ask them to create a sentence or story about their drawing that includes their rhyming words. Can they make up their own rhyme? Offer assistance, if needed.
4. Invite the children to share their work during group time.

Shifting Sands

Lesson by: NOAA

The ocean is constantly in motion, and nearshore currents carry sand and sediment along with them. Structures we build to protect the coast from erosion can change the shapes of beaches, for better or for worse!

Activity

1. Have students read background material from "Background and Model Instructions" worksheet (allow 10 minutes or so).

2. Lead whole class discussion on beach erosion, cliff erosion, and the protection of beachfront property. Describe the processes that create beaches. (Wind, waves, currents bring sand to beaches; currents and waves move sand along the coast). What types of structures do people build to protect their coastal property? (Groins, rip-rap, seawalls.) What happens when you disrupt the natural flow of sand along our coast? (Some beaches are built up, while others get smaller. Smaller beaches increase the risk of erosion of coastal cliffs and bluffs.)

3. Following instructions on worksheet, guide students in building the models. Divide students into small groups (groups of five is preferable). Distribute pans, sand, and rulers. Students should bring a pencil and unlined paper to their group. Students use tape to label the shorter sides of the pan "East" and "West." Students pour up to 4 inches of sand into the east end of their pans, and then gently add tap water up to 2 inches deep on the west end of the pan.

4. Students fold their paper into fourths. Using one section labeled Diagram #1, students draw their experimental models.

5. Student #1 uses a ruler to create a gentle wave action in the pan, in a general west-to-east movement.

6. Each student draws how the model appears after wave action (label it Diagram #2). What are the effects of erosion? How has the coastline changed as a result of the wave action?

7. Student #2 positions the sand in its original model configuration. Student #3 sets two to three rulers on-edge into the sand lengthwise about 4 inches apart, representing groins. Student #4 uses a ruler to create the same gentle west-to-east wave movement. What happens in between the groins? What happens to the shoreline? Students draw Diagram #3. Now, Student #5 makes waves coming from the northwest.

Shifting Sands cont.

Results and reflection

1. Display the beach images with groins and jetties (next page). Ask students what they think are the forces at work here. (Currents, waves, actions of waves hitting a vertical surface, water carrying sand in suspension).
2. Compare and contrast jetties with groins. (Groins protect beaches from getting washed away by waves and currents. Jetties help to protect inlets and harbors from filling up with sand moving along shore. Both jetties and groins can be constructed of rock. Both affect beaches to either side.)
3. Discuss social and political aspects of building beach protective structures on public and private land. What happens if a beachfront homeowner wants her or his beach to be larger, because she or he is concerned the home is threatened by waves, and builds a groin to nourish the beach? The homeowner's property is located north of a public beach, and the longshore current goes north to south. What will happen to the homeowner's beach? What will happen to the public beach? Should he or she be allowed to build the groin? Who will be responsible for the loss of the multi-million dollar home if the groin is not built and the waves destroy the home and property? How could this situation have been prevented? Note: in most cases, a California homeowner would not be permitted to construct such a groin.

Conclusions

Currents, waves, and wind determine movement of sand along our coast. Structures we make to protect beaches may have unintended effects. Living on the coast requires cooperation and compromise.

Extensions and applications

Hold a classroom discussion or have students write research papers on the following topics.

- What are the effects on the coast due to the armoring of coastal cliffs that normally would be eroding?
- Rules, regulations, and laws govern the construction of groins, jetties, and concrete cliff barriers. How can we balance public safety and recreation needs with needs of private property owners?
- What are the benefits and risks of building on coastal cliffs and bluffs or beaches? How can we allow the natural forces of accretion and erosion to occur with minimum disturbance to human-made structures?

Shifting Sands cont.

Background and Model Instructions

Glossary

Seawall: A structure built on a beach, often made of concrete, parallel to shoreline, designed to protect buildings from the action of waves.

Revetment or rip-rap: A structure consisting of large rocks or other materials stacked in front of an eroding cliff, dunes, or structures to protect from wave attack.

Groin: A structure built perpendicular to the shoreline designed to trap sand moving along the shore due to the longshore current. A groin or group of groins usually extend to the end of the surf zone and are used primarily to replenish or stabilize beaches.

Jetty: Structures built in pairs that extend further into the ocean than a groin, to stabilize a navigation channel and keep the water calm for harbor entrances. The construction of both groins and jetties severely affects the flow of sand moved by the longshore current, depriving downstream beaches of sand.

Beach nourishment (replenishment): The process of moving sand from the offshore continental shelf or inland areas and depositing it onto the beach. Sand is dredged from the offshore shelf, often a mile or so from shore, and is loaded onto a barge which carries it close to the shore. The sand is sprayed onto a beach with the intent of widening the beach and increasing its height. The process of beach nourishment can be expensive, and it works best when the sand will stay in place for a long time. In some areas, winter storms have removed the sand added by the nourishment process within a single year.

Background

The ocean is in constant motion, fueled by currents, winds, tides, and waves. Every time you visit California's coast, you witness the effects of the powerful forces of ocean waves and currents (whether or not you can see them at the time). Currents usually can't be seen from the surface, but you can see waves as they break on the beaches, cliffs, or just offshore over submerged reefs. The word "wave" is used to describe an actual swell of water, as well as energy that moves through water.

Tsunamis. Waves can be caused by wind, undersea volcanic eruptions, or earthquakes, though most waves are caused by wind. Those caused by volcanic activity or earthquakes are called "tsunamis". A tsunami is a series of sea waves most commonly caused by an earthquake beneath the sea floor. In the open ocean, tsunami waves travel at speeds of up to 600 miles per hour. As the waves enter shallow water, they increase in height. The waves can kill and injure people and cause great property damage where they come ashore. The first wave is often not the largest; successive waves may be spaced many minutes apart and continue arriving for a number of hours.

Since 1812, the California coast has had 14 tsunamis with wave heights higher than three feet; six of these were destructive. The worst tsunami resulted from the 1964 Alaskan earthquake—it caused twelve deaths and at least $17 million in damages in northern California. Evidence suggests that large earthquakes capable of producing large tsunamis occur every two or three hundred years (California OES Earthquake Program, Earthquake Education Center, Humboldt State University). For information on what to do in case of tsunami, check this web site: www.wsspc.org/tsunami/CA/CA_survive.html

Shifting Sands cont.

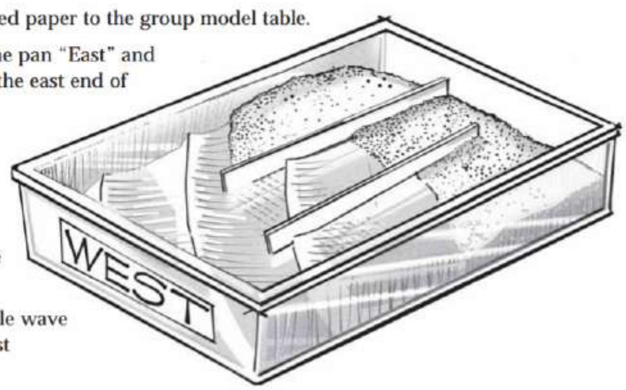
Surface Waves and Currents. Though both are powered by wind, waves and currents are different from each other. Waves transfer energy across the ocean surface from one part of the ocean to another. Surface currents are powered by the frictional drag of the wind on the ocean's surface, can be swift, sustained, and river-like, and are responsible for mixing water and transporting sediments and nutrients long distances. Surface currents are quite regular, and are formed in conjunction with major global wind patterns, whereas surface wave direction and velocity are affected by changing winds during storms and vary widely. As waves transfer the energy to the sea surface, the ocean water moves up and down, like a float bobbing on the water. The stronger and longer the duration of the wind, and the greater the distance over which it blows, the larger the waves. When a wave enters shallow water, it starts to feel the ocean floor and the lower part of the wave slows down while the upper part continues until it topples over. This is when it "breaks" on the beach. Breaking waves (or "breakers") also stir up sand and move it onto the beach.

Erosion, Transport, and Deposition. Currents and waves also move sediments along the shoreline. Removal of the sediments is called erosion. Movement of the sediment is called transport. When the sediments settle out on a beach, it is called deposition. During storms, waves and currents have more energy and more sand is removed. Coastal erosion is a natural process that occurs as cliff, bluff, or beach erosion. Coastal erosion is a fact of living on the coast, though many people (usually home and business owners who have valuable ocean front property) see it as a problem that must be contended with. Deposition causes some harbors to be filled with sand, and they then must be dredged regularly.

Building Beaches. Coastal engineers can "build" the size of their beach by constructing groins. An unfortunate side effect of jetties and groins happens on the beaches downcurrent of the structures. As the water moves with the longshore current, it carries sand with it. The water and sand hit the side of the groin, and the sand builds up on the beach that is upcoast of the jetty or groin. This means that the beach on the other side of the jetty or groin gets less sand, as the sand is stopped by the groin. What property owners do on their property can affect beachside property nearby and even public beaches.

Building a Beach Model

1. Each student brings a pencil and unlined paper to the group model table.
2. Using tape, label the shorter sides of the pan "East" and "West." Pour up to 4 inches of sand into the east end of the pans.
3. Gently add tap water up to 2 inches deep on the west end of the pan.
4. Fold your paper into fourths. Draw experimental model on one section and label it *Diagram #1* (use one-fourth of the paper).
5. Student #1 uses a ruler to create a gentle wave action in the pan, in a general west-to-east movement.
6. All students draw how the model appears after wave action (*Diagram #2*). What are the effects of erosion? How has the coastline changed?
7. Student #2 positions the sand to its original model configuration. Student #3 sets two to three rulers on-edge into the sand lengthwise about 4 inches apart, representing groins. Student #4 uses a ruler to create the same gentle west-to-east wave movement. What happens in between the groins? What happens to the shoreline? Draw *Diagram #3*. Now, Student #5 makes waves coming from the northwest. Do the beaches in between the groins change? All students draw *Diagram #4* to indicate how the beaches look after completing this wave action.



Critter Card Games

Lesson by: Monterey Bay Aquarium

Critter Concentration

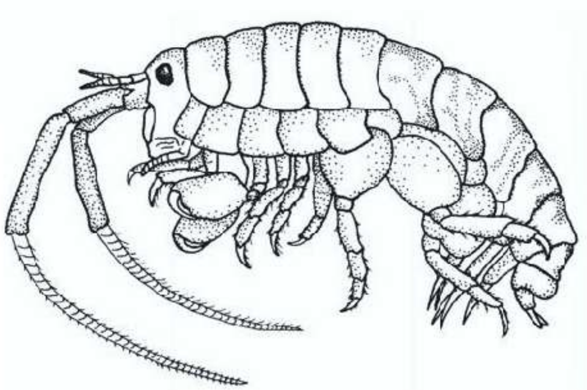
1. Print out two sets of critter cards. Color the cards and cut them out along the dotted lines.
2. Spread all the cards out face down on a table.
3. Mix them well and arrange them in rows.
4. Taking turns, each player chooses two cards and turns them face up so that all the players can see them. If the cards match, the player may keep the cards then take another turn. If the cards do not match, the player should turn the cards face down again. The next player can then take their turn.
5. The player with the most matching pairs wins.

Critter - Go Fish

1. Print several copies of the critter cards. Color the cards and cut them out along the dotted lines.
2. Use the cut-up cards to play Critter "Go Fish."

Guess Who

1. Print out two sets of critter cards. Color the cards and cut them out along the dotted lines.
2. Spread all the cards out face down on a table.
3. Mix them well.
4. Taking turns, each player chooses a secret critter card from the stack. Have the other players ask "yes" and "no" questions to guess your animal. For example, do you live in a shell? Do you have legs?

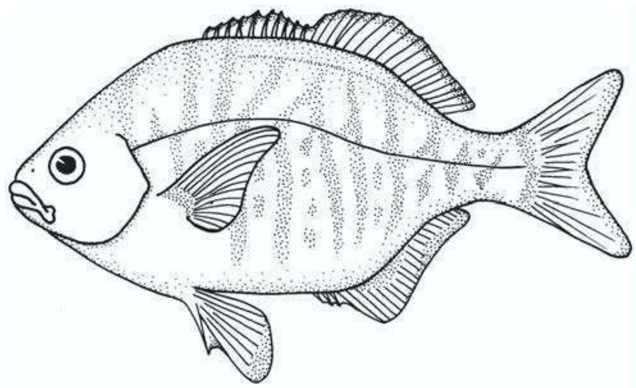


Beach hopper

Beach hopper
Orchestoidea californiana [size: to 1.1 in. (2.8 cm)]

Beach hoppers live high on the beach, out of reach of the waves. They burrow during the day to keep cool and moist and to hide from hungry shorebirds. At night, they come out and hop about in search of food.

Beach hoppers eat the seaweed that washes up on the beach.

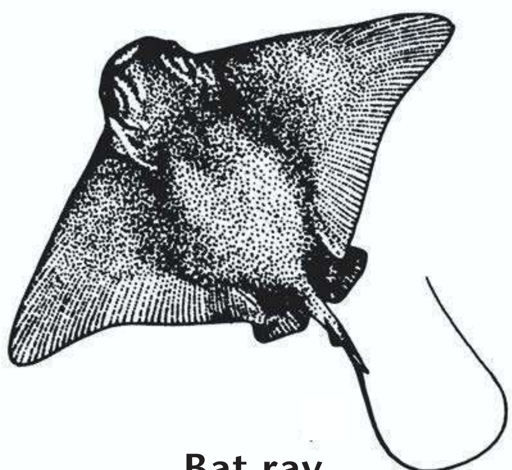


Barred surfperch

Barred surfperch
Amphistichus argenteus [size: to 17 in. (43 cm)]

Barred surfperch usually live in or just beyond the waves, but also venture into waters as deep as 240 ft. (73 m). Instead of releasing eggs, surfperches give birth to live young.

Barred surfperch feed on sand crabs, clams and other invertebrates. Fishermen catch and eat surfperches, as do seals and larger fishes.

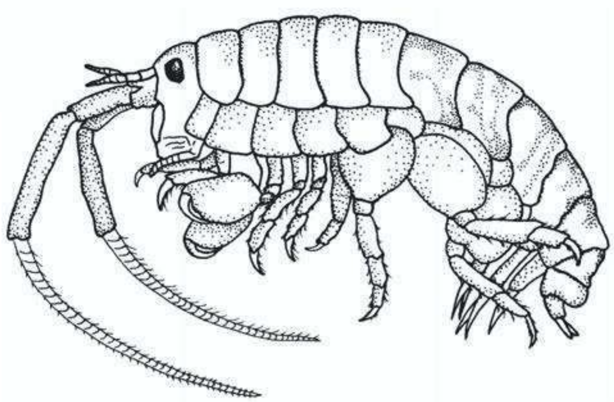


Bat ray

Bat ray
Myliobatis californica [size: to 6 ft. wide (1.8 m)]

Bat rays prey on clams, shrimp, worms and other invertebrates that live in the mud. Flapping their wings to clear away mud, rays suck up their prey, crushing the shells with their strong jaws and hard, flat teeth.

In summer, bat rays enter sloughs and bays where they give birth to live young. It's a trait they share with several other members of the shark family.



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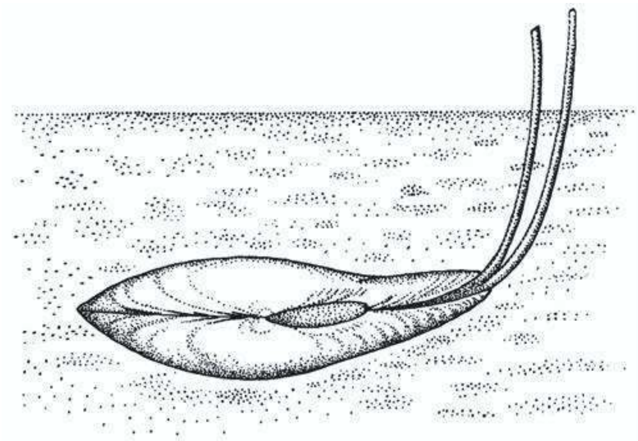
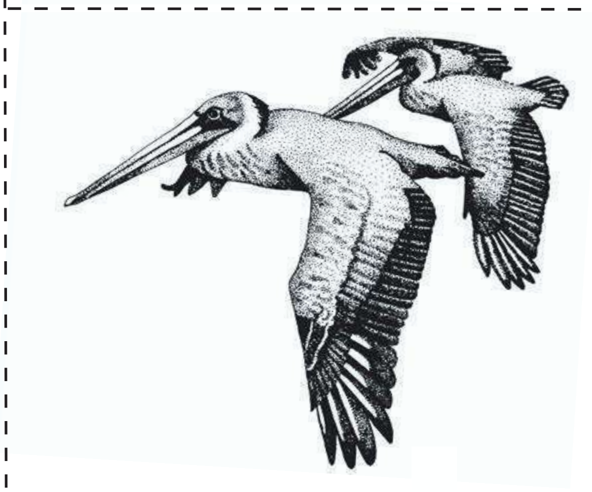


Bent-nosed clam

Bent-nosed clam
Macoma nasuta [size: to 2.5 in. (6 cm)]

Using its muscular foot, this clam digs about six inches down into the mud. It rocks back and forth as it digs, like a coin sinking in water. When it finally settles, it lies horizontally, not vertically like most clams.

To eat and breathe, it sticks a tube up to the mud's surface. Like a vacuum cleaner, the clam sucks down tiny particles, mostly the remains of plants and animals, along with sand and grit. Then it sorts the food from the muck.

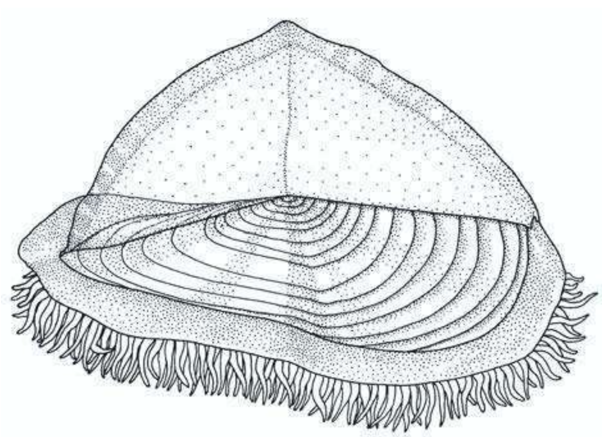


Brown pelican

Brown pelican
Pelecanus occidentalis [size: to 7 ft. wingspan (2 m)]

Thousands of pelicans visit Elkhorn Slough in summer and fall. In late fall, they migrate south to Mexico and South America where they build saucer-shaped nests on the ground or in trees and raise two to three young.

In the 1960s, heavy use of the pesticide DDT nearly killed all the brown pelicans. Today, DDT is banned in the United States. But its use in Mexico and other countries along with habitat loss within the pelican's range are still threats.

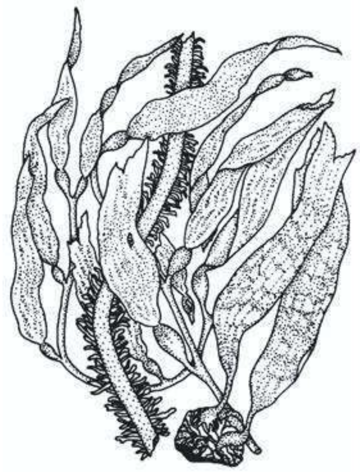


By-the-wind sailor

By-the-wind sailor
Velella velella [size: to 3 in. (7.6 cm)]

By-the-wind sailors usually live far out to sea, but many get blown ashore in the spring. The angle of the sail may determine where they land. Those whose sails angle to the left are blown to our coast, while right-angled ones sail toward Japan.

These jellyfish relatives use their tentacles to catch passing plankton.

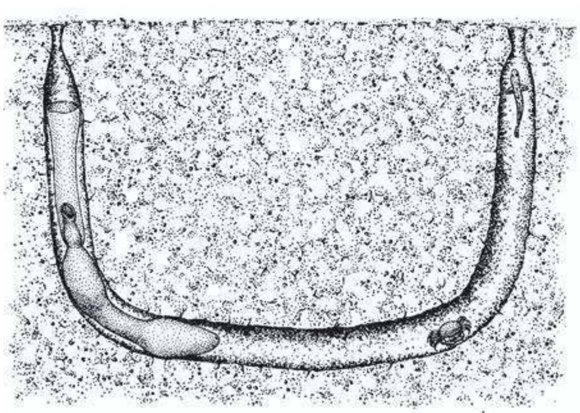


Drift seaweed

Drift seaweed

Rough waves rip seaweed from offshore rocks and toss it onto beaches. Often these tangles bring in offshore creatures that lived on the seaweed.

These seaweeds are the only large plants you'll see on the beach, so they're centers of activity. Small animals like beach hoppers eat the decaying algae and hide beneath it. Larger animals, like shorebirds, come to hunt the smaller animals.



Fat innkeeper worm

Fat innkeeper worm
Urechis caupo [size: to 20 in. (51 cm)]

An innkeeper worm digs a U-shaped tunnel in the mud. At one end, it attaches a mucous net that it secretes from special glands. Slowly pulsing its body, the innkeeper pumps water through its tunnel. As water flows through, the net traps tiny plankton floating in the water.

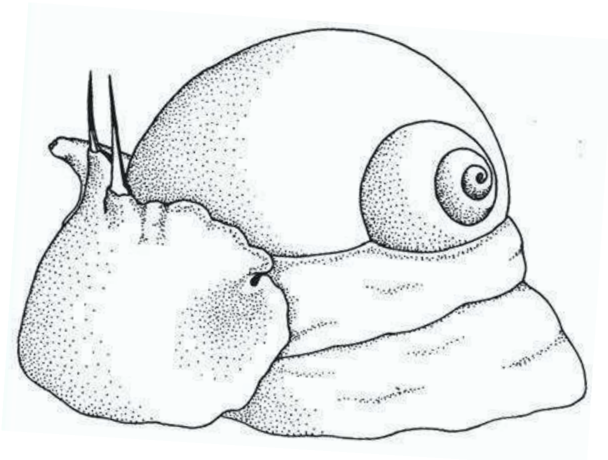
When the net is full, the innkeeper eats both it and the trapped food. Worms, crabs and even goby fish share the tunnel, eating anything the innkeeper misses.

Great blue heron

Great blue heron
Ardea herodias [size: to 6 ft. wingspan (1.8 m)]

Great blue herons live year-round at the slough. They depend on the slough to eat, rest and raise their young. Look for them standing still in shallow water, quietly waiting to snatch and eat small fishes that swim by.

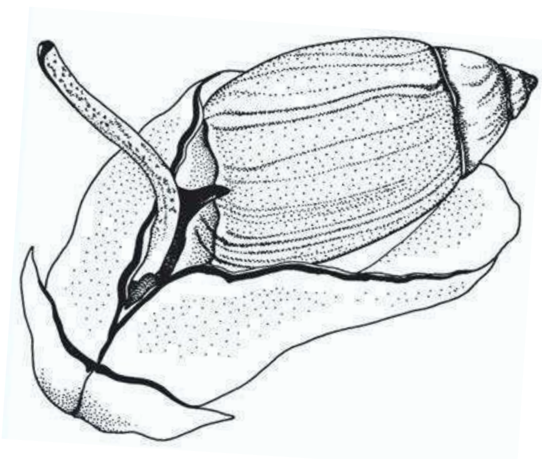
In early spring, great blue herons build nests in the tops of trees. Made of twigs and leaves, each nest shelters three to five bluish-green eggs. Both the male and female incubate the eggs, which take about two months to hatch.



Moon snail

Moon snail
Polinices lewisii [size: to 5 in. (13 cm)]

The moon snail plows slowly through the sand, hunting for clams. Finding one, the snail surrounds the clam with its huge foot. It drills a hole in the shell, rasping with its filelike tongue and softening the shell with a special liquid. When the hole is finished, the snail eats the clam's soft insides.

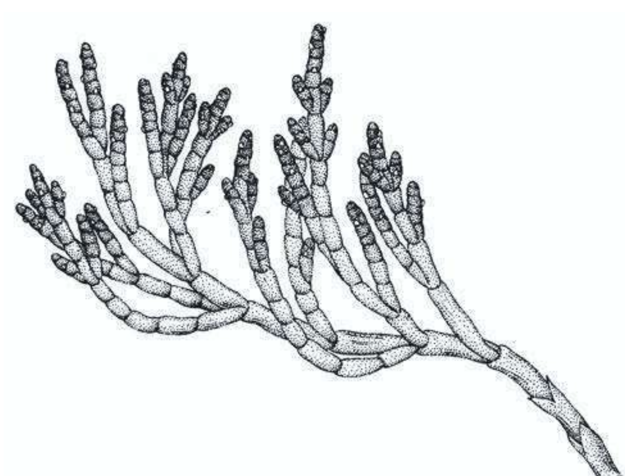


Olive snail

Olive snail
Olivella biplicata [size: to 1 in. (2.5 cm)]

The olive snail plows through the sand just below the surface, leaving a furrow behind. Its smooth, streamlined shell helps it slip through the sand. To breathe, the snail sends a tube above the sand.

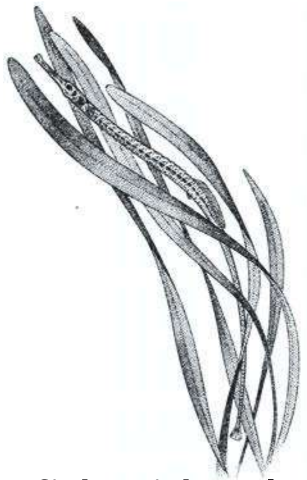
The olive snail eats dead animals and plants. It may also gather tiny food bits from the sand.



Pickleweed

Pickleweed
Salicornia virginica [size: to 25 in. (63 cm]

This plant can withstand salty conditions that would cause other plants to wither and die. Pickleweed draws the slough's saltwater into its stems and stores the extra salt in the tips of the stems. In fall, the stems turn color, becoming an orange or rosy red. Then they wither and drop off, taking the stored salt with them.

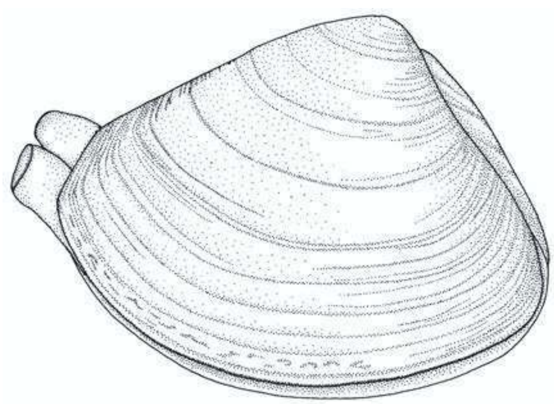


Pipefish with eelgrass

Pipefish with eelgrass
Syngnathus leptorhynchus with *Zostera marina*
[size: pipefish to 13 in. (33 cm); eelgrass to 3 ft. (91 cm)]

With its long and thin green body, a pipefish blends in well with the eelgrass blades it lives in. It even sways back and forth with the currents like eelgrass does.

Eelgrass, unlike most flowering plants, lives with its roots in mud under the water. Its matted roots trap sediments, helping to keep the mud in place and providing a stable home for many animals.

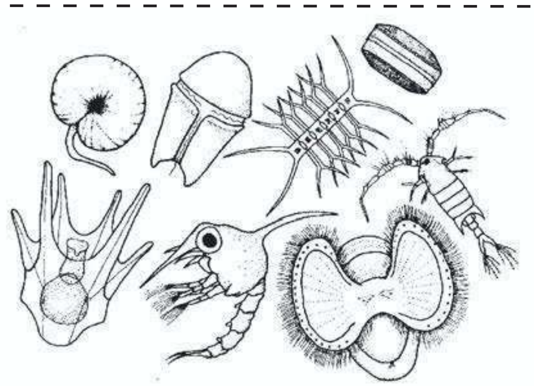


Pismo clam

Pismo clam
Tivela stultorum [size: to 6 in. (15 cm)]

Pismo clams dig into the sand near the surf zone. To dig, a clam pushes its foot downward through the sand like a wedge. Then it anchors the foot and pulls the shell along after it.

Clams send a feeding tube above the sand. They inhale water through it, filtering out tiny plants and animals called plankton.



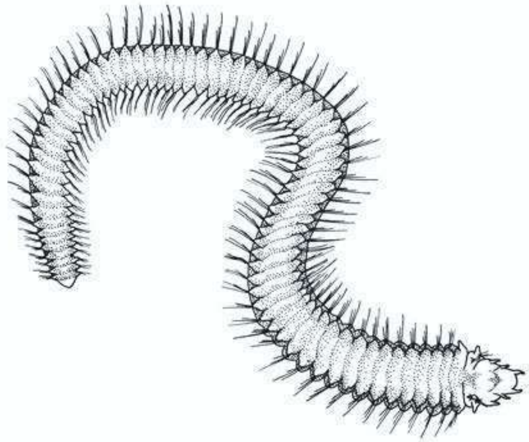
Plankton

(Plant plankton, top row from left: two dinoflagellates, chain diatom, diatom. Animal plankton, bottom row: sea urchin larva, crab larva, snail larva, copepod.)

Plankton

Plankton are plants and animals that drift on ocean currents instead of swimming. Most are tiny; these pictures are many times larger than the actual organisms.

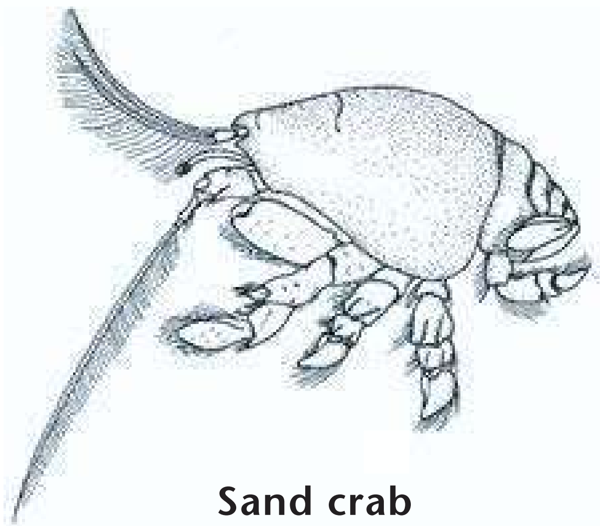
Plant plankton form the first link in many of the ocean's food chains. Animal plankton eat these tiny plants. Filter-feeders like clams and sand crabs eat both kinds of plankton.



Polychaete worm

Polychaete worm
Nephtys californiensis [size: to 12 in. (30 cm)]

This sandworm is similar to earthworms, but has a row of bristled flaps on each side. It burrows through the beach sand. If a wave uncovers the worm, it quickly swims down and digs in again. This worm preys mostly on smaller sand-dwellers.

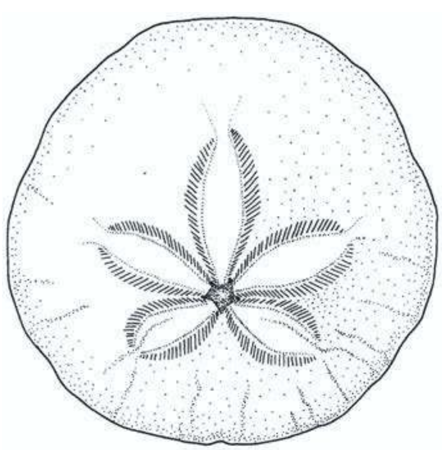


Sand crab

Sand crab
Emerita analoga [size: to 1.4 in. (3.5 cm)]

Sand crabs live in the surf zone, following the tide up and down the beach. To keep from washing away, they burrow tail-first into the sand. Burrowing also protects them from predators, like surfperches and plovers.

To filter plankton from the water, a sand crab sends fringed antennae up from the sand into the passing waves.

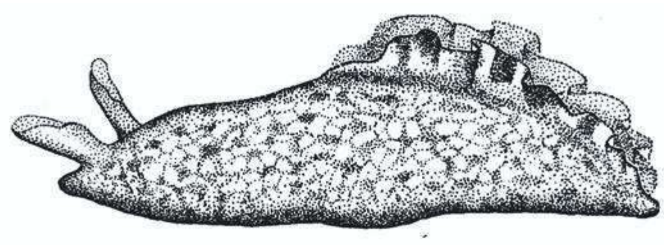


Sand dollar

Sand dollar
Dendraster excentricus [size: to 3 in. (7.6 cm)]

Sand dollars live half-buried in the sand just beyond the waves. They stand on end when the water is calm, but dig in during storms using their short spines. Young ones swallow heavy sand to weigh them down.

Sand dollars feed on plankton and small organic particles found on the sand or in the water.

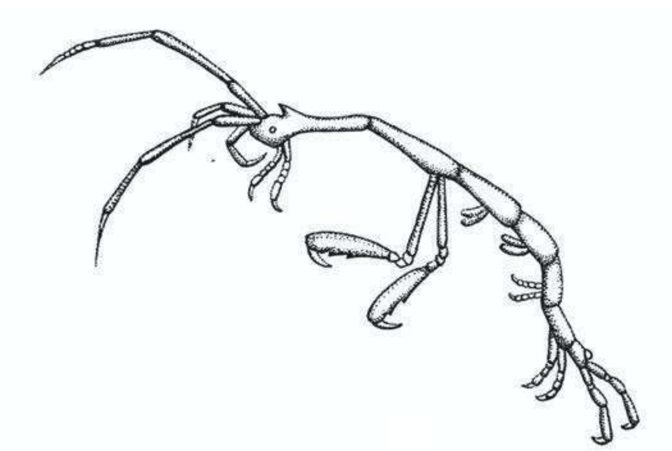


Sea hare

Sea hare
Aplysia californica [size: to 16 in. (41 cm)]

A sea hare glides along the muddy bottom, searching for algae to eat. With its filelike tongue, called a radula, it scrapes up its food, eating nearly 10 percent of its body weight a day.

An adult sea hare is both a male and a female, but it must mate with another sea hare. After mating, it lays strings of greenish eggs that look like spaghetti. Each string contains up to a million eggs.

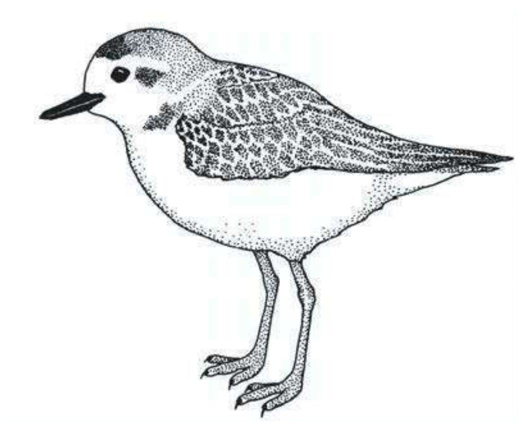


Skeleton shrimp

Skeleton shrimp
Caprella californica [size: to 1.5 in. (4 cm)]

You have to look closely to find skeleton shrimp. Their small, clear, sticklike bodies blend in well with the eelgrass where they live. They cling to the plants with three pairs of legs, and use their clawlike "arms" for grabbing food, fending off predators and cleaning themselves.

A skeleton shrimp eats whatever it can. It feeds on smaller plants and animals and scavenges for other bits of food.



Snowy plover

Snowy plover
Charadrius alexandrinus [size: to 6.5 in. (16.5 cm)]

Snowy plovers skitter about on the dry upper beach. They hollow out their nests right on the sand. This is safer than it might seem; both eggs and bird blend in so well, they're almost impossible to see.

Plovers eat sand crabs, beach hoppers and other invertebrates. They hunt in quick spurts, stopping to grab a bite, then darting off again.

MPA Migration

Lesson by: WILDCOAST

Time: 20-30 minutes

Group Size: 15+ students

Materials: Large open space, hula hoops/rope/cones/etc.

Activity:

In an open space, like a field or on the beach, denote a large rectangular playing area to represent the coast of California. Pick 3-4 students to play anglers and station themselves inside the playing field. Anglers are allowed to move throughout the game. The rest of the students will be fish, trying to migrate from one end of California to the other by running the length of the playing field without getting "caught" (tagged) by the anglers. Emphasize to the students that they are one population of fish, so they are not competing with each other. Rather, their goal is to have as many as possible successfully complete migration. Tagged students must go back to the start and wait for the next round.

For the first round play exactly as described above, expecting most of the fish to be caught. Ask students to think about what could be done to make their migration more successful. Place a hula hoop, or other marker, inside the playing field and explain to the students that this area denotes a marine protected area – a safe place where the anglers are not allowed to fish. Students standing in the MPA may not be tagged. Expect with only one MPA that migration will likely not be much more successful.

As you play continue to add more MPAs until you create a network of MPAs that spans the entire coast so students can jump from one MPA to the next without having to go in unprotected waters (students should not be tagged when jumping from MPA to MPA unless their feet touch the ground outside of the MPA). Discuss how this network approach led to the most success and why. The game ends when the entire fish population safely completes migration.

EXTENSIONS: 1) Include MPAs of different sizes. Include some so small that students may fall out and get tagged. Discuss how larger MPAs are more effective at saving populations. 2) Include different types of MPAs. For example, in state marine reserves there is no fishing, but in some state marine conservation areas there is limited fishing, so an angler could tag them (perhaps from a stationary point). Discuss how no take areas, such as state marine reserves, are the most effective at protecting populations.

MPA Detectives

Lesson Adapted From: San Diego Zoo's Ooey Gooey Guts

Activity Summary
In this activity students will dissect the "stomach" of a marine animal and use its contents to determine which animal their stomach is from and how their animal died.

Recommended Grades
4-8

Grouping
2-4 students per group

Time
Approximately 45 minutes

Anticipated Outcomes
Students will understand what a watershed is.
Students will understand human impacts on watersheds.
Students will learn to think like a scientist.
Students will learn to identify animals based on their stomach contents.
Students will learn some of the negative impacts humans are having on marine animals.
Students will brainstorm ways to mitigate the negative impacts humans are having on marine animals.

Materials
- Map of local watershed
- MPA Detectives dissecting mats (laminated)/One per group
- Gloves (optional)/One pair per student
- Goggles (optional)/One pair per student
- Smocks (optional)/One per student
- Tweezers/At least one per group
- Dissection containers (small, plastic tupperware works well)/Several per group
- Barrel of Slime (may be bought on Amazon) or clear Aloe Vera gel
- Assorted marine animal parts, shells, etc. (See Stomach Kits in Teacher Preparations for suggestions)
- Small trash items such as chip bags, plastic bags, nails, etc.
- Notebooks
- Pencils

MPA Detectives cont.

Teacher Preparations

Stomach Kits*: Assemble the following kits ahead of the activity and store them in tupperware until use. You can print and laminate pictures of the prey, use miniature figurines, or if you are feeling extra ooey gooey you can use actual animal parts! (Note: If using actual fish pieces, it is suggested to refrigerate stomach contents or add in right before lesson otherwise they get rather stinky).

Garibaldi - Anemones, moon jellies, nudibranchs, bryozoa, worms

Green Sea Turtle - Sea grass, algae

California Two-Spot Octopus - Crabs, clams, mussels, rockfish, spiny lobster

Leopard Shark - Rockfish, octopus, fish eggs, worms, crabs, clams

California Sea Lion - Abalone, squid, octopus, rockfish, anchovies, spiny lobster

***In each stomach kit add in some kind of trash (plastic bags, chip wrappers, nails, soda can rings, etc.) that will act as cause of death for that animal.**

Procedure

Introduction

Watersheds connect habitats all around us, yet few students understand what a watershed is. The primary goal of this lesson is to allow students to realize that all habitats are connected and even if they do not live near a body of water, what they do at home can have an effect all the way down to the ocean.

A watershed is any area of land where all of the water that falls in it, and drains off of it, goes to the same place. Many watersheds have bodies of water such as rivers, lakes, or ponds; however, some watersheds only get water from rainfall and human activity. Even though they may not realize it, every person on earth lives in a watershed that eventually connects to the ocean.

When exploring your local watershed it is helpful to show students a map displaying any bodies of water in your area and use it to trace how all of the bodies of water connect and eventually flow out of a single outlet.

MPA Detectives cont.

Ask students questions such as:

● Where does your local watershed start? (Typically in the mountains)

● Where does your local watershed end? (Eventually in the ocean)

● How does it get from the start to the end? (Through rivers, the ground, pipes, drains, etc.)

● How has human activity changed watersheds? (Many human activities release water into the watershed. Also, human-made drainage systems such as sewers and storm drains that have altered how water travels from the start to the end of a watershed).

Sometimes the water is cleaned and treated through a water treatment facility, but not all the water is treated. A large majority of it flows through storm drains, which is basically a big pipe that does NOT clean the water and leads straight to the ocean. So, with all that water flowing to the ocean without cleaning, the water becomes polluted.

Water becomes polluted because it is not just water that humans put into the watershed. Everyday people throw their trash on the ground. They think that they can throw anything on the ground and it will just disappear, but what really happens is it pollutes the watershed. In fact we use lots of things that pollute our watershed like pesticides, fertilizers, and oil that wash into our storm drains and sewer systems and pollute our oceans.

The stuff that ends up in our sewer system gets treated with chemicals before it is released into the ocean, but any water that runs into storm drains is left untreated. That means that any chemicals or trash in the water flows out into the ocean where it may be eaten by marine animals. So things like plastic bags get eaten by hungry sea turtles mistaking them for jellyfish and fish absorb fertilizers through their gills and get sick.

Tell students that a group of local scientists came upon a big pile of marine debris washed up on the shore at the beach today. They found a whole bunch of body parts and stomachs of animals, but are not sure how they got there or what animal they belong to. They have asked for our help to identify which animals the stomachs came from and to determine cause of death. Tell students that today they will have the opportunity to become scientists and carry out a scientific investigation.

MPA Detectives cont.

Activity

● Divide students into groups of 2-4 and pass out a kit containing one MPA Detectives Dissecting Mat, one animal “stomach,” tweezers, and several small dissecting dishes.
● Instruct students to empty the contents of their “stomach” onto the dissecting mat and use the tweezers to pick apart the stomach contents. Students may sort stomach contents into smaller dissecting dishes.
● Have students try to identify the stomach contents and record the findings in their notebooks.
● Tell students to refer to the dissecting mat to see if they can determine which animal their stomach came from based on the contents.
● Also tell students to look for any stomach contents that seem out of place to see if they can determine their animal’s cause of death.

Discussion

Have each group share what they found in their stomachs, which animal they think their stomach is from, and what they think the cause of death was.

As a whole group, or in smaller groups, ask students the following questions:

● Did your group find anything unusual in your stomach? (trash!)
● How do you think the trash got in your animal's stomach? (someone dropped trash on the ground and it went through a storm drain and into the ocean)
● Did you realize that what you do at home affects the animals in the ocean?
● Do you think most people realize that what they do at home affects the animals in the ocean?
● What are some possible ways that we can help prevent trash from entering into our local watershed and ending up in the ocean?

Assessment

Have each group design a poster that encourages people to protect the local watershed.

WILDCOAST
COSTASALVAJE

MARINE PROTECTED AREA DETECTIVES

Do you have the guts to solve the mystery?