Estuary: Background Information
& Pre and Post Activities

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.

<u>Everything is related to everything else</u>

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.

<u>Everything depends on something else</u>

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.

<u>Everything must go somewhere</u>

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.

<u>Earth's resources are limited</u>

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 SAN FRANCISCO ESTUARY ECOSYSTEM

An *ecosystem* is "a community of plants and animals and the environment with which it is interrelated." The Bay has distinct ecosystems, some of which are covered with water and some of which are not. These areas are divided into open water, salt marsh, mud flat, salt pond and upland. Many of the Estuary's animals and plants can be found in more than one ecosystem or habitat.

The San Francisco Bay-Delta Estuary is California's largest and best-known *estuary*. A bay is a partially enclosed inlet of the ocean. An estuary is a partially enclosed coastal inlet where fresh water and salt water meet and mix. Fresh water enters San Francisco Bay primarily from the Sacramento and San Joaquin rivers and also from creeks and streams. Salt-water enters through the Golden Gate from the Pacific Ocean. These two kinds of water are mixed by winds and tidal currents, and as a result, the water of San Francisco Bay is termed *brackish*.

This rich and complex ecological system supports the largest sport fishing area and the largest remaining marshes in the state. Thirty species of endangered plants and animals use the Estuary during at least part of their lives. Two-thirds of the state's salmon and nearly half of the waterfowl and shorebirds migrating on the Pacific Flyway pass through the Estuary each year.

GEOLOGIC HISTORY

Twenty thousand years ago there was no Bay. At that time, much of the earth's water was frozen in glaciers that covered a large part of the northern continents. The Pacific shoreline lay out beyond the Farallon Islands, and the Bay itself was dry bedrock composed of sandstone, siltstone, chert, and greenstone known as the Franciscan Formation (Harold B. Goldman 1969).

As the glaciers slowly melted, the ocean waters rose, and by 10,000 years ago the ocean had spread inland through a gap in the outer Coast Range known today as the Golden Gate. For thousands of years the water rose rapidly, at a rate of about one inch a year, advancing the shoreline nearly 100 feet each year. Gradually the rate slowed until several thousand years ago when sediments accumulated in the shallows faster than the sea could cover them. This thick, young Bay mud supported the expansion of tidal mudflats and marshes along the Bay's shore, and offered habitat for a diverse population of organisms.

HUMAN HISTORY

Native Americans occupied the shores at least as early as 3,500 years ago. The abundance of food and the mild climate supported over 50,000 native people, but today the only physical remains of that society are 400 shell mounds, or middens, scattered around the Bay.

The Spanish established a mission and presidio at San Francisco in 1776, but there were few settlers in the region until 1848, when James Marshall found a golden nugget in the American River. The Gold Rush caused some of the earliest, major environmental destruction in California, and reduced the size of the Estuary considerably. Hydraulic mining, practiced by gold rushers between 1853 and 1884, added millions of cubic yards of sediment into Sierra foothill rivers, much of which was deposited in the Estuary. High-pressure water jets were used to quickly erode mountainsides. The resulting sludge and rock were sluiced through boxes designed to catch the heavier particles of gold. Eventually, sediments flowed southward causing massive population depletion of oyster beds.

Between 1860 and 1930, all but a small percentage of the Delta's 350,000 acres of freshwater marsh were diked and planted with crops to feed the state's growing population. The Bay's waters have been severely polluted and over 60% of the Bay has been filled with garbage or levied off from tidal action. In 100 years, the larger Bay territory has decreased from 720 to 480 square miles. In the process, many fishery resources have been lost and valuable wildlife habitat and recreation space have been lost or altered.

INTRODUCED SPECIES

Scientists estimate there are now about 212 non-native species now living and reproducing in Bay waters (Cohen and Carlton, 1995). The first invasions occurred in 1848, when gold seekers came to the area in wooden ships. Water stored in the hold of the ships, called ballast, is used to stabilize large vessels; once the vessel arrives in port, the ballast is flushed out, instantly transporting a myriad of foreign organisms into the Bay. Many invertebrates have been particularly successful in their adaptation to a new environment, and have taken over habitats that once belonged to native species. For example, the Asian clam *Potamocorbula* was brought over by ship ballast in 1986, and has taken over the bottom of the North Bay, resulting in depleted phytoplankton populations. The introduced red fox *Vulpus fulva* preys on the eggs of the endangered California clapper rail (*Rallus longirostris obsoletus*). Exotic or introduced species are now being more closely studied as an environmental phenomenon that could obliterate many native species in the Bay.

THE IMPORTANCE OF BIODIVERSITY

Biological diversity (or biodiversity) is the variety of all life forms on Earth - plants, animals and microorganisms. It refers to species (species diversity), variation within species (genetic diversity), and interdependence within species (ecosystem diversity). Today, 17,500 species become extinct every year. Obviously, this is having a negative effect on the biodiversity of Earth's ecological system. This accelerated rate of extinction should be of concern to us all for several reasons.

- The first and perhaps most important reason is *moral.* As the dominant species on the planet we have a responsibility to protect our only known living companions in the universe.
- Second, within the 5 to 30 million species that exist there is a vast unidentified wealth of *genetic and medicinal information*.
- The third reason is *aesthetic*. Although it is impossible to put a monetary value on the enjoyment we receive from seeing and learning about wild animals or hiking through forests and meadows, we nevertheless know that quality of life is enhanced by the amount of unpolluted areas which exist adjacent to human communities.
- The last, but not least reason is *interdependence*. An ecosystem is made up of both biotic (living: plants, animals, bacteria and fungi) and abiotic (non-living: soil, climate andgeological formations) components. These components are inextricably and intricately intertwined.

BIODIVERSITY IN THE BAY AREA

Sea otters used to be a common sight in the San Francisco Bay. Grizzly bears came down from the hills to hunt salmon and cougars singled out individual deer, elk and antelope from herds as big as 400! With the exception of deer and the few salmon that remain, all these animals have been extirpated (eradicated).

The two main causes of species extirpation in the Bay Area are *habitat loss* and *pollution*, although disease and human disturbance such as hunting, dredging and freshwater diversion are also part of the problem.

Habitat is a broad term and can be broken down into various components, depending on the species. A species nesting site can be very different from where it forages or where it overwinters. For example, the California clapper rail is a non-migratory resident of the Bay Area. It is doubly threatened because its nesting habitat, the high tidal salt marshes, are being converted to salt ponds and urban developments, while its foraging habitat, eelgrass beds in low tidal areas, is being destroyed by increased motorboat use in the Bay.

Setting aside small wildlife preserves usually secures some habitat for some species, but it often results in two significant threats to populations: habitat fragmentation and genetic isolation. Populations limited to isolated habitats are vulnerable to extirpation by natural or human-caused catastrophes such as floods, developments or chemical spills. In addition, isolated populations have a severely limited genetic pool, which can lead to inbreeding and a general weakening of the population, bringing extinction that much closer.

Pollution is defined as a harmful degradable or non-degradable contaminant (usually waste, sediment or chemical in form) discharged into the environment. The primary sources of contaminants in the Estuary include urban runoff, river inflow from agricultural discharges, municipal waste treatment effluents, industrial effluents, and dredging and dredge material disposal.

OPEN ESTUARY ECOSYSTEM

The open waters of the Estuary are a very special kind of environment. As the largest habitat in the Estuary, open water extends from the Delta to the Golden Gate and includes Suisun, San Pablo, and San Francisco Bays. The rivers and streams that empty into the Delta carry many nutrients from the land, as does the tidal cycle, which allows a vital exchange between the ocean and the Bay.

The Estuary currently supports two small commercial fisheries for herring and bay shrimp. The most important class of sport fishes are the *anadromous* fish, which live some or all of their adult lives in salt water, but move upstream into fresh water to spawn. These species include Chinook salmon, steelhead trout, striped bass, American shad, white and green sturgeon, and Pacific and river lamprey. These fish, and others such as leopard sharks, halibut, sculpins, and anchovies, are born in the marshlands and shallow areas bordering the Bay. The abundance of nutrients in the water can support a large number and variety of organisms.

Large predators of the open ocean do not frequently enter the Estuary. Protection from predators and an abundance of food make this a good place for the young of many species to live. A large portion of the marine animals that humans use for food spends part of their life cycle in an estuary. For this reason, estuaries are sometimes called the nurseries of the sea. The rich diversity of fish, in turn, provides feeding opportunities to harbor seals and diving ducks. Even shallow open water is critical for invertebrates, ducks and various shorebirds.

OPEN ESTUARY PLANT AND ANIMAL SPECIES

Plankton
Spider crab *Pyromaia tuberculata*
Tube worm *Asychis sp.*
Mud mussel *Musculus senhousia*
Asian clam *Potamocorbula amurensis*
Leopard shark *Triakis semifasciata*
Bat ray *Mylobatis californica*
Starry flounder P*latichthys stellatus*

HUMAN IMPACT ON THE BAY

Urban, industrial, and agricultural development of California has dramatically altered the San Francisco Estuary. The watershed of the San Francisco Estuary (the area of land that forms the drainage for many streams and rivers) covers 40 percent of California and extends north into Oregon. Nearly half of the Estuary's watershed has been turned into farms and range lands, and about a fifth is now irrigated. Changes in land use and population are the fundamental causes of many of the changes in the Estuary, including the diking and filling of its wetlands, the increase in pollution, and the increase in water diversion.

LOSS OF WETLANDS

Of the original 720 square miles of natural marshland that once covered two-thirds of the Estuary's surface, only about 75 square miles remain. The wetlands have been eliminated by filling and diking for urban development, agriculture, and salt evaporation ponds. Since these marshes are of great importance in the productivity of the Estuary, their loss has a definite and direct impact on fish and wildlife populations. At least seven species of insects, one reptile, three birds, and five mammals have completely disappeared from the Estuary, primarily as a result of habitat loss.

Many of the Estuary's rare or endangered species are found only in specific wetland habitats. Before the destruction of its marshes, the Delta was a major nesting area for waterfowl, and supported herds of tule elk and antelope, along with grizzly bear and mountain lion, all of which have now disappeared from this area. Today, over 100 species are now protected by a combination of state and federal laws, although destruction still occurs.

DREDGING

Over 7 million cubic yards of sediment are dredged from the shipping channels of the Bay each year. Most of this material is dumped at three sites in the Estuary: the Alcatraz Site; the San Pablo Site; and the Carquinez Strait Site. Local fisherman complain that this has ruined the fishing in recent years due to increased turbidity (opacity of water, an indicator of how much sediment, plankton or organic matter is suspended in the water). Benthic invertebrates may also be displaced by dredging, or buried by sediment disposal. Until 1975, dredged sediments were also used to fill in diked wetlands, including those underlying Foster City, the San Francisco and Oakland airports, and parts of Alameda.

DAMS & DIVERSIONS

About half of the average flow of fresh water coming into the Estuary is diverted to Bay Area cities, Delta farmers, and Southern California for farm irrigation. Dams and other disruptions of the natural flow of water have damaged *anadromous* (fish that spend their adult life in salt-water, yet migrate upstream to fresher water to spawn) fish populations. Pumps that draw water from the Sacramento River Delta, primarily for irrigation, suck up about half of the Chinook salmon that are born each year. The decline in the amount of fresh water input also affects the populations of plankton species and benthic organisms.

POLLUTION

Pollution is a harmful degradable or non-degradable substance (usually waste, sediment or chemical in form) discharged into the environment. Pollution has been a problem in the Bay since the early 1900s when raw sewage was dumped into the water and the first major oil refinery was built. The sources of pollution in the Bay include industry, farms, boats, and even our own houses, cars, gardens and pets. Although progress has been made over the past several decades, the region still does not meet the standards set by the Clean Water Act of 1972. Surface water pollution falls into two main categories, point source pollution and non-point source pollution.

Point Source Pollution - This type of pollution enters the water at a particular point, or site. An example is the 50 municipalities and 140 industries that dump untreated wastes into the Estuary each year, including 300 tons of trace metals. Areas of water with poor circulation, such as the far South Bay, are thought to be most vulnerable.

Non-point Source Pollution - Non-point source pollution does not enter the water from any one traceable source. After a rain, urban runoff carries pollutants such as oil, grease, lead and zinc from the streets, into rain gutters and into tributaries and stormchannels. These channels bypass any treatment and feed directly into the Estuary. Agricultural runoff, which contains pesticides, herbicides, nitrates and metals leached from the soil, is responsible for huge amounts of non-point source pollution entering the Estuary. Other contaminants are accidental spills, pollutants from landfills, smog which becomes acid rain, and fire.

HEAVY METALS

Of the many non-point source pollutants entering the estuary, heavy metals are a great concern because of their potentially toxic effects on animals, including humans. Very small amounts of some metals are essential to the proper functioning of body systems. However, excessive amounts of these metals have been shown to be highly carcinogenic and damage body systems necessary for life. Metals entering the estuary that are bioavailable can accumulate in animals, causing illness and even death.

Some heavy metals entering the Bay are:

- Cadmium: This may get into water from waste discharged by electroplating and battery plants. It is neither essential or beneficial for plants and animals, and considered a highly toxic metal.
- Copper: Essential to all organisms, mostly for respiration functions. A major source of copper is its common use as an algacide.
- Lead: Lead is not an essential element needed for human nutrition. The main source of lead is from automobile exhaust. Where bridges cross waterways, lead may be concentrated in sediment.
- Zinc: Zinc is essential for organisms in very small amounts. The main source of zinc is the residue left on roads due to the normal wear of rubber tires.

PROTECTING THE ESTUARY

The reduction of non-point source pollution is one area where people can make a dramatic impact on the overall health of the Estuary. All storm drains in the Bay Area lead directly to the Bay. Just one quart of oil dumped into a storm sewer can contaminate up to 250,000 gallons of Bay water. Recycling used motor oil rather than dumping it, taking a car to the car wash instead of washing it at home, and picking up litter are all examples of how an individual can make a difference. Other examples include substituting safe alternatives for toxic household products, recycling hazardous wastes, carpooling to reduce air pollution, and of course the 3 R's: Reuse, Reduce, and Recycle. Understanding that an individual has the power to have a positive impact, however small, and committing to making the appropriate changes in our everyday lives, is the first step in preserving the health of the Estuary.

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.
BENTHOS	The substrate at the bottom of a body of water; the adjectival form of benthos is benthic.
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.
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.
CARAPACE	In crustaceans, a hard portion of the exoskeleton that covers the fused head and thorax.
CARNIVORE	An animal that consumes other living animals.
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.
ECOLOGY	The study of relationships between organisms and their environment.
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.
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.
NUTRIENTS	The raw materials necessary for continuing life processes.
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.
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.
SCAVENGER	An organism that is an opportunistic feeder; scavengers usually include dead and decaying animal flesh in their diets.
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 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.
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.
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.

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PRE-VISIT ACTIVITIES

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.

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.

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."

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

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

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.

WRITING THANK YOU LETTERS

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.