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EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

February 13, 1991

Dear Dave:

Thank you very much for the packet of materials that you gave me during the PCAST meeting last Thursday. Clearly, Dr. Steven Webster of the Monterey Bay Aquarium and his staff have done an excellent job in developing their programs for teachers.

Your note of January 30, 1991 and the duplicate packet arrived yesterday. The Postal Service may not have been at fault, since there are sometimes security-related delays in receiving packages here at the Executive Office Building.

Best wishes.

Sincerely yours,



J. Thomas Ratchford
Associate Director

cc: D. Allan Bromley

Mr. David Packard
26580 Taaffe Road
Los Altos Hills, CA 94022

DAVID PACKARD
26580 TAAFFE ROAD
LOS ALTOS HILLS, CALIFORNIA 94022

January 30, 1991

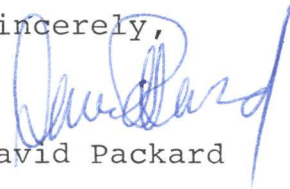
Dr. J. Thomas Ratchford
Assistant Director
Policy and International Affairs
Office of Science and Technology
OEOB, Room 494
Washington, D.C. 20506

Dear Dr. Ratchford:

Enclosed is a packet of materials prepared
by Dr. Steven Webster, Director of Education, for
the Monterey Bay Aquarium.

The materials are representative of the
Aquarium's Teacher Programs projects and materials.

Sincerely,



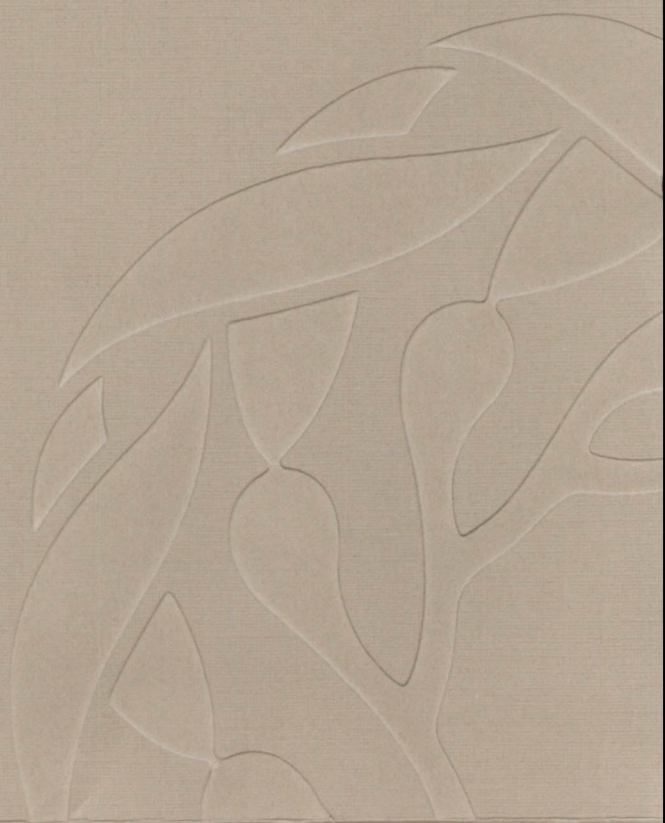
David Packard

DP/gd

Enclosure



MONTEREY BAY AQUARIUM





ABOUT THE AQUARIUM

The Monterey Bay Aquarium focuses on the marine life of Monterey Bay, one of the richest, most varied marine areas in the world. A gift to the community from David and Lucile Packard, the aquarium is operated by the non-profit Monterey Bay Aquarium Foundation. Its goal is to increase public awareness and enjoyment of the marine and shoreline communities of Monterey Bay.

The aquarium occupies the site of the Hovden Cannery, where tons of sardines were processed during Cannery Row's heyday. Though little of the old cannery remains, three huge boilers and replicas of the original smokestacks are colorful reminders of the historic cannery days.



EXHIBIT HIGHLIGHTS

Three main exhibits (Kelp Forest, Monterey Bay Habitats and Sea Otters) provide views of the undersea world previously available only to SCUBA divers. The Kelp Forest and Monterey Bay Habitats are among the world's largest aquarium tanks. These and 83 smaller exhibits are home to more than 5,500 plants and animals representing 550 species of fishes, birds, mammals, invertebrates and plants.

Volunteer Aquarium Guides in rust-colored jackets and aprons are stationed throughout the exhibits to answer questions and help your class investigate the mysteries of the bay.

MARINE MAMMALS GALLERY

A 27-foot gray whale skeleton leads the way into the Marine Mammals gallery, where full-sized models of Monterey Bay marine mammals swim overhead, suspended in mid-air. A 43-foot mother gray whale and her calf, complete with barnacles and whale lice, crowd the air along with orcas, dolphins, porpoises, seals and sea lions. Interpretive graphics and videos reveal their adaptations to the aquatic realm.

Four sea otters romp in the sea otter exhibit. Three were orphaned by winter storms; the fourth was a twin abandoned by her mother. Views of the animals above and below the water surface provide unique study opportunities for scientists and students alike.

THE KELP FOREST EXHIBIT

This 335,000-gallon, three-story exhibit gives a diver's-eye view of a complex kelp forest community. Towering stands of giant kelp sway in the surge created by a wave machine hidden in the rockwork walls. Giant kelp provides a home for hundreds of seaweeds, invertebrates and fishes. The tank height, 28 feet, makes it the tallest such exhibit in the country.

In the second floor Kelp Forest gallery students get a closer look at kelp forest inhabitants and learn about their roles in the community. At the Kelp Lab they touch slippery seaweeds and use dissecting scopes to observe the tiny creatures that live in a holdfast.

OCTOPUS AND KIN

Two giant octopuses and some remarkable relatives live here. The most primitive, the chambered nautilus, is one of our few non-native species.

MONTEREY BAY HABITATS EXHIBIT

The 326,000-gallon Monterey Bay Habitats exhibit gives you a view of five distinct habitats of Monterey Bay: the deep reefs, the sandy seafloor, the shale reefs, the wharf and open ocean. Large sharks and other open-sea fishes roam the huge tank. The surrounding galleries provide close-up views of the creatures living in each habitat.

THE SLOUGH

The Elkhorn Slough gallery focuses on one of the state's most important remaining wetlands. You can view clams, see ghost shrimp in their subterranean homes, peek at a fat innkeeper worm and try to find pipefishes and flatfishes camouflaged in an eelgrass bed.

THE SANDY SHORE AVIARY

Enter our aviary for a walk from the saltmarsh past dunes to a wave-swept sandy beach. You'll come within inches of ducks, plovers, stilts and others, most hatched and hand-raised at the aquarium. Surfperches, sharks and other fishes swim in tidal creeks and along the beach.

BAT RAY POOL

At this sand-bottomed pool, visitors can pet gentle, graceful bat rays. These placid shark cousins enter shallows to bear their young.

THE ROCKY SHORE

Fierce competition for space dominates the world between the tides. Learn about rocky shores through interactive exhibits: a viewer-operated camera that pokes among crevices, a touch pool, an indoor wave crashing into outdoor tide pools, videos and more.

From the deck you can view the Great Tide Pool, which encloses a natural community of seaweeds, invertebrates and fishes. Sea otters, seals and sea lions make unannounced visits from time to time; rehabilitated harbor seals and birds can recuperate here, too.

THE COASTAL STREAM

These indoor/outdoor granite pools display the coastal streams steelhead and salmon breed in on their return from the sea.

SPECIAL EXHIBITS

Gallery space on the second floor features a new and different exhibit each year. Some of these special exhibits introduce exotic sea life from the Pacific; others focus on fascinating favorites from Monterey Bay.

BIRDVIEWING

From the second floor you can enjoy a panoramic view, and look through telescopes to spot seabirds and shorebirds in the bay.



MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT



MONTEREY BAY AQUARIUM

MISSION STATEMENT

The purpose of the Monterey Bay Aquarium is to stimulate interest, increase knowledge and promote stewardship of Monterey Bay and the world's ocean environment through innovative exhibits, public education and scientific research.

This mission is to be accomplished with a high regard for quality and creativity, and with policies and programs that ensure financial self-sufficiency, a challenging and satisfying environment for employees, sensitivity to our community, and a clear focus on the needs and interests of our diverse audience.

MISSION OBJECTIVES

Offer exhibits that are creative, educational and enjoyable; that set high standards for quality and scientific accuracy; and that present living systems in a stimulating, original way.

Conduct programs in public science education that serve all ages and backgrounds and instill greater understanding of natural systems and the need to protect them.

Conduct scientific research on the biology and husbandry of organisms relevant to the aquarium's exhibit program; collaborate with other ocean science research institutions to further mutual research goals; and interpret research efforts for the public.

Promote public stewardship of the natural world, leading to wider environmental awareness, a stronger conservation ethic and a greater commitment to protection of ocean resources.

Manage the aquarium so that it is financially self-supporting on a continuing basis with adequate reserves for necessary maintenance, improvement and replacement of equipment and facilities, in order to meet the aquarium's non-profit objectives.

Maintain strict adherence to the highest standards of quality, and by exercising a leadership role among aquariums worldwide, encourage others to do the same.

Create and maintain a work environment for paid and volunteer staff that promotes teamwork, attracts competent, motivated people and provides creative challenges and incentives.

Enrich the quality of life in our community by providing a cultural and educational resource that promotes appreciation of the region, creates employment opportunities for residents and remains sensitive to community needs.



MONTEREY BAY AQUARIUM

886 Cannery Row Monterey, CA 93940-1085
Telephone (408) 648-4800 FAX (408) 648-4810

Overview

GRAND OPENING:	October 20, 1984
LOCATION:	886 Cannery Row, Monterey, California
HOURS:	10:00 a.m. to 6:00 p.m. daily except Christmas
ADMISSION RATES:	General \$8 Students and seniors (65 and over) \$5.75 Children (ages 3 through 12) \$3.50 Group rates for 20 or more (by reservation, 408-648-4860)
PUBLIC INFORMATION:	(408) 648-4888
OPERATING BASIS:	Nonprofit, self-supporting
GROUND BREAKING:	Spring, 1980
COST:	\$55 million
GALLERIES AND MAJOR EXHIBITS:	More than 100 galleries and exhibits explore the many habitats of Monterey Bay. The three largest exhibits are the Kelp Forest (335,000 gallons); Monterey Bay Habitats (326,000 gallons); and Sea Otters (55,000 gallons).
SPECIMENS:	More than 6,500 specimens represent 525 species of fishes, invertebrates, mammals, birds, and plants found in Monterey Bay.
FEEDING SHOWS:	Sea Otters at 11:00, 2:00 and 4:30 Kelp Forest at 11:30 and 4:00 (diver hand feeding)
ATTENDANCE:	First year: 2.35 million Average annual: 1.7 million Total through 1989: 9.2 million
STAFF AND ADMINISTRATION:	280 full and part-time; 600 volunteers. Eight divisions: Curatorial, Education, Research, Exhibits, Facilities, Finance and Administration, Marketing, Merchandising
ACCOMMODATIONS FOR DISABLED:	All exhibits, graphic displays and aquarium facilities are accessible to disabled persons.
ACCOMMODATIONS FOR FOREIGN VISITORS:	Free, self-guided tour scripts with maps in Japanese, German, Spanish, and French.



MONTEREY BAY AQUARIUM

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Aquarium Facts

GOAL:

The Monterey Bay Aquarium is a non-profit, self supporting institution. Its purpose is to increase understanding and awareness of Monterey Bay and the marine environment through sea life exhibits, public education and scientific research.

THEME:

Monterey Bay ranks among the world's most spectacular marine regions, and the aquarium's interpretive exhibits and galleries highlight the colorful and complex array of marine life found here. This local focus is unique among major aquariums.

NATURAL HISTORY:

From late winter through early fall, cold, nutrient-rich waters well up from within Monterey Bay's 10,000 foot-deep submarine canyon. This upwelling of nutrients is the base of a food chain that supports the great diversity of sea life found in the bay's varied habitats.

PROJECT HISTORY:

Four marine biologists at Stanford University's Hopkins Marine Station in Pacific Grove first proposed the aquarium in 1977. In 1978, a group of marine scientists, local residents and members of the David and Lucile Packard Foundation of Los Altos, California formed the non-profit Monterey Bay Aquarium Foundation to pursue the project. Demolition of the abandoned Hovden cannery began in 1980; construction began in spring of 1981.

FUNDING:

Initial construction costs of \$55 million were provided for by a one-time gift from David and Lucile Packard. The non-profit aquarium receives no public funding. All operational costs and education and research programs are funded solely by revenues from admission and membership fees, donations, business sponsorships, evening admissions and proceeds from the gift and bookstore and restaurant.

SITE:

The aquarium stands on the former site of Cannery Row's largest cannery, the Hovden Cannery. Built in 1916, Hovden operated until 1972, the largest of the canneries and the last to close. Stanford University purchased the property to protect the shoreline next to its Hopkins Marine Station, then sold it in turn to the aquarium foundation in 1978. Initial plans to use the actual cannery structure proved impractical, though aspects of the original building are preserved.



AQUARIUM FACTS

ARCHITECTURE:

The new design intentionally preserves the historic flavor of Cannery Row and the old cannery that inspired it. Several important elements of the aging Hovden complex were restored for use or display in the aquarium, including the old boilers, pumphouse and warehouse. The majority is new construction.

DIMENSIONS:

Site: 2.2 acres

Exhibits and other public areas: 81,700 sq. ft. (excludes decks)

Ocean-view decks: 20,500 sq. ft.

Behind-the-scenes: 113,800 sq. ft.

Total aquarium square footage: 216,000 sq. ft.

SEAWATER SYSTEM:

Fresh, unpolluted sea water pumped in continuously from the bay maintains the great diversity of plant and animal life in the exhibits. By day, filtration clears the water for viewing. By night, filtration shuts down. The unfiltered sea water not only feeds filter feeders, but also carries in spores and larvae of plant and animal life that settle and grow in the exhibits. Two 16-inch-diameter, 980-foot-long intake lines draw up to 2,050 gallons of sea water per minute each from a depth of 55 feet in the bay into the aquarium sea water distribution system. Four operating modes permit varying levels of filtration, from raw sea water to pressure-sand-filtered, de-embolyzed sea water. Most aquariums are located on polluted bodies of water, making "open" system designs impossible.

OTHER FACILITIES:

A 1200-square-foot research laboratory; 183-seat ocean-view restaurant with cafeteria, oyster bar and waiter service; 273-seat auditorium; theater for special slide presentations; and gift and bookstore.



MONTEREY BAY AQUARIUM

Education Program Fact Sheet

The purpose of the Monterey Bay Aquarium is to stimulate interest, increase knowledge and promote stewardship of Monterey Bay and the world's ocean environment through innovative exhibits, public education and scientific research.

More than 50 staff members and 600 volunteers in the Education Division work toward these goals. Education programs of the non-profit Monterey Bay Aquarium Foundation, with an annual budget of \$1.9 million, are supported by admission revenues, fees, and grants from foundations, businesses and individuals.

On-Site Programs

School programs at the aquarium serve about 75,000 school children each year through tours, classroom programs and auditorium presentations. They are tailored to K-12 students, and include distribution of classroom materials (developed by the education staff) to teachers before they come to the aquarium so they can build a science lesson plan around the visit. All programs are free to the participants.

Outreach Programs

The outreach program's Aquaravan carries marine education programs to more than 20,000 people a year at schools, hospitals, fairs and parks, primarily in the Monterey Bay region. Staff and volunteers present lively skits ("Billy the Squid" and "Perils of Pollution," among others) as well as auditorium programs and classroom activities that include live marine animals. Special programs are conducted for preschoolers, migrant workers and their children, the handicapped and the elderly. Programs are provided free or at a nominal cost.

Teacher Programs

Teacher programs covering marine, environmental and science education topics serve more than 1,300 elementary and secondary school teachers each year. Seminars--lasting from several hours to 13 days--train them to be more effective at teaching science and at sharing their skills with colleagues. Enrichment lectures and workshops are offered during the year, either free or at a nominal cost.

Volunteer and Interpretive Programs

The education staff recruits, trains and supports more than 600 volunteers, who donate more than 60,000 hours to the aquarium each year. By answering visitors' questions at major exhibits, leading tours and assisting at evening events, they add a rich dimension to aquarium exhibits. About 125 new guides are trained each year during a 48-hour, three-unit college course taught by credentialed aquarium staff and lecturers from local marine science institutions.

Publications

Education staff members write and produce a wide range of interpretive materials for teachers, aquarium members and the general public. Curriculum materials for teachers include lesson plans and classroom aids (in English and Spanish) for students from preschool through high school. They also write and publish a natural history book series about Monterey Bay and the Pacific Coast, covering topics ranging from sharks to sea otters.

Exhibits

Education staff members research, develop and write all the text for exhibit graphics as well as video scripts, feeding show scripts and training materials for aquarium guides. They produce tour scripts (in five languages) and other print materials for visitors, and are involved in planning and developing future exhibits.

Library and Internship Programs

The aquarium library houses books, periodicals and videos for staff, volunteers and--by arrangement--educators, aquarium members and the public. The education staff also offers internships to college and secondary school students in the region. Interns receive experience, school credit and stipends.

Ecology of kelp forests

INTRODUCTION TO KELP FORESTS

Along the west coast of North America live some of the largest, fastest-growing plants in the world. Forests of these giant algae are complex natural communities that provide food and shelter for a great variety of other organisms.

WHAT IS A KELP PLANT?

"Kelp" is a specific group of algae belonging to the plant phylum Phaeophyta (the brown algae). Two of the larger kelps are important members of kelp forests in Monterey Bay. Giant kelp (*Macrocystis pyrifera*) forms dense beds just off the aquarium and around the bay; bull kelp (*Nereocystis leutkeana*) is common in the more turbulent waters to the south, in Carmel Bay.

A giant kelp plant has several distinct parts. (See Fig. 60.) A cone-shaped holdfast made up of rootlike branches (haptera) attaches the plant to rocks or other solid substrate. A number of fronds grow from the top of the holdfast. Each frond includes a ropelike stipe and numerous blades, each with a gas-filled float at its base. The floats support the fronds, allowing them to grow up toward the surface. New blades are added at the tip of the frond; fronds get

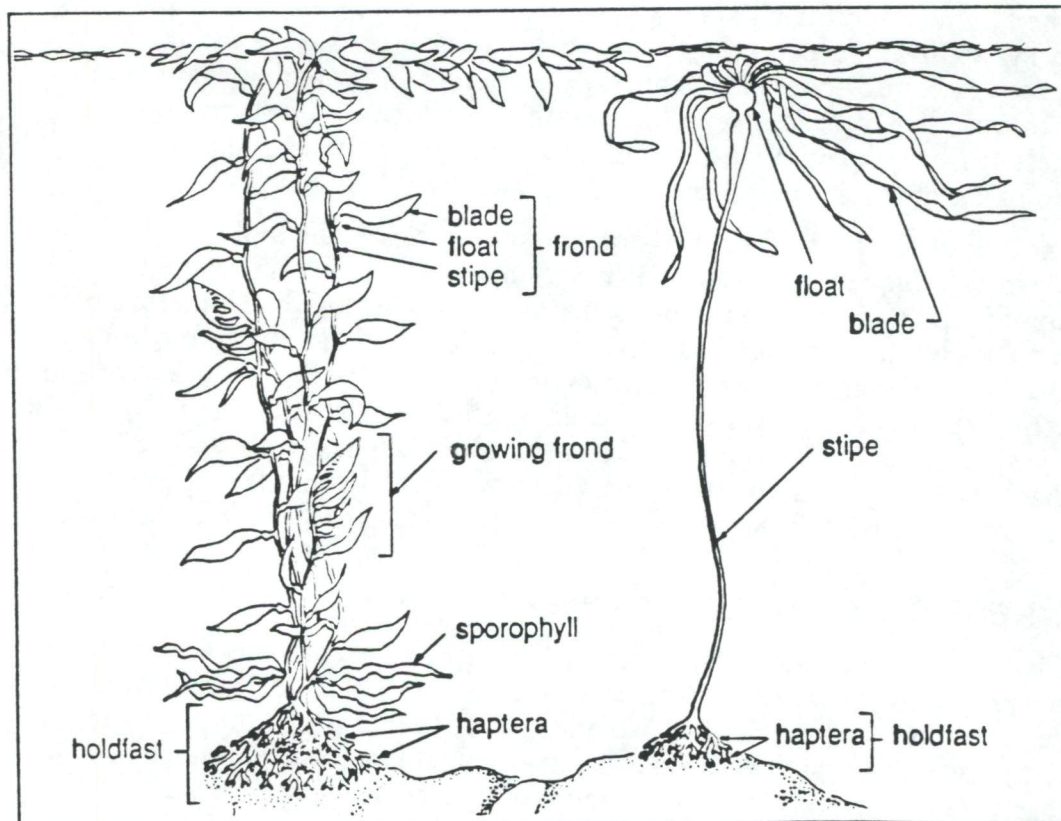


Figure 60 Morphology of kelp plants

longer as the stipe grows between the blades. During the peak growing season, fronds may grow 10 inches (25 cm) per day. Once they reach the surface, the fronds continue to grow and form a floating canopy. As old fronds die, new fronds sprout and grow from the top of the holdfast. Specialized blades called sporophylls grow at the base of each frond. These blades, which lack floats, are used for reproduction.

The structure of a kelp plant (numerous long but flexible fronds) is well-suited for life in nearshore habitats. The blades have a large total surface area to trap light for photosynthesis, while the flexible stipes allow fronds to bend, but not break, in wave surge and currents. If kelp plants were rigid like trees, they would be quickly broken or swept away.

THE LIFE OF A KELP PLANT

Giant kelp has a complex life cycle. The large plants you see in the Kelp Forest exhibit are called sporophytes; they release spores that swim to the substrate and grow into microscopic male and female plants (gametophytes). Male plants release sperm, but only a tiny fraction of them find and fertilize an egg, which the females retain. The resulting embryo grows into a sporophyte and the cycle begins again. It takes about 18 months to complete one full cycle.

The number of fronds per plant and the thickness of the surface canopy vary seasonally, especially in central California. Rates of frond addition and frond growth are highest from early spring to late summer, when the ocean is usually calm and levels of light and nutrients are high. In central California, the kelp canopy reaches its greatest thickness at this time. During the fall and winter when light and nutrients are low, many of the fronds produced the previous spring are torn loose by storm waves; new fronds grow slowly and the surface canopy becomes noticeably thinner. Even though an individual giant kelp plant may live three to seven years, a single frond lives only six months. For these reasons, the number of fronds on a plant doesn't tell you how old it is. Biologists have no accurate method of aging a giant kelp plant.

Another important species that grows in kelp forests is the bull kelp, *Nereocystis luetkeana*. This species has a small holdfast and a single thick stipe topped with a large float; it looks something like a bull whip. Numerous blades grow in clumps from this float. (See Fig. 60.) These plants may grow to lengths of 100 feet (30 m) or more. The life cycle of bull kelp is similar to that of giant kelp. Reproductive spores are produced by all the blades rather than by only a few specialized blades as in giant kelp. Most bull kelp sporophytes live less than a year, though some individuals may live up to 18 months. Sporophytes appear in late winter; they grow, release spores and die by the following fall.

WHERE DO KELP PLANTS LIVE?

Giant kelp forests grow only in cool, nutrient-rich waters along temperate coasts. Wherever water temperatures exceed 70°F (21°C) for part of the year, kelp plants don't do well. No one's sure whether this is due solely to temperature or a more complex interaction of temperature and nutrient levels (as temperature rises, the amount of nutrients dissolved in sea water decreases).

In the Southern Hemisphere, giant kelp forests grow along nearly all temperate coasts where upwelling occurs. In the Northern Hemisphere, giant kelp forests grow only along the west coast of North America from northern Baja California to central California. From central California up to Alaska, a few isolated populations do occur, but bull kelp is the dominant kelp forming forests.

Factors that affect where giant kelp grows include substrate type, substrate depth, availability of light, turbidity and water motion.

Kelp plants typically grow on hard substrates (though near Santa Barbara large forests do grow on sand). A kelp canopy on the surface usually means that there's a rocky reef below.

How deep many kelps can grow is strongly influenced by the availability of light for photosynthesis. Kelp cannot grow at depths where there's less than 1% of the light present at the surface. Depending on how clear the water is, this depth varies between 10 and 100 feet (3-30m). The depth at which kelp grows can also be affected by the presence and thickness of a surface canopy.

Water motion is also important to kelp plants. Low flow rates (one to two inches (2.5-5 cm/sec) make it easier for the kelp blades to take in nutrients. However, when water motion is strong—such as during winter storms—fronds, or even whole kelp plants, may be ripped off the bottom. Once a plant is torn loose, its fronds often become entangled with neighboring plants, pulling them up, too. Extreme water motion is probably the major reason kelp plants die in central California.

Along the coast near Monterey, winter waves higher than 13 feet (4m) are common. At 30 feet (10m) deep, such waves produce a surge equivalent to a 126 mph wind reversing direction every 20 seconds.

Consistently strong waves can bury young plants with constantly shifting sand or rip out larger plants. At other sites, kelp forests may appear during the summer and be removed the following winter. Bull kelp is not as easily broken and often occurs in areas too rough for giant kelp.

Interactions with other organisms can also affect where kelp plants grow. Such interactions include competition with other sessile organisms for space on rocks, competition with other plants for light, and grazing by sea urchins. The microscopic gametophytes can be affected by factors that are just as important but much less obvious. A thin layer of sediment that would have no effect on a large sporophyte could easily bury and smother a whole generation of gametophytes.

THE KELP FOREST

The physical presence of kelp helps make these forests rich, diverse communities. First of all, kelp plants change the physical environment. A dense stand of kelp dampens the water motion caused by swells, creating a zone of calmer water within its borders. Many juvenile fishes (rockfishes, seniorita, kelp surfperch, blacksmith) spend the early part of their lives in kelp forests, feeding on plankton concentrated there. The surface canopy reduces the amount of light that reaches the bottom, which may affect the other plants that live in the forest.

The kelp forest itself can act as a direct or indirect filter, strongly affecting which species live there in what numbers. Studies in southern California show that when bryozoan larvae encounter the edge of a kelp canopy, they metamorphose and settle onto the blades. When sea urchin larvae enter a kelp forest, many are quickly eaten by plankton-eating fishes. Because of this, encrusting bryozoans and sea urchins are often less abundant inside kelp forests than along their edges.

A second way kelp plants enrich the forest is by providing new habitats. The canopy, the fronds and the holdfast all provide places for hundreds of different organisms to live. Sea otters and shorebirds use the canopy for shelter or places to forage. Hydroids, bryozoans, tube worms, turban snails, crabs and isopods all live on the blades and stipes. Shrimplike mysids and small fishes, like the senorita and kelp surfperch, live in the water between the plants, closely associated with the fronds. Amphipods, brittle stars, crabs and many other invertebrates live among the tangled haptera of the holdfast.

The high growth rate of giant kelp is a third reason why kelp forests are so rich and diverse. Because they grow quickly and reach a large size, kelp plants can supply food to a large number of herbivores. Turban snails, kelp crabs and isopods, as well as herbivorous fishes like the halibut and opaleye, graze directly on kelp plants. When fronds break off and sink to the bottom, abalones, sea urchins, bat stars and others consume the detached "drift" algae. Most of the drift algae that remains within the kelp forest breaks down into fine detritus, food for filter-feeders and deposit-feeders like crevice-dwelling sea cucumbers, brittle stars and ornate tube worms. Predators like sea stars, rockfishes and crabs prey on many of the herbivores, and so benefit from the kelp's bounty.

Even though many species use drift kelp within the forest, over half of all the drift produced by a forest goes out to other communities. Many organisms living in deep reef or sandy seafloor habitats, where kelp does not grow, depend on drift kelp for much of their food. Even when kelp fronds are cast up on the beach, they still support a complex community of kelp flies, beach hoppers and other land dwellers.

Very few organisms depend completely on giant kelp for their existence. If giant kelp disappeared from our coast, most of the organisms could survive, but their abundances and distribution patterns would be affected drastically.

COMMUNITY STRUCTURE

The kelp forest is a bewildering mosaic of animals and plants. Two seemingly identical spots within the same forest may contain very different groups of organisms. If you observed these two spots for a long period of time, you'd probably see different progressions of species replacing one another in each. What could be responsible for such differences? How do these changes occur? These are the kinds of questions that scientists who study these communities ask. So far, there are many questions and relatively few answers. There are few absolute truths concerning kelp forests. For every generalization ("kelp plants grow on hard substrate") there's usually an important exception ("except off Santa Barbara"). It's also important to remember that natural communities are

always in a state of flux. A single visit to a kelp forest or a short term study often gives the mistaken impression that these communities don't change. A kelp forest is always changing and its present condition may depend strongly on recent events in its past.

Along the California coast, there is no such thing as a typical kelp forest. Giant kelp is one of the few species that nearly all California kelp forests have in common. Many other kelp forest species live only in southern California or only in central California. Seasonal fluctuations also differ; they're more pronounced in central California. Within a region, local differences in bottom topography and exposure to waves can make two forests that are only a few miles apart look very different.

Despite the great variability of kelp forests, there are several general patterns. One pattern is vertical layering of plants. (See Fig. 61.) Many kelp forests have four vertical layers. The surface, or primary, canopy is usually composed of giant kelp or bull kelp. One alga, *Cystoseira*, grows long reproductive fronds that reach the surface during the spring and summer. These fronds are present only for part of the year; the base that remains is only three feet (1 m) tall. Below the surface canopy is the understory, or secondary canopy, which is made up of a variety of smaller brown algae: oarweed (*Laminaria* sp.), *Pterygophora*, *Eisenia*. These plants are usually less than six feet (2 m) tall. Underneath the secondary canopy are a variety of small, low-lying red algae and prostrate brown algae such as *Gigartina*, *Corallina*, *Rhodymenia*, *Dictyonium* and *Desmarestia*. These species are generally much less than three feet (1 m) tall. The layer closest to the substrate is the crustose coralline layer. Coralline algae form thin crusts on the rock surfaces and usually don't have any erect parts.

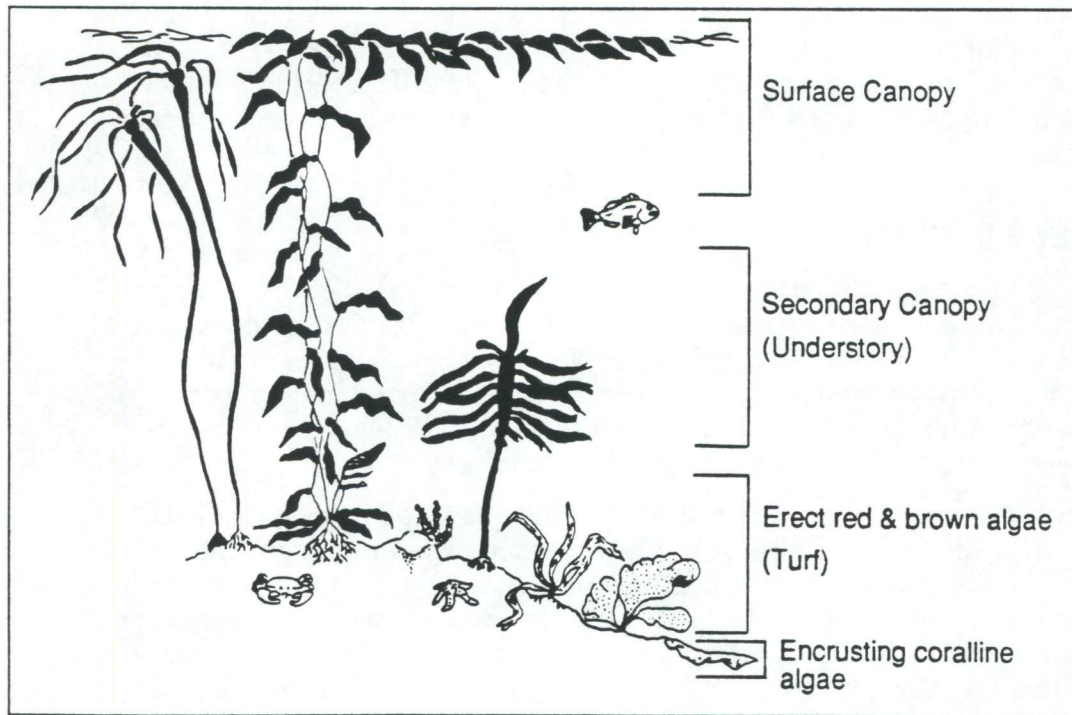


Figure 61 Vertical layering of kelp forest algae

The development and species composition of the different layers is highly variable. Kelp forests in semi-protected, calm areas often have a sparse understory, while those in exposed, wave-swept areas may have no surface canopy and a thick understory. Seasonal changes and irregular, unpredictable disturbances also cause variability. For instance, if winter storms remove the primary and secondary canopies, light levels on the bottom increase and the remaining low-lying plants may grow into a lush, thick cover. Such a thick cover may prevent the canopy species from settling and growing for long periods of time. Only when this bottom cover is thinned or removed can the larger species recolonize and grow. Once they do become re-established, they persist by shading-out other plants. As you can see, life in a kelp forest is anything but cooperative. Because so many species are always struggling to gain a foothold, any given spot inside a kelp forest is always in a state of transition.

DISTRIBUTION AND DEPTH ZONATION

Plants in kelp forests live in zones according to depth. Where a species grows may depend on differences between water motion, light, competition with other algae, and grazing at different depths. For instance, those species that are more tolerant of rough water and surf generally live in shallow water close to shore (like feather boa kelp and oarweed). Because large canopy-forming species are bulky, they'd easily be ripped up in such rough water motion, so they grow in slightly deeper, calmer water. In still deeper water, few algae grow at all, possibly because light levels are too low. In the deepest portions of the kelp forest, sessile animals like bryozoans, sponges, solitary corals and colonial tunicates cover most of the rock surfaces. There is still much to be learned about what causes these patterns of zonation.

There are also differences between horizontal and vertical rock faces. Plants dominate horizontal surfaces, while sessile animals dominate most vertical surfaces. No one is sure why, but this may be due to differences in light levels, differences in patterns of water flow or larvae and spores preferring different surfaces.

FOREST IN FLUX

Most of the changes that occur in kelp forests are cyclical, like the canopy thinning out in winter and growing back in summer. Even unusually severe disturbances that remove many plants are followed by a fairly predictable pattern of recovery. However, other changes have occurred in kelp forests along the California coast that were more permanent. The factors responsible for these changes have been the focus of much research.

Between 1940 and 1960, many southern California kelp forests dwindled drastically. The immediate cause of plant mortality was intense grazing by large numbers of sea urchins. Under normal conditions, sea urchins eat drift algae and remain nestled in cracks and crevices. When sea urchin populations increase, the animals move out from these sheltered areas and begin grazing on attached algae. Grazing by sea urchins can particularly damage kelp plants, because they eat the sporophylls and base of the stipe. The weakened fronds

break easily and drift away. Thus, even though the sea urchins actually eat very little of the kelp, they can quickly clear large areas, leaving only holdfast stumps behind. (What caused the increase in sea urchin populations in southern California is unclear. One popular misconception has been that the sea otter [or its absence] has been responsible.)

OTTERS, URCHINS AND KELP

The sea otter (*Enhydra lutris*) is a voracious predator that consumes up to 25% of its body weight per day of abalones, sea urchins, crabs and other invertebrate prey. It once ranged from the Aleutian Islands to Baja California, but fur traders hunted it to near extinction along the California coast well over 170 years ago. Sea otters strongly influence the nearshore communities in which they live. Observations from California and Alaska indicate that where there are otters there's lots of algae but few invertebrate grazers like sea urchins. In many (but not all) areas where there are no otters, there are generally more grazers and fewer algae. In Alaska, researchers mimicked sea otter predation by removing sea urchins. Within a short time, bull kelp plants appeared where none had been previously. No kelp grew in an adjacent control area, where sea urchins were not removed.

These observations led to the proposal that when hunters removed the sea otter from southern California, sea urchin populations increased, which then destroyed the kelp forests. Despite its appeal, this explanation is probably incorrect. First of all, sea otters disappeared from southern California over 150 years before the decline of the kelp forests began. If the sea otter had been the major factor controlling sea urchin populations, sea urchins would have probably increased well before 1940. Second, the areas with the most drastic kelp forest destruction were associated with large sewer outfalls in Los Angeles and San Diego. Raw sewage from these outfalls increased turbidity of the water and covered the substrate with sediment and sludge. Lower light levels and sedimentation would probably have damaged kelp populations (especially gametophytes) even if there had been no overgrazing by sea urchins. Lastly, several successive years of unusually warm water occurred in the late 1950s that were probably the final blow for the kelp populations. The recent El Niño condition has been accompanied by a similar reduction of kelp canopies in southern California.

Other studies in southern California have found that a region can be abundant in both sea urchins and kelp. Today, areas off San Diego and San Nicholas Island are a patchwork of sea urchin "barren grounds" and dense stands of kelp. Areas with high vertical relief generally have more kelp, since they provide shelter for predators like sheephead and spiny lobsters that eat sea urchins. These areas also trap more drift algae, so the sea urchins feed less often on attached plants. Kelp populations on flat rocky areas tend to fluctuate more: sea urchins periodically remove all kelp plants, which then recolonize from nearby stands and persist until the urchins remove them again.

Even though sea otters can have important effects on giant kelp populations, their absence has had little to do with fluctuations of southern California kelp forests over the last four decades. Sewage pollution, unusually warm water

temperatures and possibly human activities (removing sea urchin predators like spiny lobsters or competitors like abalones) have probably been more influential.

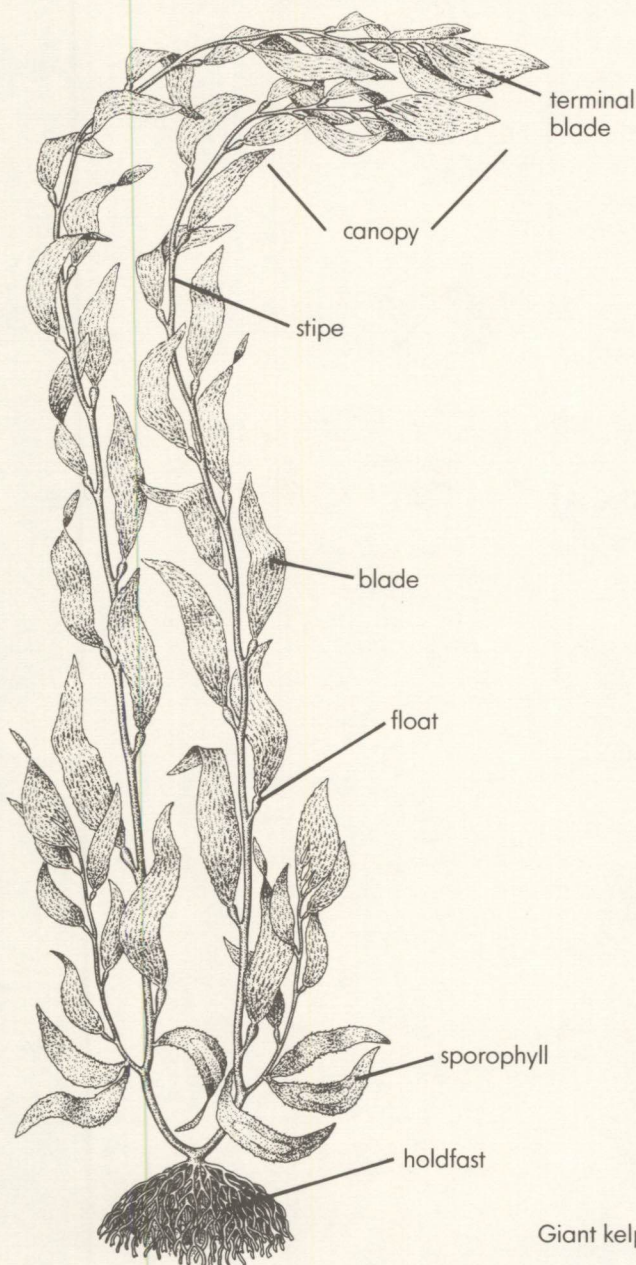
In central California, the sea otter's range expansion has been accompanied by increases in kelp forests. However, this does not mean that the kelp forests would be destroyed by sea urchins if there were no otters. Studies of kelp forests on the exposed coast north of Santa Cruz (where there are no sea otters) have shown that severe winter storms control sea urchin populations; the storms remove all individuals not protected by cracks and crevices. Even though sea otters are not present, there is no overgrazing by sea urchins. Another factor that may control sea urchin populations is disease. In the mid 1970s, massive sea urchin mortality occurred near Santa Cruz, followed by expansion of the kelp forests. What caused this outbreak and how frequently others may occur is not yet known.

Kelp forests are highly complex natural communities. How human use can be balanced with conservation of kelp forests and their inhabitants has raised many biological, economic and political questions. In order to answer these questions sensibly, we must learn much more about the subtle inner workings of these underwater forests.

WHAT IS A KELP FOREST?

Giant kelp plants (*Macrocystis pyrifera*) form submarine forests in the cool waters of many of the world's oceans. Extensive forests grow along the Pacific coast of North America. Beautiful, biologically complex communities, they provide food and shelter for a rich array of plants and animals. They're also a very important economic and recreational resource in Monterey Bay.

During World War I, California kelp forests were harvested as a source of potash for gunpowder. Today giant kelp is harvested for algin, used in food and pharmaceuticals. Between 100,000 and 170,000 tons of giant kelp are harvested annually in California.



Giant kelp

THE GIANT KELP PLANT

"Kelp" refers to large brown algae in the phylum Phaeophyta. Like other seaweeds, giant kelp has no true roots, stems, leaves or flowers. The part of the plant that attaches it to the substrate (usually rock) is the holdfast. The stemlike part is called the stipe; the leafy parts are known as the blades. At the junction of stipe and blade is a small air-filled float (pneumatocyst) that buoys the plant toward the sunlit surface. Thick tangles of fronds (blades and a stipe) reach from seafloor to the surface, where the fronds spread out, forming a canopy. They capture the sun's energy for photosynthesis.

Giant kelp is one of the largest and fastest-growing plants in the world. In spring and summer, when Monterey Bay is calm and there's an abundance of light and nutrients, a giant kelp frond may grow 10 inches a day. An individual plant may live three to eight years; a single frond lives about six months. The huge plants are only half of the kelp life cycle. These sporophytes release spores that swim to the bottom and grow into tiny male and female plants (gametophytes) which carry out the other half of the cycle. The tiny male plants release sperm and fertilize the females' eggs. The resulting embryos grow into huge giant kelp plants (sporophytes) and the cycle begins again. It takes about a year and a half to complete the reproductive cycle.

GROWTH OF KELP

Giant kelp grows best in areas with rocky bottoms, plenty of light and enough water motion to keep nutrients circulating around the plant. Interactions with other organisms also affect where kelp grows. First, kelp must compete with other plants and animals for space to settle and grow. Then, as it grows toward the surface, kelp competes with other plants for light. At all stages of its life, kelp must survive being grazed by urchins, abalones, other invertebrates and some fishes.

THE KELP FOREST COMMUNITY

The kelp forest has a greater variety and higher density of plants and animals than almost any other marine community, largely because its complex physical structure offers more kinds of homes than homogenous areas like mudflats. Like trees, kelp provides a variety of living spaces. Some organisms swim in the canopy, and others live on the fronds, between the stipes, or in the holdfast.

Another reason this community is rich and diverse is that kelp is an abundant, continuous source of food. Some animals, like turban snails, graze directly on the growing plant, but many animals (like abalones, urchins and bat stars) feed on detached fronds that have drifted to the bottom. Drift kelp that isn't eaten is decomposed by bacteria into small particles called detritus. The detritus is filtered from the water and eaten by filter-feeders like sponges or ingested from the sediment by deposit-feeders like sea cucumbers. Many of these animals are eaten by predators like crabs, rockfishes and sea stars.

About ninety percent of the kelp produced in the forest is exported to the beach or deep water. Only about ten percent is eaten within the kelp forest itself.

ADAPTATIONS FOR KELP FOREST LIFE

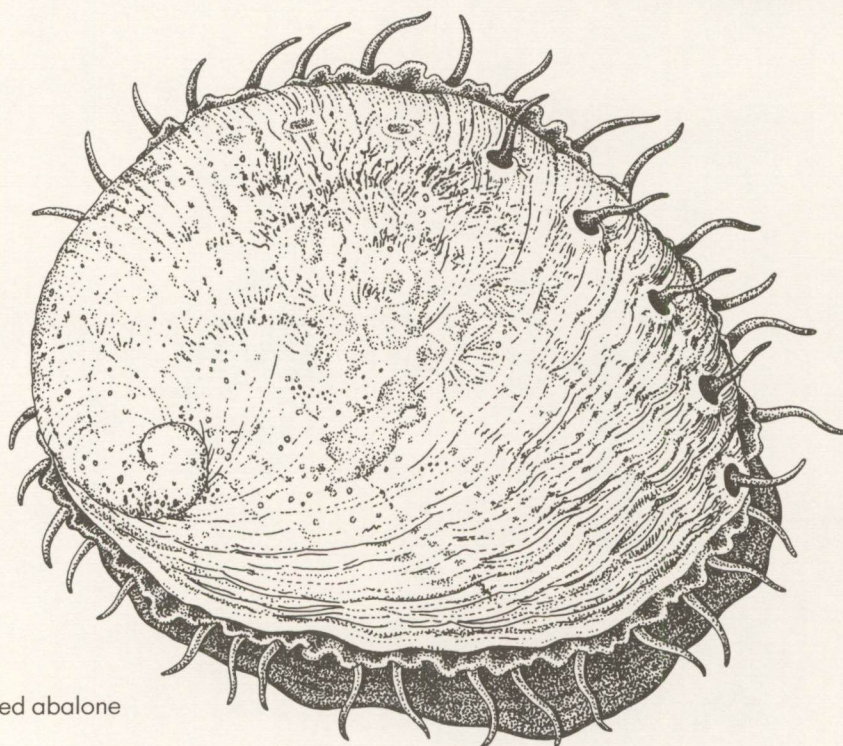
All kelp forest inhabitants have similar problems: they must avoid being eaten, find food, reproduce and adjust to the physical environment. We study characteristics like mouthparts, body shape and locomotion to tell what such adaptations are for and what role (predator, herbivore, planktivore, etc.) the plant or animal plays in the community.

When you visit, you can have the class look at the horn shark: the spotted body is adapted for camouflage on the rocky floor. What about the orange sea cucumber? A planktivore, its finely divided tentacles are adapted to filter plankton and detritus from the water; the soft body is adapted to fit into rocky cracks and crevices.

Making similar studies of other kelp forest inhabitants will help you understand the roles and relationships of organisms in the kelp forest community.



MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT



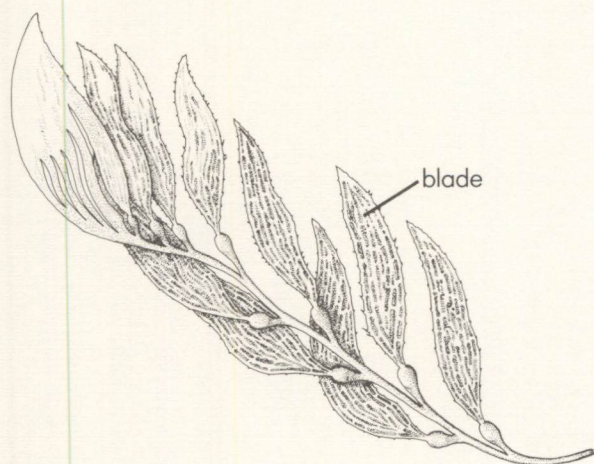
Red abalone

adaptation: a characteristic (body part, behavior, etc.) that helps a plant or animal survive

algae (singular—alga): simple non-seed-bearing plants including one-celled diatoms and multicellular seaweeds

benthic: occurring on the bottom (of the ocean, lakes, rivers, etc.)

blade: the leaflike part of a seaweed



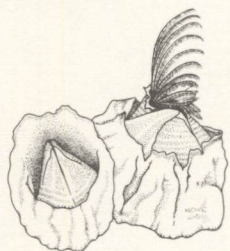
canopy: the top layer of the kelp forest where fronds float on the sea surface and shade the forest floor

community: all of the plants and animals living in a specific area (habitat); often described by the most abundant or obvious organisms (kelp forest community, mussel bed community, etc.)

decomposer: an organism, like a bacterium, that causes the decay of dead plant and animal matter

drift seaweed: a piece of seaweed that breaks free of its attachment and drifts with ocean currents

filter-feeder: an animal like a barnacle or mussel that filters or strains small food particles from the water



frond: a kelp stipe and the attached blades

habitat: the place where a plant or animal lives

herbivore: an animal that eats plant matter

holdfast: the part of a seaweed that attaches it to the seafloor

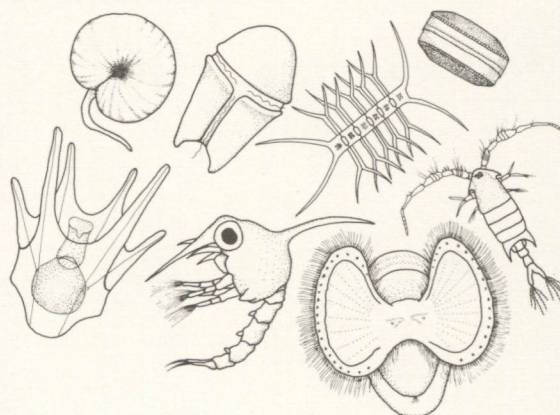
kelp: any of the large brown seaweeds, like *Macrocystis*

invertebrate: an animal without a backbone

***Macrocystis*:** the scientific name of giant kelp

photosynthesis: the process by which green plants use energy from sunlight to produce sugar and oxygen from carbon dioxide and water

plankton: plants and animals that swim weakly, or not at all, and drift with ocean currents; most are tiny



planktivore: an animal that eats plankton

producers: life forms (plants, diatoms, some bacteria) that produce their own food through photosynthesis

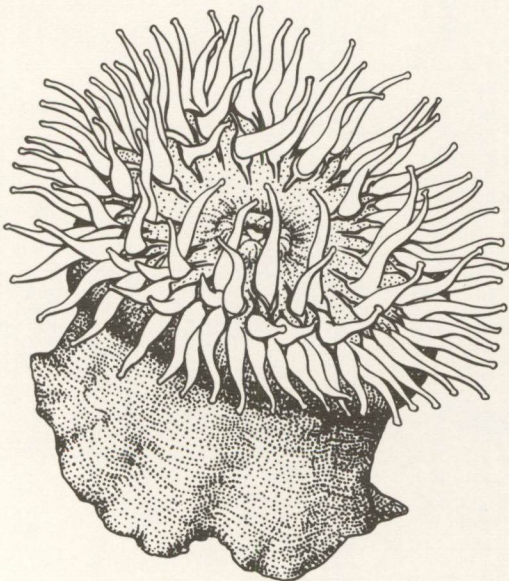
sessile: stationary; attached to the seafloor or an object like a pier piling

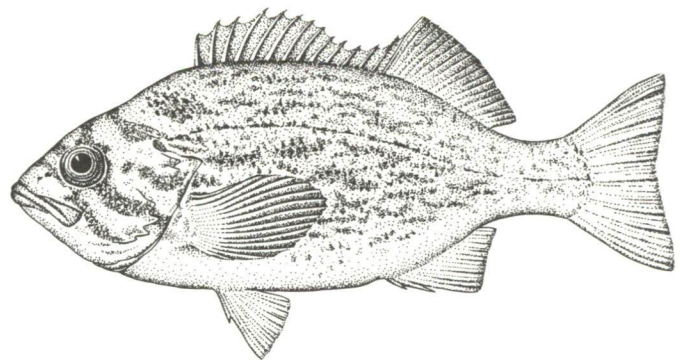
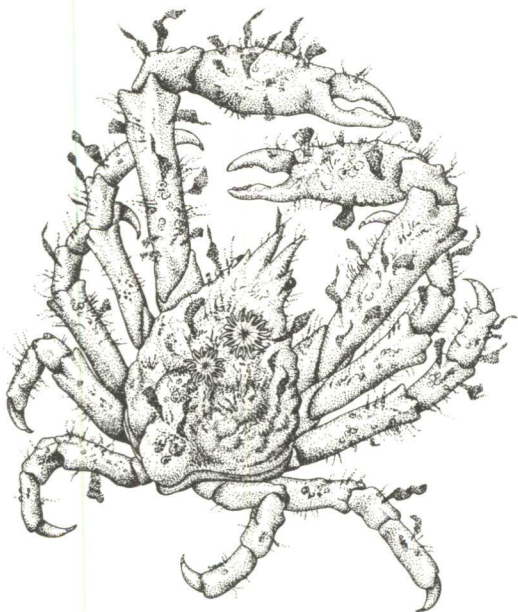
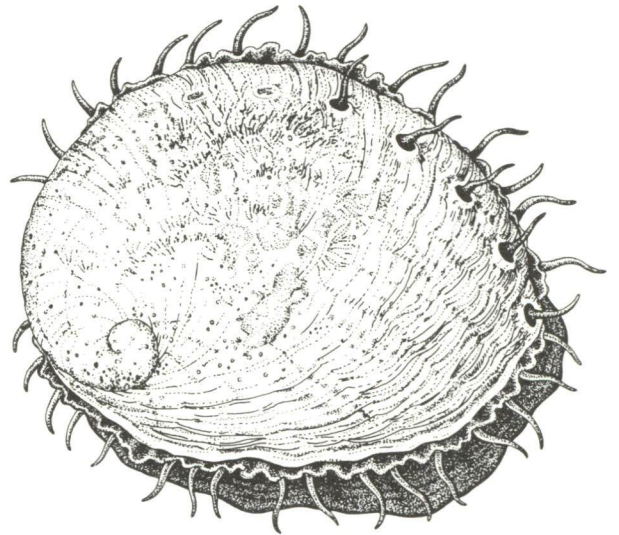
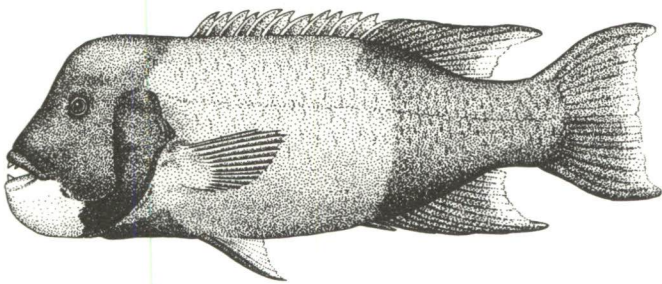
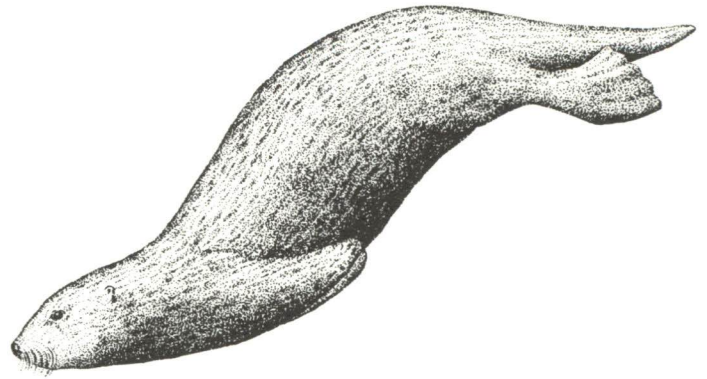
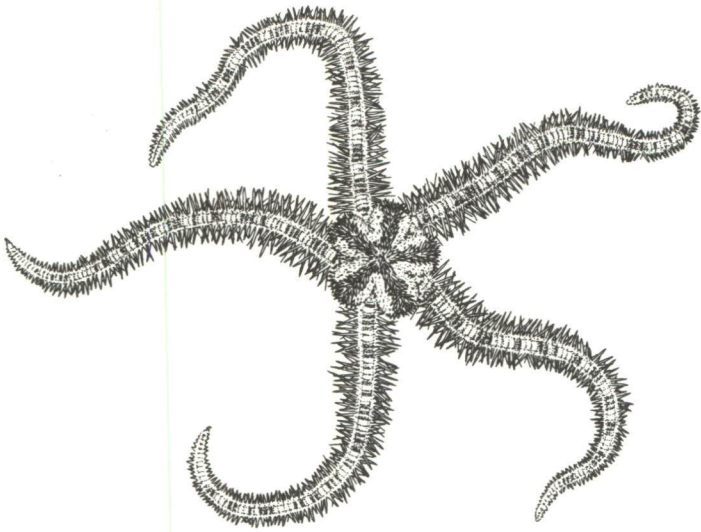
stipe: the stemlike part of a kelp plant connecting the holdfast to the blades



MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT

NOTES





Sea otter

size: to 4.9 ft. (1.5 m)

Sea otters dive down through the kelp forest to catch their food. They pull prey like crabs, abalones and sea urchins from the rocks. To break the hard shells, otters pound them with rocks.

Brittle star

size: to 5.7 in. (14.4 cm)

Delicate brittle stars hide among rocks and in kelp holdfasts. They stick their long, skinny arms out to catch food. If a fish bites off an arm, the brittle star can grow a new one.

Red abalone

size: to 11.8 in. (30 cm)

An abalone is a large ocean snail. It has tentacles all around the shell that feel for drifting seaweed. When they sense a piece, the abalone's large foot reaches up and grabs it for dinner.

Sheephead

size: to 3 ft. (91 cm)

When sheephead are born, they're all red and female. When they grow to about 12 inches long, their color changes to red and black, and they become male. Both males and females use their big teeth to pry food off rocks.

Blue rockfish

size: to 21 in. (53 cm)

Blue rockfish swim among the kelp plants. They hunt small floating animals there. Rockfishes have poisonous spines on their fins for protection. Swimming in schools protects them, too.

Decorator crab

size: to 3.5 in. (8.8 cm)

Decorator crabs cover their shells with seaweed, sponges and other things. They pick these decorations from nearby rocks. When a decorator crab sits still, it looks like a rock. Hungry fishes and otters pass by without seeing the crab.

La nutria

tamaño: hasta 1.5 m

Las nutrias nadan debajo del agua por el quelpo para agarrar su comida. Arrancan de las rocas presa como cangrejos, abulones, y erizos de mar. Las nutrias usan rocas para pegar contra las conchas duras para romperlas.

La estrella quebradiza

tamaño: hasta 14.4 cm

Las estrellas quebradizas delicadas se esconden entre rocas y en los talos del quelpo. Ponen los largos brazos flacos hacia afuera para agarrar la comida. Si un pez le arranca un brazo con los dientes, las estrellas quebradizas pueden crecer un brazo nuevo.

El abulón rojo

tamaño: hasta 30 cm

Un abulón rojo es un gran caracol del océano. Alrededor toda la concha tiene tentáculos los cuales sienten por el alga flotante. Cuando sienten un pedazo, la pata grande del abulón alcanza hacia arriba y la agarra para la comida.

La cabeza de oveja

tamaño: hasta 91 cm

Al nacer las cabezas de oveja, todas son rojas y hembras. Cuando han crecido a un tamaño alrededor de 30 cm o 12 pulgadas de largo, el color se cambia a rojo y negro, y se vuelven machos. Machos y hembras usan los dientes grandes para arrancar comida de las rocas.

El pez azul de roca

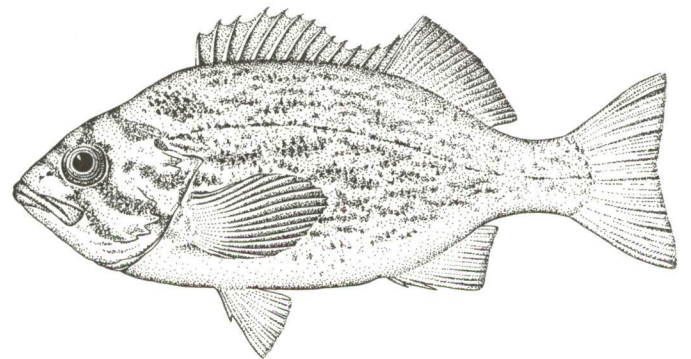
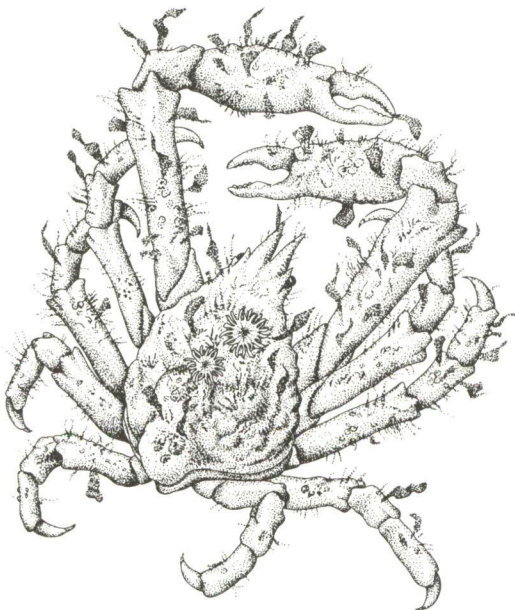
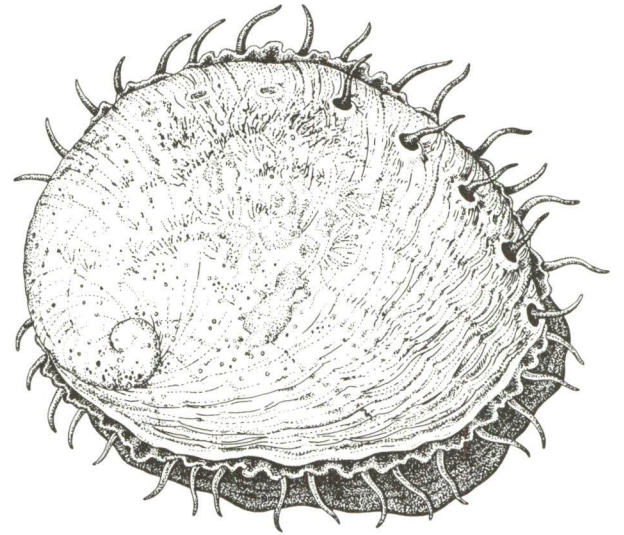
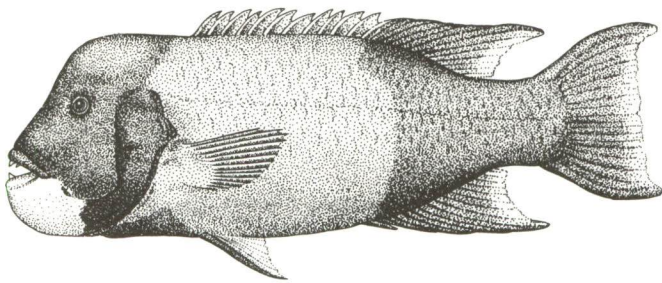
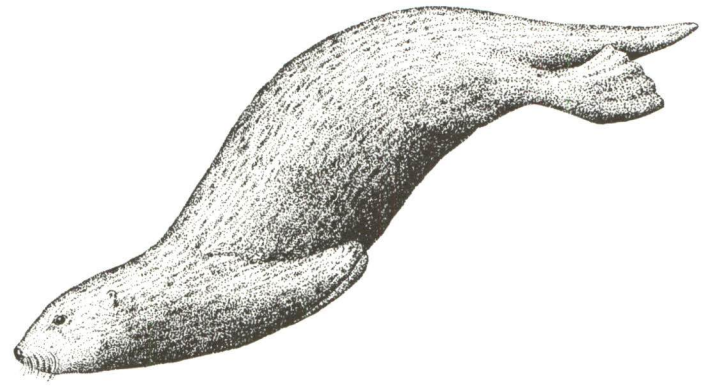
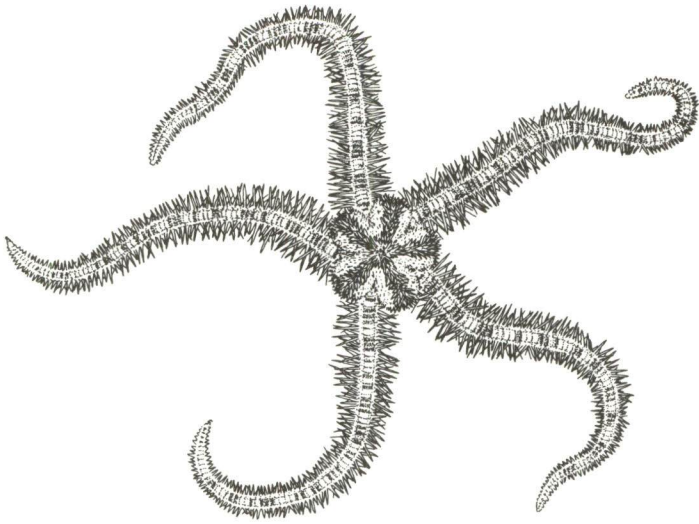
tamaño: hasta 53 cm

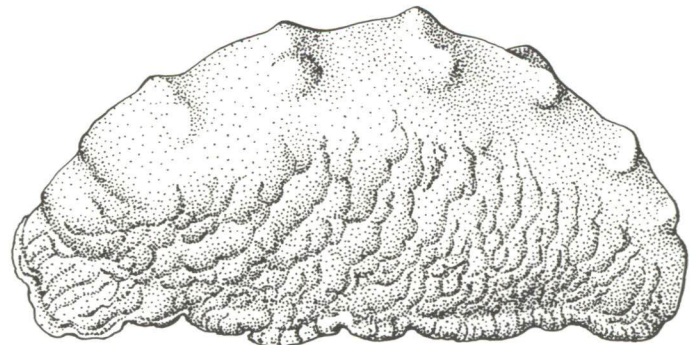
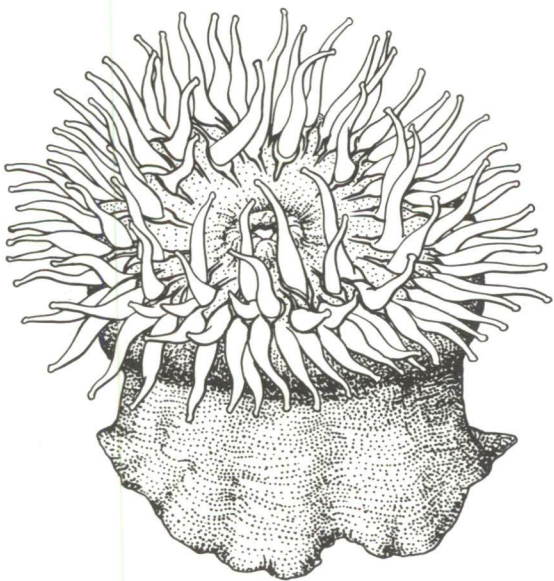
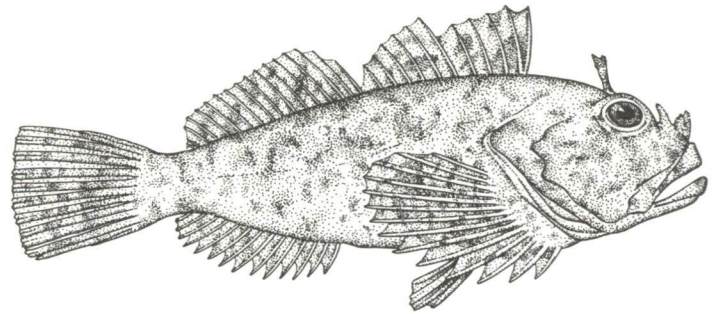
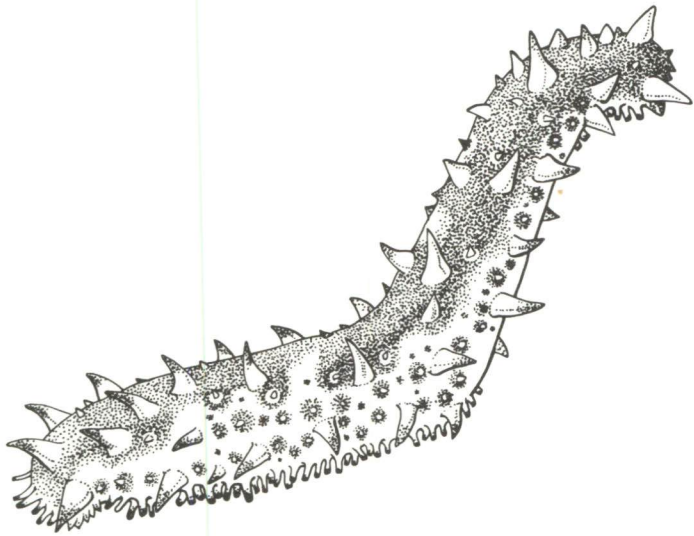
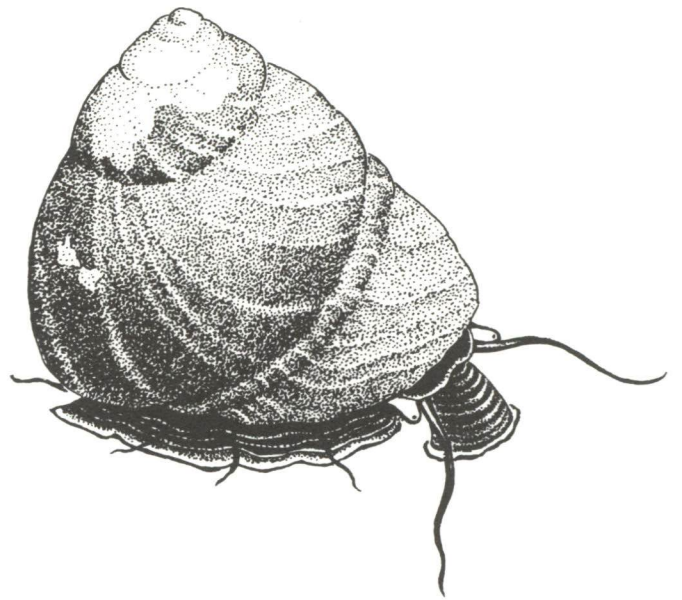
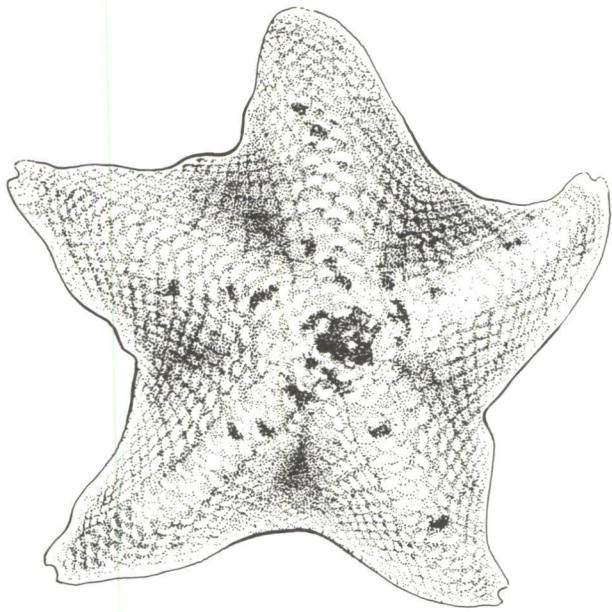
Los peces azules de roca nadan entre las plantas de quelpo. Ahí cazan pequeños animales flotantes. Los peces azules de roca tienen espinas venenosas en sus aletas para protección. Otra protección que usan es nadar en un banco.

El cangrejo "decorador"

tamaño: hasta 8.8 cm

Los cangrejos "decorador" cubren la concha con alga, esponjas, y otras cosas. Consiguen estas decoraciones de las rocas cercanas. Cuando el cangrejo "decorador" está quieto, se parece a una roca. Peces hambrientos y nutrias pasan sin verlo.





Brown turban snail

size: to 1 in. (2.5 cm)

Brown turban snails eat kelp, and find a good home high on the kelp plants. Living up there, they are safe from hungry sea stars that live on the bottom.

Bat star

size: to 8 in. (20 cm)

A bat star doesn't bring food to its stomach. Instead, it pushes the stomach out of its mouth to the food. The bat star covers the meal with its stomach to eat.

Cabazon

size: to 3.25 ft. (99 cm)

"Cabazon" means "big head" in Spanish. This fish has a big mouth, too—it can gulp large prey. Cabezons often swallow whole abalones. Then they spit out the shells.

Sea cucumber

size: to 16 in. (40 cm)

Sea cucumbers have hundreds of tiny suction cup feet, like sea stars. They use them for creeping slowly across the kelp forest floor. As they go, their mouth tentacles sweep the seafloor, looking for bits of food.

Gumboot chiton

size: to 12 in. (30 cm)

The gumboot chiton clings to rocks with its single large foot. See the bumps on its back? Under each bump is a shell. Gumboot chitons have eight shells inside like a skeleton.

Fish-eating anemone

size: to 8 in. (20 cm)

This anemone is an animal, not a plant. It catches shrimps and small fishes with its tentacles. The tentacles sting till the prey is stunned. Then the anemone swallows its meal.

El caracol turbante de color café

tamaño: hasta 2.5 cm

Los caracoles turbantes de color café comen el quelpo y viven bien arriba en las plantas de quelpo. Viviendo ahí arriba, están seguros de las estrellas de mar hambrientas que viven en el fondo.

La estrella murciélago

tamaño: hasta 20 cm

Una estrella murciélago no trae la comida hasta el estómago. Pero empuja el estómago afuera por la boca hacia la comida. La estrella murciélago cubre la comida con su estómago para comerla.

El cabezón

tamaño: hasta 99 cm

"Cabezón" quiere decir "cabeza grande." Este pez también tiene una boca grande - puede tragar preso grande. A veces los cabezones tragan los abulones enteros. Entonces escupan las conchas.

El pepinillo de mar

tamaño: hasta 40 cm

Los pepinillos de mar tienen centares de patas de succión, como las estrellas de mar. Usan estas patas para caminar muy despacio sobre el fondo del bosque de quelpo. Mientras caminan, los tentáculos de la boca andan por el fondo buscando alimento.

El quitón de bota de goma

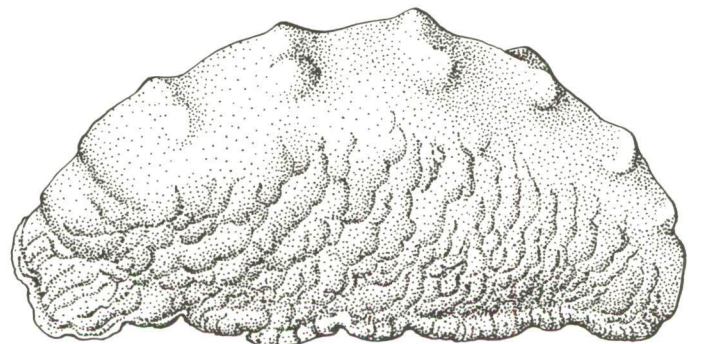
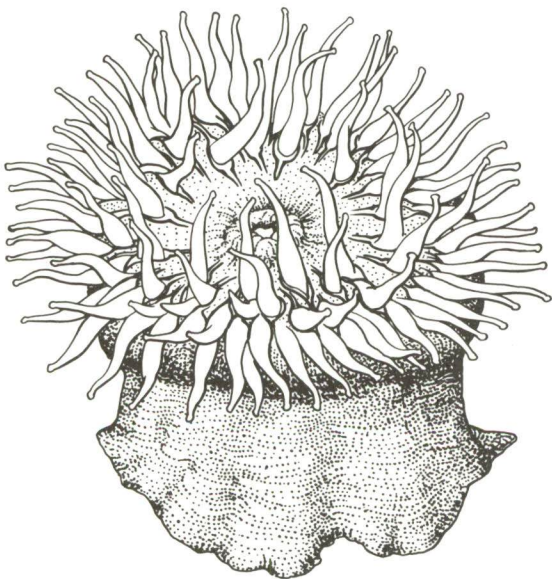
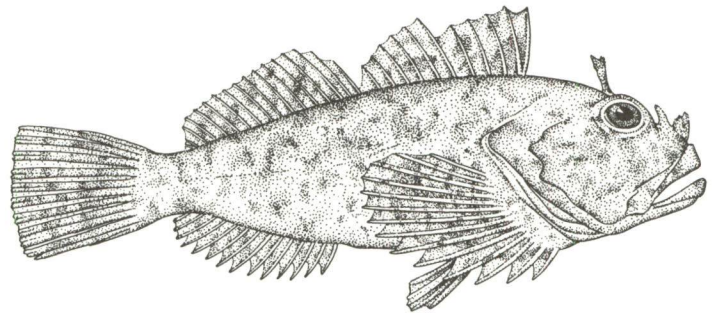
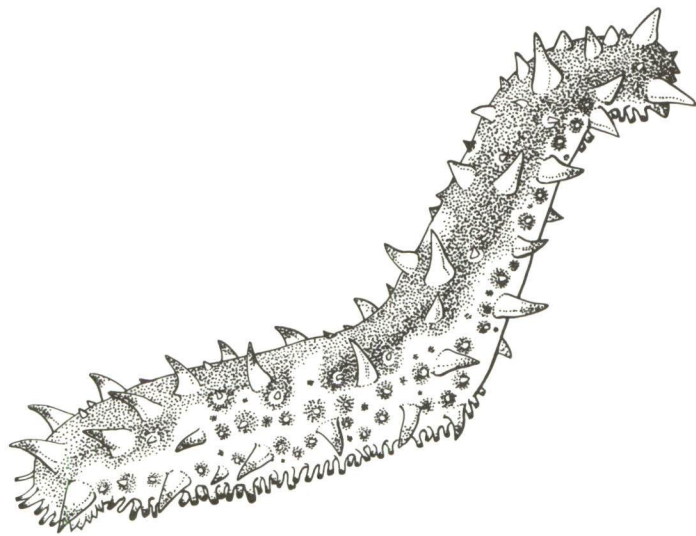
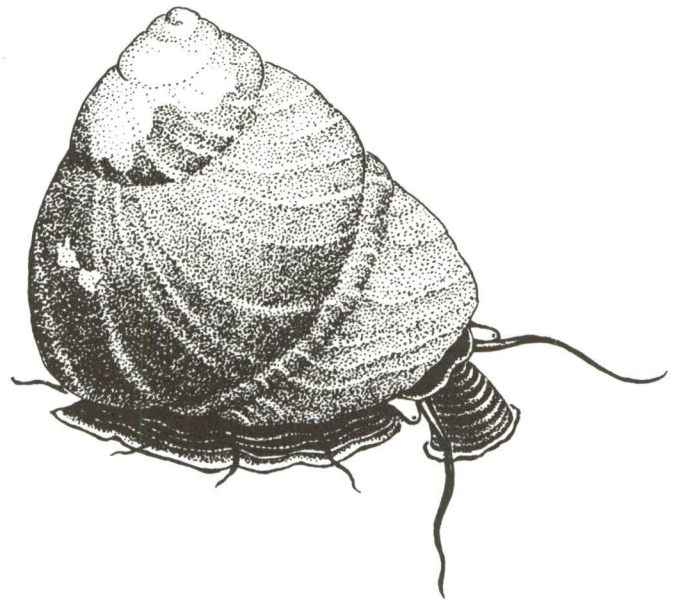
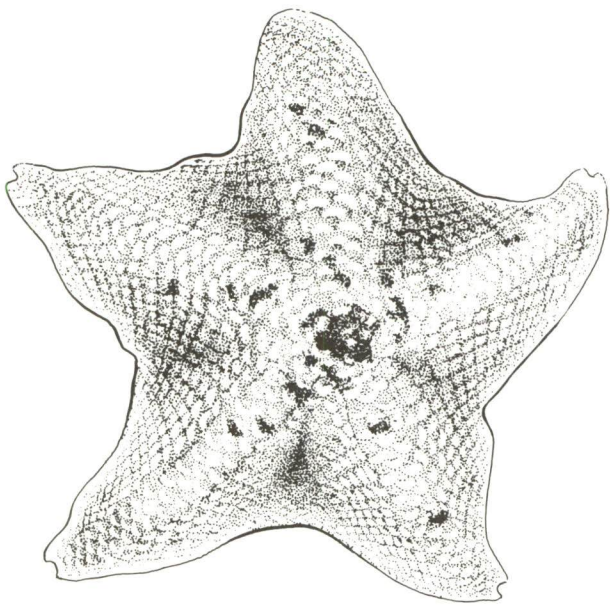
tamaño: hasta 30 cm

Los quitones de bota de goma cuelgan de las rocas con su única pata grande. ¿Pueden ver las protuberancias en la espalda? Hay una concha debajo cada protuberancia. Los quitones de bota de goma tienen ocho conchas adentro como un esqueleto.

La anémona que come peces

tamaño: hasta 20 cm

Esta anémona es un animal, no una planta. Agarra camarrones y peces pequeños con sus tentáculos. Los tentáculos pican hasta el preso está atontado. Entonces la anémona traga su alimento.



Monterey Bay Aquarium Teacher Programs
Kelp Forest Habitat Slide Set

Overview

These slides were compiled to give students an overall picture of a Kelp forest habitat. Included in the set are examples of physical factors, kelp forest animals and human uses of kelp.

Sequence

The slide descriptions do not follow a specific story line. They were prepared to assist you in using the slide set with your students as a teaching aid. Please preview the slides and descriptions first, before showing them to your students. Also consider the background and interest level of your students before selecting the appropriate level of information to share for each slide.

Copyrights

The following sources contributed images for the slide set: Steve Webster, Harold Dorr, and the Kelco Company.

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1. Kelp canopy: The canopy is the top layer of the kelp forest where fronds float on the surface utilizing sunlight for photosynthesis.
2. Kelp forest: Beneath the canopy is a true underwater forest. The kelp canopy shades the forest below, which provides food and shelter for a great variety of animals.
3. Giant kelp: Giant kelp (Macrocystis pyrifera) is a brown alga which belongs to the plant phylum Phaeophyta. Giant kelp is one of the fastest growing plants in the world and can reach lengths of 200 feet or more.
4. Kelp frond: A kelp plant has several distinct parts. Each frond has a stemlike stipe and numerous leaflike blades, each with a gas filled float at its base.

5. Kelp holdfast: The holdfast is made up of rootlike branches which attach the plant to a rock or other hard surface. The holdfast also creates a protective habitat for small invertebrates like the brittle star.
6. Rockfish: Many species of rockfish, like this copper rockfish (Sebastes caurinus), can be seen in a kelp forest. They are often found hanging motionless between the kelp blades or hiding in a rocky crevice.
7. Garibaldi: The beautiful garibaldi (Hypsypops rubicundus) is a damselfish. Since it is scarce in some areas, it is now fully protected by law. The adults are territorial and they often "garden" a patch of kelp in their territory.
8. Sculpin: This little snubnose sculpin (Orthonopias triacas) sits perfectly still on the kelp forest floor relying on camouflage for protection.
9. Leopard shark: The leopard shark (Triakis semifasciata) has greenish brown spots for camouflage in the kelp forest. They eat small fishes, crabs, clams and an occasional octopus.
10. Sea urchin: When kelp fronds break off and sink to the bottom, they provide food for herbivores like the purple sea urchin (Strongylocentrotus purpuratus).
11. Red abalone: The red abalone (Haliotis rufescens) is another kelp forest herbivore. It grazes on the kelp using a filelike tongue called a radula.
12. Turban snail: If a kelp blade is full of holes its probably because brown turban snails (Tegula brunnea) have been eating it. The snails' shells are often covered with "hitchhikers" like encrusting coralline algae, slipper snails and barnacles.

13. Kelp crab: The kelp crab's (Pugettia producta) color is its camouflage. It gets its color from eating the kelp. If it starts to eat red algae, it will begin to turn red.
14. Gumboot chiton: The gumboot chiton (Cryptochiton stelleri) is the largest chiton in the world. It grazes on drift kelp and red algae growing on the kelp forest floor.
15. Bat star: The bat star (Patiria miniata) is a kelp forest scavenger and is very common in Monterey Bay.
16. Sea cucumber: As drift kelp breaks down, it becomes food for deposit feeders like this sea cucumber (Parastichopus parvimensis).
17. Melibe: The melibe (Melibe leonina) may look like a jellyfish, but it is actually a nudibranch, commonly known as a sea slug. Melibes attach themselves to kelp fronds and capture plankton from the water.
18. Sea otter: California sea otters (Enhydra lutris) find almost all of their food in the kelp forest. They eat urchins, abalone, crabs, snails and an occasional sea star.
19. Otter in kelp: Sea otters often wrap kelp fronds around themselves while they sleep so they don't drift away.
20. Surface kelp: People use kelp, too. The kelp canopy is harvested and algin is extracted. Look for algin, a smoothing agent (emulsifier) in products like ice cream, yogurt, pudding, toothpaste and paint.



MONTEREY BAY AQUARIUM*

886 Cannery Row Monterey, CA 93940-1085
Telephone (408) 648-4800 FAX (408) 648-4810

EDUCATION MATERIALS ORDER FORM

The Education Department provides free curriculum materials for specific programs when you register for an aquarium or outreach visit. Use this form to order any additional materials you may need.

	Qty.	Amount
Recipe for a successful aquarium visit lists logistics to consider when you visit the aquarium.	_____	_____
Chaperone tips sheet helps chaperones prepare for their visit to the aquarium.	_____	_____
Planning for Our Visit (Assembly) describes specific ways to set up your school for our visit.	_____	_____
Planning for Our Visit (Classroom) describes specific ways to set up your classroom for our visit.	_____	_____
Do-it-yourself Lab guidelines (Onsite) explains how to reserve and use our labs to teach your own class.	_____	_____
New! Do-it-yourself Lab guidelines (Outreach) explains how to request our Aquaravan with live animals to help you teach a lesson you design.	_____	_____

Program Introduction sheets list the objectives of aquarium programs and suggest pre- and post-program activities.

Grades Pre-K:	Seashore Friends Aquaravan Classroom Program	.25	_____	_____
Grades K-2:	Tide Pool Discovery Lab	.25	_____	_____
	Marine Mammals Great and Small Discovery Lab	.25	_____	_____
	Aquarium Treasures Auditorium Program	.25	_____	_____
	Supper in the Sea Aquaravan Classroom Program	.25	_____	_____
	Monterey Bay Shorelines Aquaravan Classroom Program	.25	_____	_____
	Monterey Bay Habitats Aquaravan Assembly Program	.25	_____	_____
	An Otter Adventure Aquaravan Assembly Program	.25	_____	_____
Grades 3-5:	Exploring Rocky Shores Discovery Lab	.25	_____	_____
	A Sea of Adaptations Discovery Lab	.25	_____	_____
	Marine Mammal Mysteries Discovery Lab	.25	_____	_____
	Some Things Fishy Auditorium Program	.25	_____	_____
	Secrets of the Aquarium Auditorium Program	.25	_____	_____
	The Hungry Ocean Aquaravan Classroom Program	.25	_____	_____
	Monterey Bay Shorelines Aquaravan Classroom Program	.25	_____	_____
	Monterey Bay Habitats Aquaravan Assembly Program	.25	_____	_____
	Marine Mammals on the Move Aquaravan Assembly Program	.25	_____	_____
Grades 6-8:	Undersea Forests Discovery Lab	.25	_____	_____
	Sea Otters and You Discovery Lab	.25	_____	_____
	More Secrets of the Aquarium Auditorium Program	.25	_____	_____
	Sharks Auditorium Program	.25	_____	_____
	Monterey Bay Shorelines Aquaravan Classroom Program	.25	_____	_____
	Monterey Bay Habitats Aquaravan Assembly Program	.25	_____	_____
	Creatures from the Deep Aquaravan Lab Program	.25	_____	_____
Grades 9-12:	Kelp Forest Ecology Discovery Lab	.25	_____	_____
	Marine Mammal Lifestyles Discovery Lab	.25	_____	_____
	Sharks Auditorium Program	.25	_____	_____
	Deep Sea Research Aquaravan Lab Program	.25	_____	_____
All levels:	New for Special Education! Fins and Fur Aquaravan Classroom Program	.25	_____	_____

Self-Guided Tour Introduction sheets help your class prepare for an aquarium tour that you lead.

Grades K-2:	Exploring Monterey Bay: Sea Life	.50	_____	_____
Grades 3-5:	Exploring Monterey Bay: Ocean Homes	.50	_____	_____
	New! Exploring Monterey's Deep Canyon	.25	_____	_____
Grades 6-8:	Exploring Monterey Bay: Undersea Survival	.50	_____	_____
Grades 6-12:	New! Exploring Monterey's Deep Canyon	.25	_____	_____
Grades 9-12:	Exploring Monterey Bay: Marine Communities	.50	_____	_____

Background Information sheets provide you with content information on subjects covered in our education programs.

Monterey Bay Aquarium	.25	_____	_____
Secrets of the Aquarium	.50	_____	_____
Monterey Bay Habitats	.50	_____	_____
Kelp Forests	.25	_____	_____
Rocky Shores	.25	_____	_____
Sandy Shores	.25	_____	_____
Deep Sea	.50	_____	_____
Sharks, Skates and Rays	.25	_____	_____
Marine Mammals	.50	_____	_____
Gray Whale	.25	_____	_____
Sea Otter	.50	_____	_____
Ocean Food Webs	.25	_____	_____
Fishes	.50	_____	_____
Adaptations in the Sea	.25	_____	_____
Tides	.25	_____	_____
Scuba	.25	_____	_____

Glossaries define vocabulary used in programs and on Background Information sheets.

Secrets of the Aquarium	.25	_____	_____
Monterey Bay Habitats	.25	_____	_____
Kelp Forest	.25	_____	_____
Rocky Shores	.25	_____	_____
Sandy Shores	.25	_____	_____
Deep Sea	.25	_____	_____
Sharks, Skates and Rays	.25	_____	_____
Marine Mammals	.25	_____	_____
Feeding	.25	_____	_____
New! Fishes	.25	_____	_____
Adaptations in the Sea	.25	_____	_____

Bibliographies list sources for additional information on a particular subject.

Deep Sea	.25	_____	_____
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Page 1 subtotal _____

Caption sheets have 4-8 illustrations of sea creatures each, with descriptions written for specific grade levels.		Qty.	Amount
Grades K-2:	Kelp Forest (1 sheet)	.25	
	Rocky Shores (2 sheets)	.50	
	Sandy Shores (2 sheets)	.50	
	Aquarium Treasures (1 sheet)	.25	
	Spanish Rocky Shores (2 sheets)	.50	
	Spanish Sandy Shores (2 sheets)	.50	
Grades 3-5:	Kelp Forest (2 sheets)	.50	
	Rocky Shores (2 sheets)	.50	
	Sandy Shores (2 sheets)	.50	
	Adaptations in the Sea (1 sheet)	.25	
	Fishes (1 sheet)	.25	
	Spanish Rocky Shores (2 sheets)	.50	
	Spanish Sandy Shores (2 sheets)	.50	
	Spanish Kelp Forest (2 sheets)	.50	
Grades 6-12:	Marine Mammals (3 sheets)	.75	
	Deep Sea (3 sheets)	.75	
	Kelp Forest (2 sheets)	.50	
	Rocky Shores (2 sheets)	.50	
	Sandy Shores (2 sheets)	.50	
	Sharks, Skates and Rays (2 sheets)	.50	
	Marine Mammals (3 sheets)	.75	
	Color guide to the caption sheets	.25	

Activity sheets reinforce vocabulary and concepts learned in aquarium education programs.

Grades K-12:	Monterey Bay Habitats Map	.25	
	New! Trash's Trek to the Sea	.25	
Grades K-2:	Rocky Shores Coloring Pages (2)	.50	
	Marine Mammals Coloring Pages (2)	.50	
Grades K-3:	Ollie Otter Lunch Bag Puppet.....	.25	
Grades 3-5:	Rocky Shore Word Search	.25	
	Secrets of the Aquarium Word Search.....	.25	
	Schooling Fishsticks Classroom Activity	.50	
	New! Fish Bingo Aquarium Activity	.25	
Grades 6-8:	Secrets of the Aquarium Word Search	.25	
	Undersea Forests Word Search	.25	
	Shark Word Search	.25	
Grades 6-12:	Secrets of the Aquarium Crossword Puzzle	.25	
Grades 9-12:	Kelp Forest Crossword Puzzle	.25	
	Conservation Conversation Classroom Activity	.25	
Entire packet of printed materials (\$34.75 value)		\$25.00	

Narrated slide sets include over 50 slides. (Please allow two weeks for delivery.)

A Visit to the Rocky Shore, teaches about tide pool life.	\$75.00		
The Rocky Shores, 3-6, looks at the rocky shore and the adaptations of creatures living there.	\$75.00		
The Monterey Bay Aquarium: A View into Monterey Bay, 3-6, helps prepare your class for a visit.	\$75.00		
Descent into Monterey Submarine Canyon: A Biological Expedition, 9-12, takes you on a research dive into a submarine canyon to study deep sea creatures.	\$75.00		
The Monterey Bay Aquarium Video Collection is a collage of aquarium exhibit videos and others, including marine mammals, kelp forest, deep sea, rocky shore, squid and collecting footage. It is also available through the Monterey Bay Aquarium Gift and Bookstore. (VHS; Time: 69 min.)			
	\$24.95		

Page 2 subtotal		
Subtotal from page 1		
Total order		
CA add 6.75% tax (6.25% after Jan. 1, 1991)		
Shipping: up to \$5 = \$1.50		
\$5.25 to \$10 = \$2.50		
\$10.25 to \$15 = \$3.50		
\$15.25 and up = \$5.00		
Total due		

Please note: We accept purchase orders only for orders of \$20 or more.

Send this completed order form with a check payable to Monterey Bay Aquarium to: Education Materials
 Monterey Bay Aquarium
 886 Cannery Row
 Monterey, CA 93940-1085

Name _____ Day phone _____

School _____

Address _____

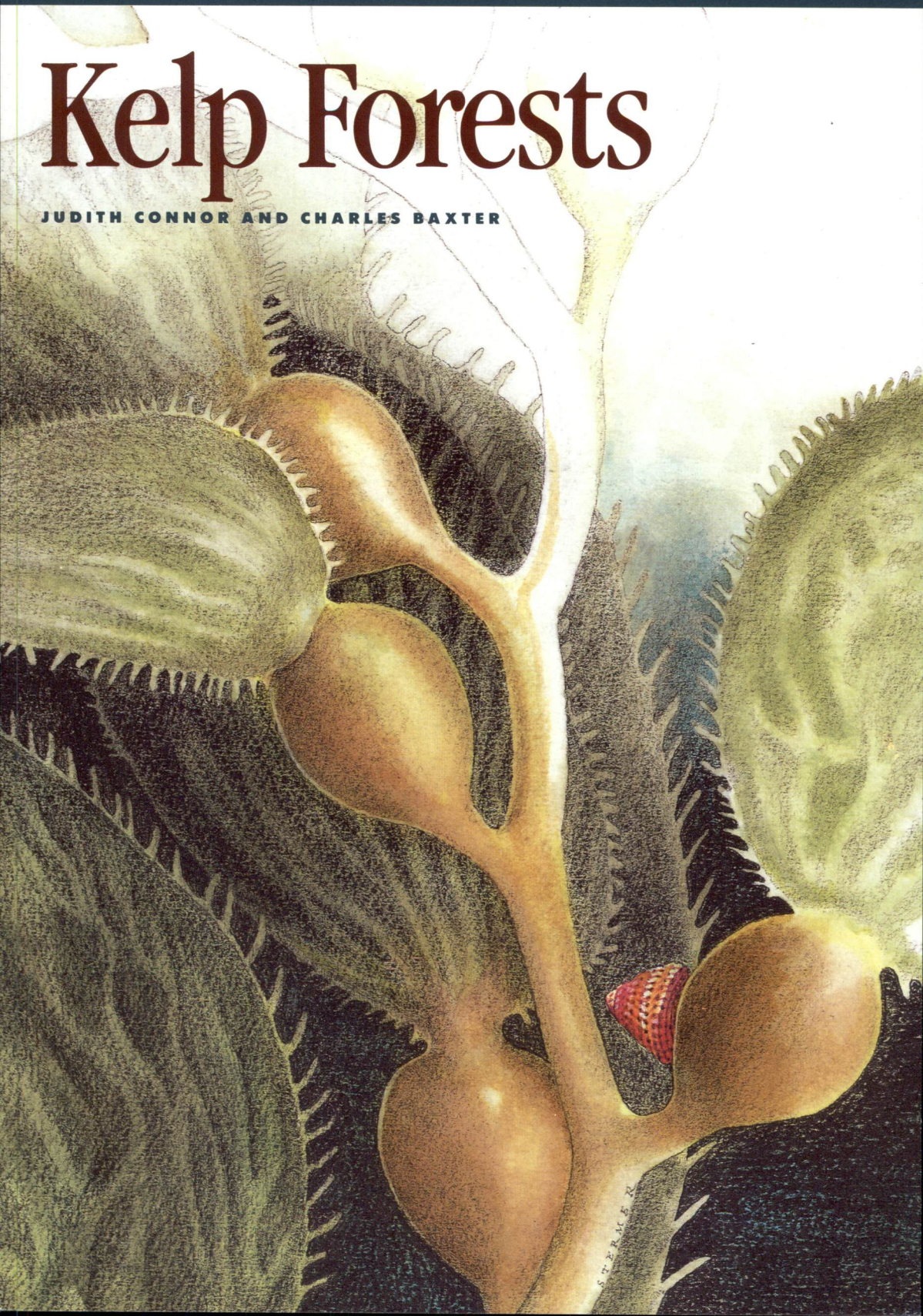
City _____ State _____ Zip _____



MONTEREY BAY AQUARIUM

Kelp Forests

JUDITH CONNOR AND CHARLES BAXTER



level and meet State Science Framework objectives. But you don't have to be a science teacher to come to the aquarium; you can use the visit to stimulate learning in any subject.

Your students are discovering their roles in the world, and they'll soon have a say in decisions that affect our planet. Let them listen to the bay now, so they'll be able to speak up for it later.

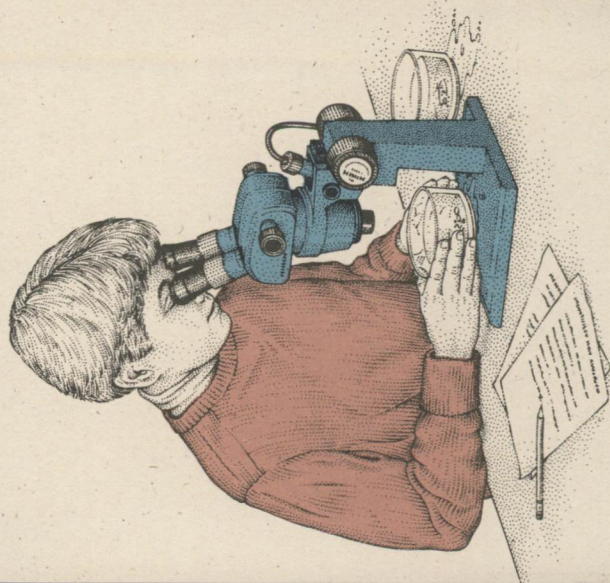


Free Teacher Resources

The Monterey Bay Aquarium has free resources available for teachers who participate in our education programs.

Pre-visit Packet

When you make a reservation, we'll send you a packet of curriculum materials for use before, during and after your visit. The packet includes activity and information sheets for your program theme and grade level, as well as a map, parking directions and tips for chaperones and teachers to help make your day a success.



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MONTEREY BAY AQUARIUM

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Education programs at the Monterey Bay Aquarium 1990-91

Discover

what the bay
has to say....



at the
Monterey Bay Aquarium

For grades 6-8

In **Undersed Forests**, students discover the kelp forest inhabitants' adaptations for survival, from decorator crab camouflage and abdome feeding behavior to turban snails' escape responses.

M, T 9:30, 10:45 Afternoons by arrangement

Sea Otters and You gives your class a close-up look at these nearshore marine mammals. Students will learn how sea otters are adapted to life in the sea, yet face an uncertain future.

W, Th 9:30, 10:45

Afternoons by arrangement



For grades 9-12

To study **Kelp Forest Ecology**, students focus on food webs, predator/prey relationships and kelp forest zonation. Experiments let students discover the defense and feeding adaptations of kelp forest organisms.

M, T 9:30, 10:45 Afternoons by arrangement

In **Marine Mammal Lifestyles**, students handle pelts and skeletons while investigating the adaptations of sea otters, seals, dolphins and whales. They'll compare the lifestyles of different groups, then explore the effects of human interactions with marine mammals.

W, Th 9:30, 10:45 Afternoons by arrangement



For grades 6-8

In **Sharks I**, students learn about remarkable shark adaptations and how sharks differ from other fishes. They'll also discover how we use sharks for food and research and how some sharks are being overfished. Students will have a chance to feel shark skin, jaws and teeth.

M-W 9:45, 11:00

For grades 9-12

In **Sharks II**, students focus on sharks' remarkable senses. Then they discover how people and sharks interact—from myths about sharks, to their use in research, to the fisheries that threaten some shark populations.

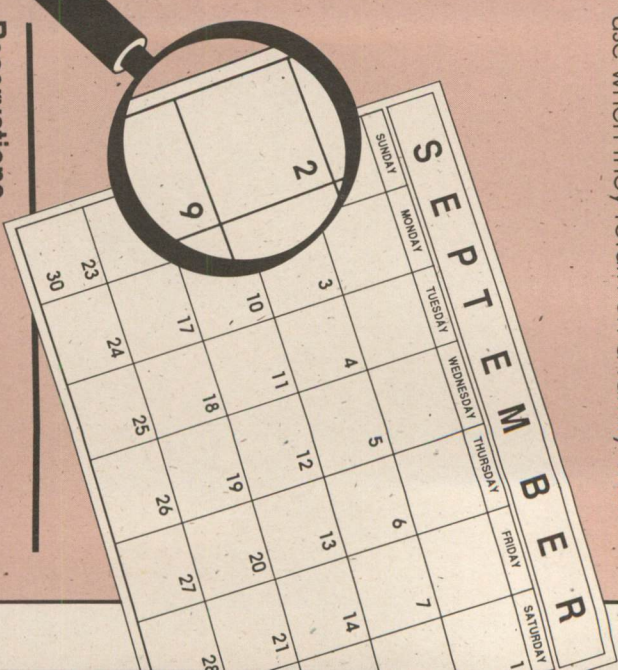
M-W 9:45, 11:00 Afternoons by arrangement



Visit us before March

Fall and winter months are best for visiting the aquarium: fewer crowds, more room to roam, more time to learn.

Visit before March 1 and we'll give you complimentary tickets your students can use when they return on a family visit.



Reservations

You must make reservations at least two weeks in advance for education programs. Reservations may be made up to four months before your visit. For reservations or more information, call the Education Reservationist Monday through Friday, between 8:30 a.m. and 4:00 p.m.

(408) 648-4850

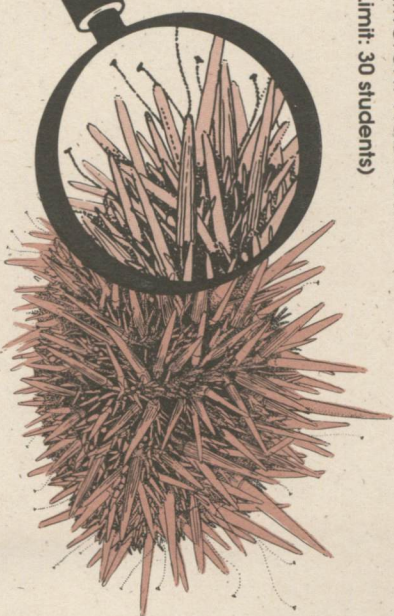


MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT

Discovery Labs

These 50-minute labs feature hands-on investigations of marine life. Through observation and experiments, students learn how animals are adapted to their different habitats.

(Limit: 30 students)



For grades K-2

In **Tide Pool Discovery**, young children learn to move like sea stars and have the chance to handle sea urchins, hermit crabs and other tide pool dwellers.

W, Th 9:30, 10:45

During **Marine Mammals Great and Small**, students learn about gray whales and sea otters, meet the animals sea otters like to eat, handle a whale's great comblike baleen and use fur and "blubber" mittens to learn how whales and sea otters stay warm in cold water.

M, T 9:30, 10:45

For grades 3-5

In **A Sea of Adaptations**, students learn how sea creatures from anemones to olive snails find food and protect themselves in the sea.

M-Th 9:30, 10:45 Afternoons by arrangement

In **Marine Mammal Mysteries**, students discover some secrets to success in the sea—how seals, sea otters, whales and dolphins are adapted to life in the ocean.

Auditorium Programs

These 30- to 40-minute group programs feature lively demonstrations and slide presentations. Younger students will learn surprising facts about aquarium "treasures," or discover how fishes survive in the sea. Older students will examine myths and facts about sharks, or learn how deep sea animals survive in their cold, dark environment.

Limit: 60 or 90 students; call for schedule

For grades K-2

In **Aquarium Treasures**, students discover the wealth of animals living in Monterey Bay and their adaptations to kelp forest, rocky shore or sandy seafloor habitats. After the program, students can hunt for these living gems in the aquarium's exhibits!

Th 9:45, 11:00



For grades 3-5

In **Some Things Fishy**, students find out that all fishes are not alike. By examining fishes from the kelp forest, open ocean, sandy seafloor and deep sea, they'll learn how different fishes are adapted to their homes in the sea.

M-Th 9:45, 11:00 Afternoons by arrangement

Do-it-yourself Labs

Imagine bringing your class to the aquarium—and having access to a lab complete with microscopes, running sea water and ocean animals. Now you can use our classroom resources to design your own program, for one lesson or a whole unit.

We'll provide guidelines and a staff member to help you; you're free to teach! M-Th by arrangement

Self-guided Tour

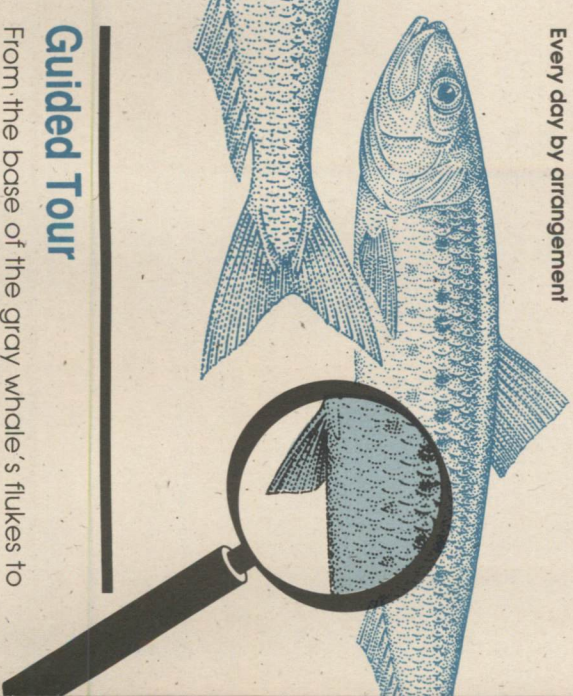
Does a school of fish have a leader? How well can an octopus see? Explore these and other intriguing questions as you and your chaperones lead your group through the aquarium with the help of our activity sheets. Go at your own pace and take as long as you like, investigating whatever interests your students most.

Every day by arrangement

Guided Tour

From the base of the gray whale's flukes to the waves that crash on our decks, our Aquarium Guides can give you an hour-long overview of the aquarium—from an insider's point of view.

M-F 9:30 a.m.





Monterey Bay's brimming with exciting tales of life in the sea!

Our education programs bring these stories to life. We'll introduce your students to gripping dramas in wave-washed tide pools, epics of survival in towering kelp forests and the dark mysteries of a vast submarine canyon. Share their excitement as they hold a hermit crab, explore the deep sea with scientists or see a sea otter eye-to-eye.

At the Monterey Bay Aquarium, you have your choice of education programs:

- hands-on **Discovery Labs**
- dramatic **Auditorium Programs**
- **Guided Tours** that offer an aquarium overview
- **Self-guided Tours** you lead at your own pace, or
- **Do-it-yourself Labs**, where you use our onsite lab to create your own lesson.

Following your education program, go ahead and explore the aquarium with your students.

Teacher's Planning Visit

When you schedule a field trip, you can also make a reservation to visit alone ahead of time to help you prepare. Please call at least two days in advance of the date you'd like to make your planning visit.

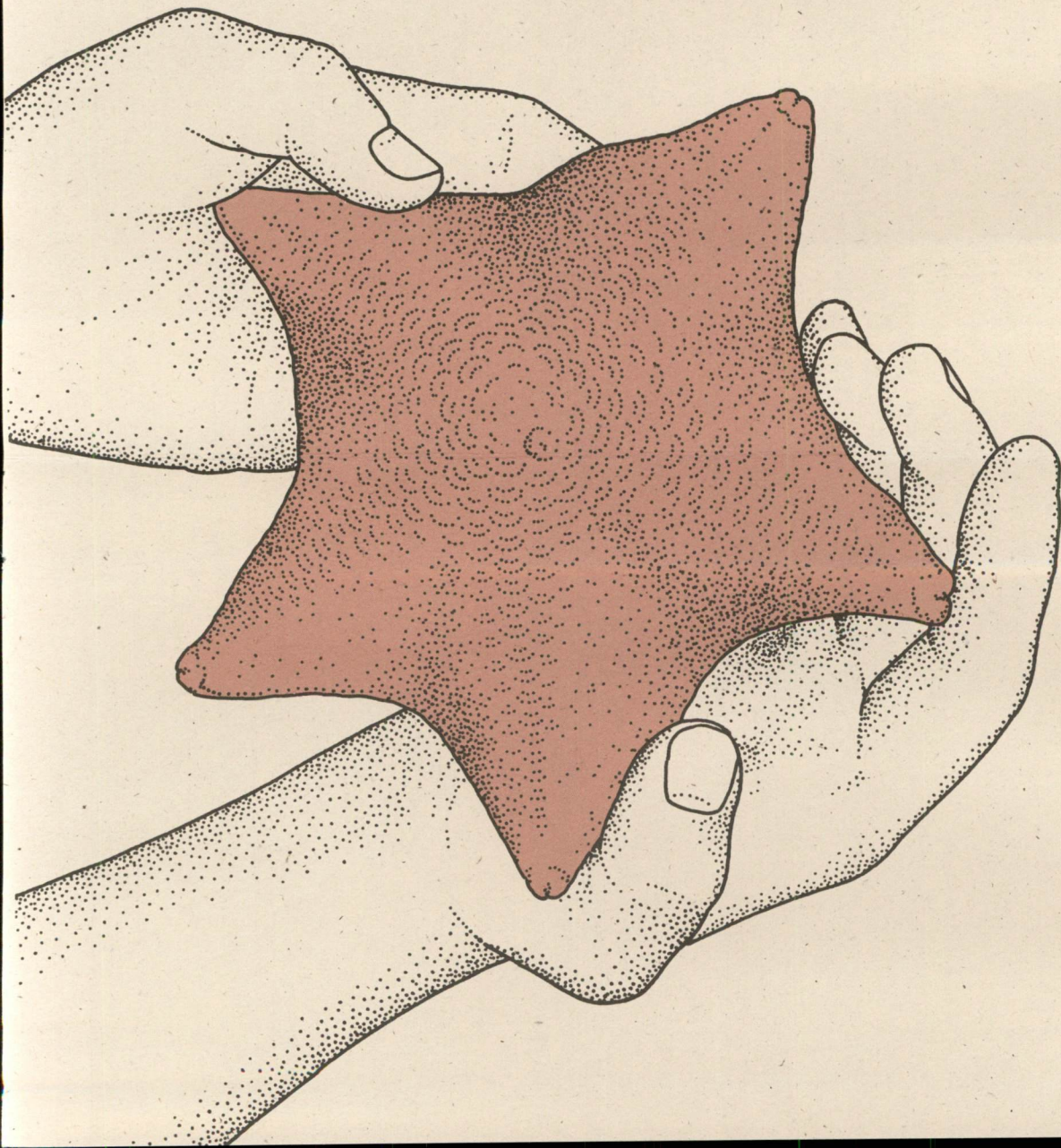
To make a field trip reservation and arrange for your teacher's planning visit, call the Education Reservationist Monday through Friday between 8:30 a.m. and 4:00 p.m. at (408) 648-4850.

Chaperones

We require an adult-to-student ratio of 1 to 10, but recommend you bring 1 chaperone for every 5 students (see **Fees**.)

Fees

Students, teachers and chaperones (up to 1 adult for every 5 students) are admitted free. Additional adults pay \$7 each, or \$8 each after December 31, 1990.



Aquarium Volunteers share what's inside.



Our volunteers share more than the wonders inside the Monterey Bay Aquarium. As they share their love for the sea, they share their lives with others.

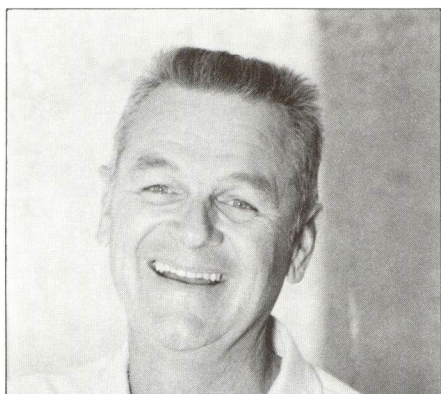
That's because a volunteer is in the best position to enjoy the aquarium: from the inside. When you volunteer, you become an important part of a world-class aquarium, an institution dedicated to bringing people closer to the sea.

You'll gain new skills and knowledge as you work side by side with aquarium professionals, meeting different people who share your interest in the marine environment.

And there are so many ways to get involved. Volunteers staff our Information Desk, assist in the Gift & Bookstore, act as Aquarium Guides, and work behind-the-scenes in the administrative, husbandry, education, marketing and other departments.



MONTEREY BAY AQUARIUM



There are other rewards, too. Aquarium volunteer benefits include free admission, discounts at the Gift & Bookstore, newsletters, social activities, field trips, library access, family guest passes, and special awards and recognition.

Whether you're a student, teacher, professional, homemaker or senior, the Monterey Bay Aquarium needs your skills and talents. Anyone 14 or older can volunteer on weekends, weekdays or evenings.

All you need is the desire to share what's inside.

Enrollment opens in spring for the September Aquarium Guide training course, but we accept applications all year round. Other volunteer positions are always open; you can sign up today.

For more information, send in the form, or call the Volunteer Office:

(408) 649-6466



Name _____

Address _____

City _____ State _____ Zip _____

Home phone _____ Business phone _____

Best time to call _____

Employer _____ Hrs/wk _____

Age (check one):

☐ 14-17 ☐ 18-30 ☐ 31-45 ☐ 46-60 ☐ 61 and over

Highest grade completed _____

Please rank by number the areas in which you'd like to volunteer:

____ Aquarium Guide ____ Info Desk ____ Administrative
____ Certified Diver ____ Bookstore ____ Curatorial
____ Summer Junior Program (ages 14-17)

How many hours per month are you available? _____

Which days are you available? _____ a.m. or p.m.?

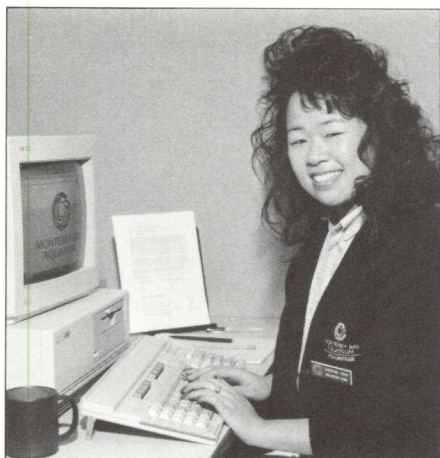
Signature _____

Date _____

Please return to:

Monterey Bay Aquarium Volunteer Office
886 Cannery Row
Monterey, CA 93940-1085

or call **(408) 649-6466**. Ask for the Volunteer Office.



Administrative Volunteer

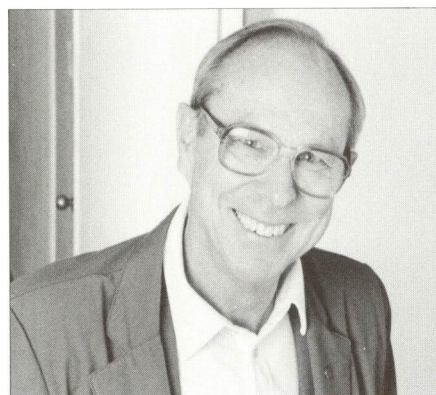
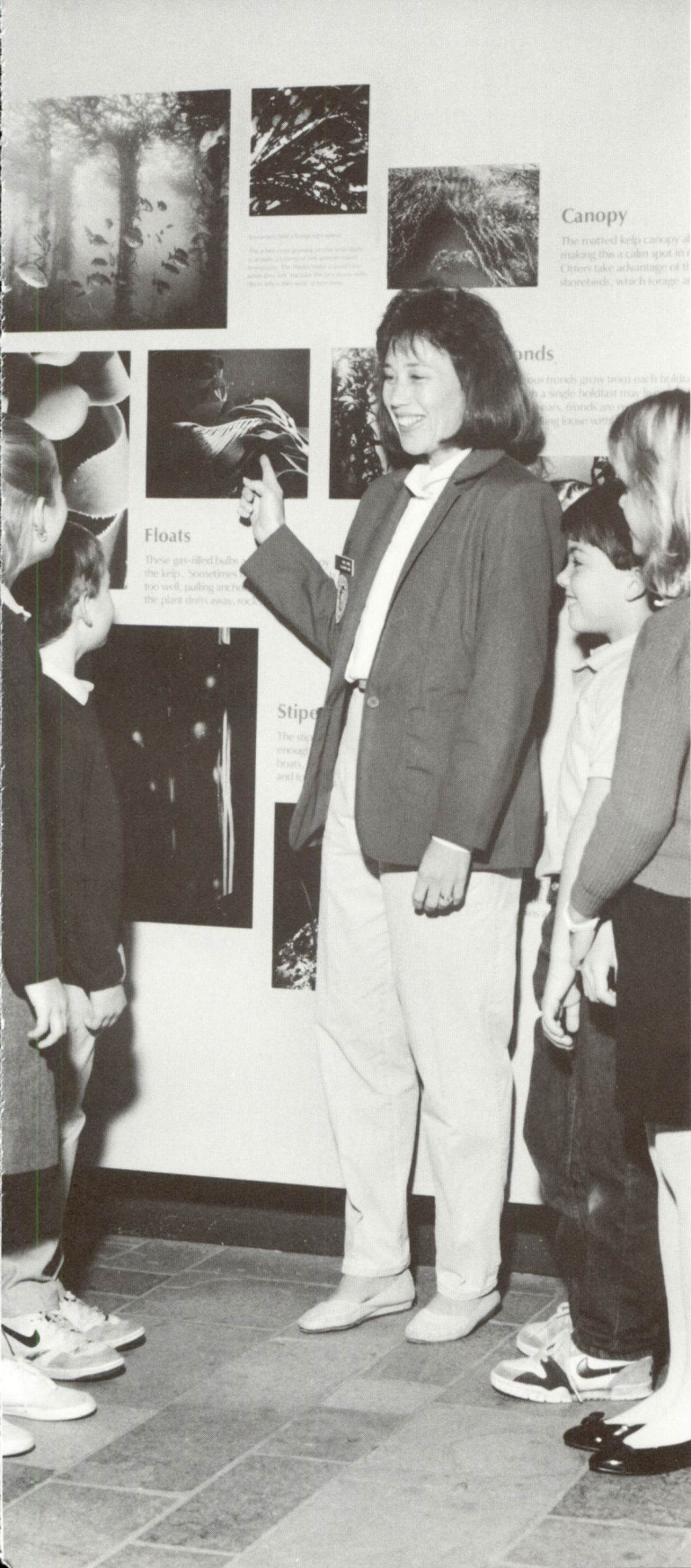
Whether it's typing, filing, phoning, assisting with events, memberships and mailings, contributing to the volunteer newsletter or filling any of a score of special needs, administrative volunteers help keep the aquarium running round-the-clock.

Bookstore Volunteer

With thousands of nature books and prints at their fingertips, Gift & Bookstore volunteers help visitors find just what they're looking for.

A Gift & Bookstore volunteer can help take the terror out of buying the right book on sharks, or finding toys for a child whose first word was "otter."





Aquarium Guide

After a 16-week training course, Aquarium Guides not only know all the best stories about Monterey Bay, they know how to make a visitor's face light up with discovery.

Guides lead school tours, answer questions at exhibits, and put people in touch with the sea at the Kelp Lab, Touch Pool and other hands-on displays.

Information Desk Volunteer

"What should we see first?"

"When do you feed the otters?"

Information Desk volunteers come face to face with people from around the world, answering questions, making suggestions and getting big smiles in seven languages.

Behind-the-scenes Volunteer

Some volunteers commute 90 miles to wash the Kelp Forest windows... from the inside! Volunteer divers also hand-feed the fishes. Other behind-the-scenes volunteers take part in everything from bird-feeding to otter-sitting.



Information you should know:

The Monterey Bay Aquarium's array of exhibits and galleries offers a dramatic view of Monterey Bay, one of the world's richest marine regions. *We recommend you begin your visit by following the Habitats Path to your left as you enter.*

While you meet all of our colorful and curious creatures eye-to-eye, many of the exhibits encourage you to investigate further—through microscopes, magnifiers and telescopes, and even by touching some of the aquarium's residents.

You can learn fascinating details about these creatures' lives by talking with volunteer guides stationed throughout the aquarium. They're wearing rust-colored jackets or aprons for easy identification.

To make your stay more enjoyable, we ask that you observe these rules in the aquarium:

- No smoking inside the aquarium
- No food, drinks or chewing gum
- Don't litter or throw coins or objects. Help keep our animals and plants healthy.

Emergencies: Go to the Information Desk in the lobby, or contact the nearest security officer or volunteer guide.

Information: For general information, go to the Information Desk or call (408) 375-3333.

Re-entry: Remember to have your hand stamped as you leave if you wish to return to the aquarium today.

Portola Cafe/Gift & Bookstore: Portola Cafe hours are 10 am to 5 pm. Be sure to visit the Gift & Bookstore as well, open 10 am to 6 pm (have hand stamped for re-entry before entering store).

Membership: Unlimited admission for an entire year, *Shorelines* newsletter and other benefits are part of membership. Today's admission can be applied to your membership fee. Please inquire at the Group and Members' Entrance.

Comments: We appreciate your comments and suggestions. Forms may be obtained at the Information Desk.

Hours: 10 am to 6 pm daily; closed Christmas Day.

The Monterey Bay Aquarium is a non-profit, self-supporting institution. Its purpose is to increase understanding and awareness of Monterey Bay and the marine environment through sea life exhibits, public education and scientific research.

Contact the Education Department at (408) 649-3133 for details on specific programs for school groups and others.

Kodak picture-taking spots:

To best capture the details of the aquarium's exhibits, move in close to photograph. Avoid the aquarium's biggest photography problem—reflections—by only using your flash at a 45° angle. If you have a 35mm camera, use a fast film (available in the Gift & Bookstore).

Following are the best of Kodak's picture-taking spots, with suggestions for great photos. See the map for locations.

1. *The Sandy Shore (aviary)*

Rare close-up photos of killdeer, avocets and sandpipers (among other shorebirds) can be taken here. Remember: look and photograph, but please don't touch.

2. *Monterey Bay Habitats*

After shooting through the big underwater windows in the center exhibit, try some close-ups in the galleries surrounding: Deep Reefs, Sandy Seafloor, Shale Reefs and Wharf.

3. *Tough Pool*

Try for a close-up with subject, tidepool animal and aquarium guide in frame. Shoot with the windows behind you to reduce glare.

4. *The Great Tide Pool*

Several angles are possible; try at least one with Monterey Bay in the background. Watch for the harbor seals who frequently visit this open exhibit.

5. *Outdoor Decks*

An excellent view is from the top of the pump house, looking back towards the sculpture. Remember to get the ocean in your photos from the decks.

6. *The Kelp Forest*

The aquarium's centerpiece exhibit deserves several photos. After a traditional one from the first floor seating area, experiment with the circular windows found on both floors.

7. *Sea Otters*

The sea otters make a difficult subject, as they always seem to be moving. Best shots are from the surface, where light is good. Pick a spot and wait—they'll make the rounds.

8. *Marine Mammals*

Best shot is from the Group and Members' Entrance, looking toward the 43-foot California gray whale. Include people for scale.

This visitor's guide courtesy of



MONTEREY BAY AQUARIUM

886 Cannery Row Monterey, CA 93940-1085

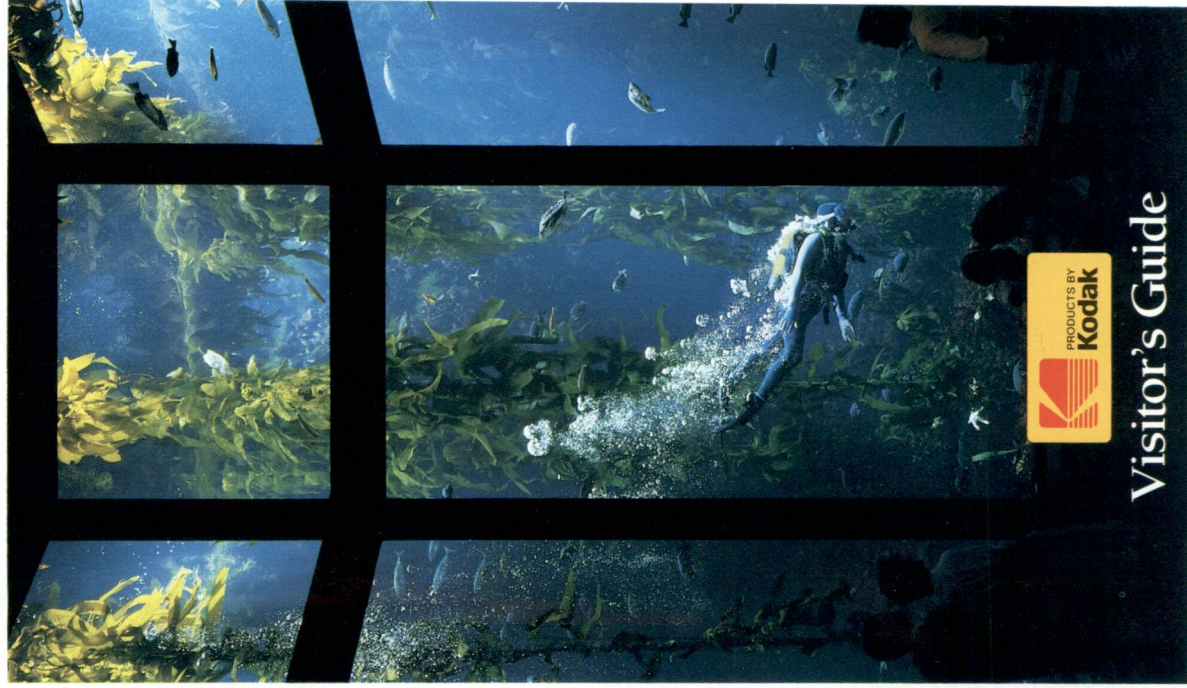
Kodak
America's
Storyteller

Printed in USA

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MONTEREY BAY AQUARIUM®



Visitor's Guide

Welcome to the Monterey Bay Aquarium.

We recommend you begin your visit by following the Habitats Path to your left as you enter.

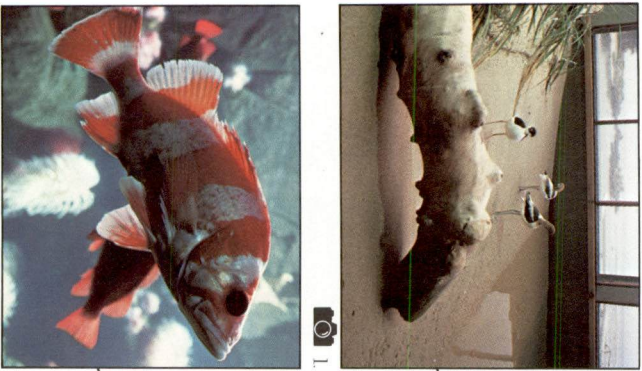
Daily Feedings

The usual feeding schedule is:

Sea Otters 11 am, 2 pm, and 4:30 pm

Kelp Forest 11:30 am and 4 pm

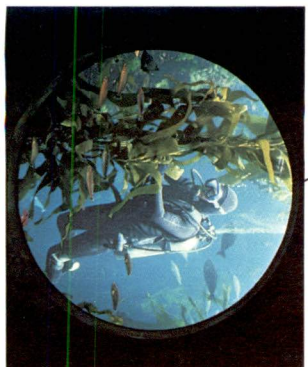
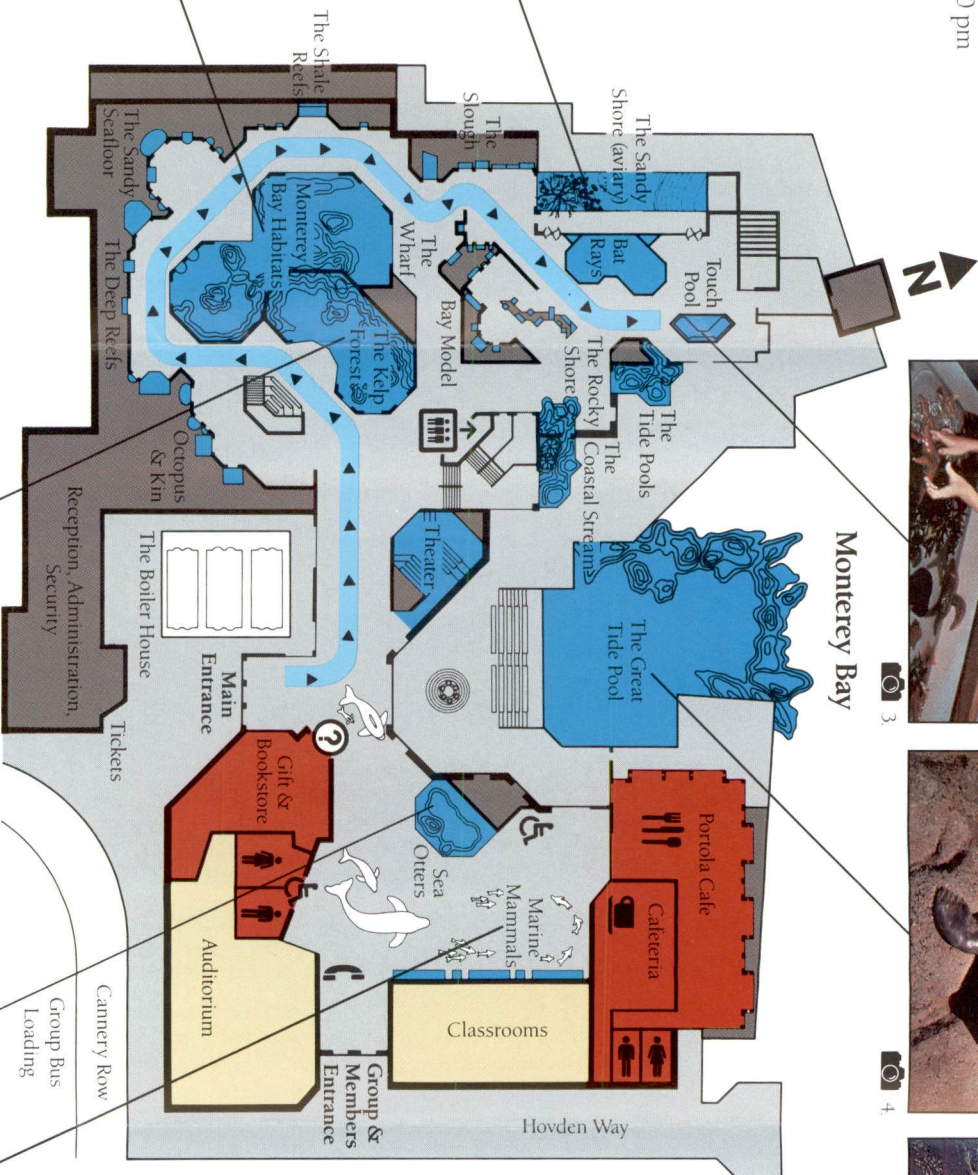
This schedule is subject to change. Check the Information Desk for today's times.



1. 2.

- Picture-taking Spots
- Information
- Restrooms
- Public Telephones
- Elevator

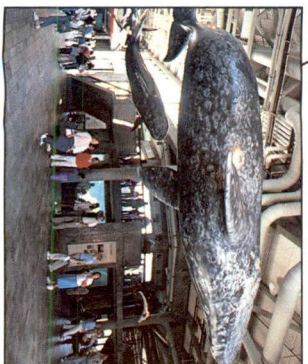
Main Floor



6.

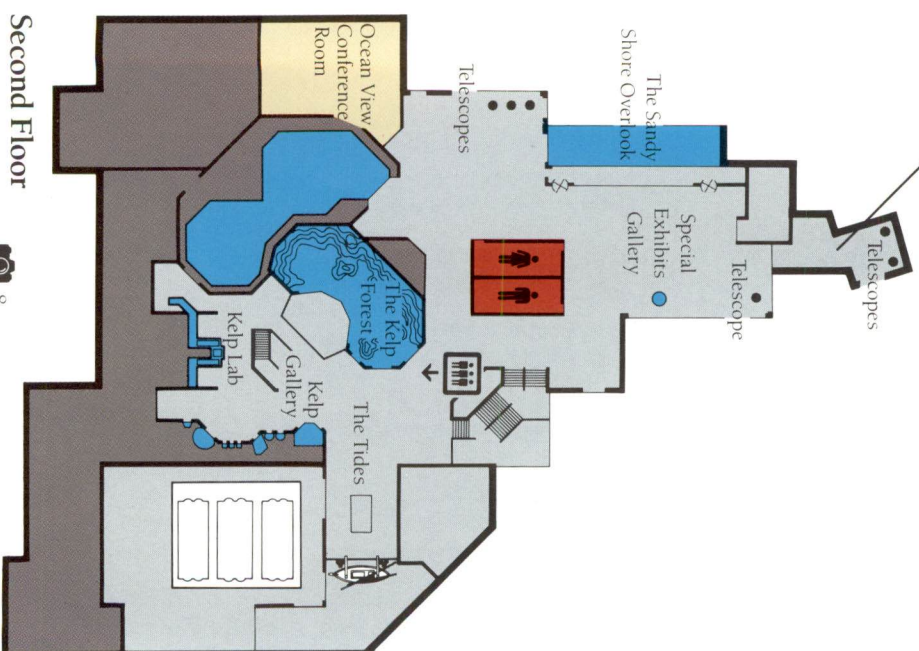


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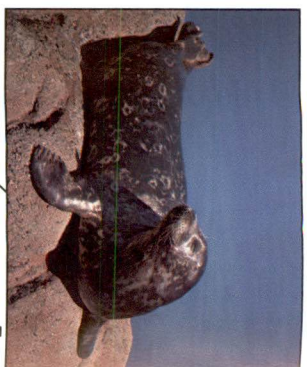


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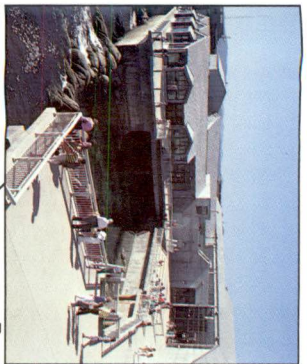
Second Floor



3.



4.



5.

- Cafeteria
- Portola Cafe
- Handicapped Access (Refer to "Guide for the Handicapped" available at the Information Desk)



Aquaravan programs from the
Monterey Bay Aquarium 1990-91



MONTEREY BAY AQUARIUM

886 Cannery Row Monterey, CA 93940-1085

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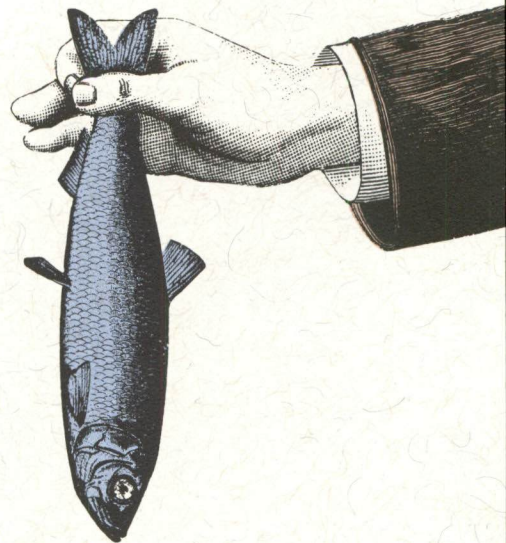
Address correction requested
Forward and return postage guaranteed

Aquaravan programs from the Monterey Bay Aquarium 1990-91

Order one of
the Monterey Bay Aquarium's
education programs and we'll
bring it right to your door!

Our full menu of programs offers you a
new way to see the sea, without ever
leaving your school.

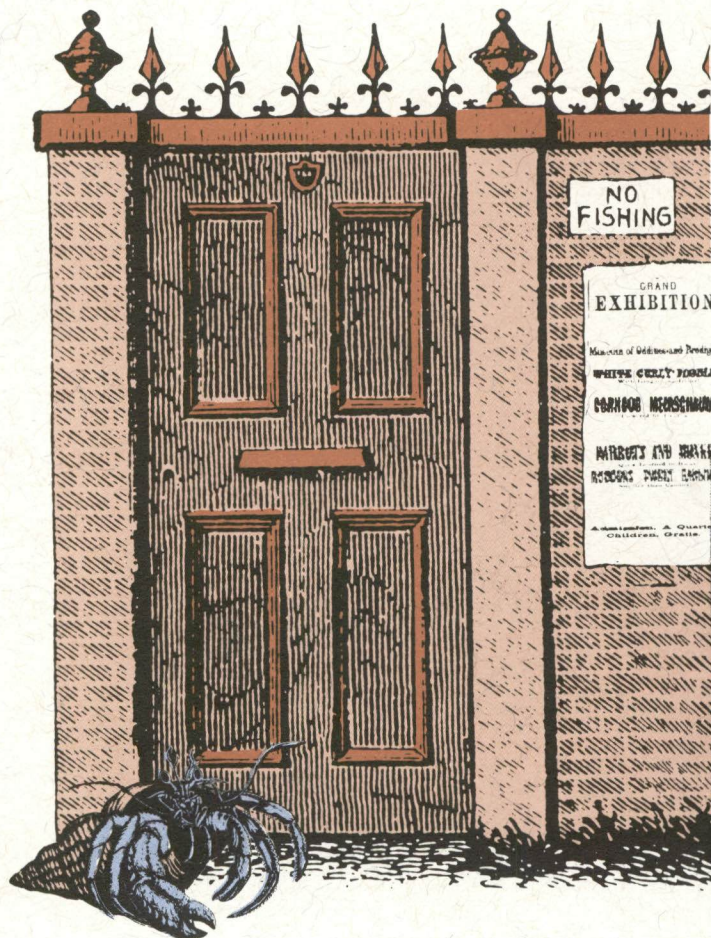
When the aquarium's traveling **Aquaravan**
comes to your school, younger students
will have the chance to dress up as whales
or build an ocean food web, while older
students will delve into the mysteries of
deep sea life.



(408) 648-4850



MONTEREY BAY AQUARIUM®
EDUCATION DEPARTMENT



Free Teacher Resources

Aquaravan programs are tailored to your grade level and State Science Framework objectives. **Programs are in English**, but we can work with your translators on request. Once you order a program, we'll send a free packet of curriculum materials to use in the class before and after our visit.

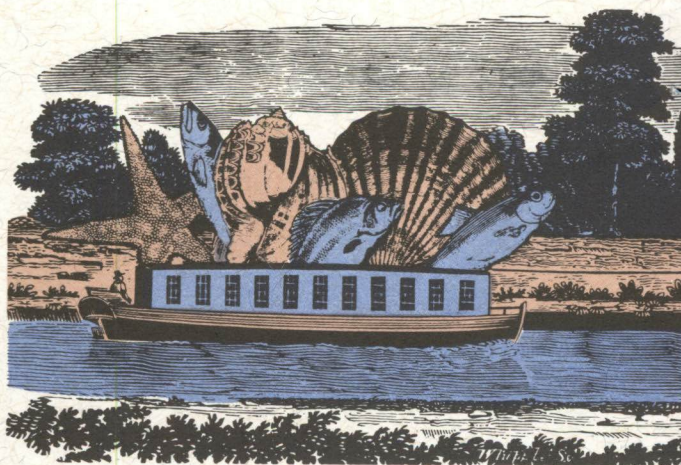
Fees

We deliver to Monterey, Santa Cruz and San Benito counties. Mileage is free in a 20-mile radius from the aquarium and costs 50¢ each additional mile.

Reservations

Won't you call now and order an Aquaravan program to go?

To schedule a program or for more information, call us weekdays, 8:30 a.m. to 4:00 p.m.



Classroom Programs

These lively classroom programs reveal the secrets of our local coast from the rocky shore to the dark deep sea. Your group can see for themselves how shore creatures like sea stars and sand crabs cope with crashing waves and changing tides. Through pantomimes, dress-ups, discussions and live animal observations, they'll find out firsthand who eats whom, and how deep sea animals are adapted to life in the cold, dark depths.

M-Th

length: 60 minutes or 1 class period

limit: 32 students

sessions: 2-6 per day

fees: \$50 each session

For preschoolers

In **Seashore Friends**, students take an imaginary tour of the seashore with Freddie the Fish, meeting other tide pool animals along the way.

For grades K-12

New! Do-it-yourself Labs let teachers create their own marine science programs. Choose a subject, then order Aquaravan animals à la carte to use in your instruction! The Outreach staff works with you to deliver the animals *and* the lesson.

For grades K-2

During **Supper in the Sea**, students discover how sea stars slurp food through their stomachs and barnacles catch food with their legs, then compare their own eating habits to those of ocean animals.

New! In Shorelines, students learn about the ups and downs of life along rocky and sandy seashores, where animals must hang on or dig in to survive.

For grades 3-5

After **Marine Mammals on the Move**, students explore the lifestyles of marine mammals they met in the assembly by listening to marine mammal sounds, touching whale baleen and handling otter pelts.

Following your **Monterey Bay Habitats** assembly, students can handle and observe the living seashore creatures introduced by Professor Habitat.

New! After **The Perils of Pollution** assembly, this mini-lab lets students investigate the effects of pollution on ocean life, then discover some simple things they can do at home to help clean up the ocean. (Available January 1991.)



Assembly/Class Mini-labs

This program combines the assembly with a follow-up mini-lab in your classroom. The mini-lab gets your class in touch with animals they met in the assembly—sea stars, crabs and other living creatures from the bay—plus marine mammal pelts and artifacts.

M-Th

length: assembly 30-45 minutes;
mini-lab 45 minutes

limit: assembly 200 students;
mini-lab 32 students

sessions: 1 assembly/day;
2-6 mini-labs per day

fees: assembly \$120;
each mini-lab \$30

For grades K-2

After your **Alice in Waterland** assembly, your students will head back to the classroom for a close-up look at living crabs, snails and other sea "stars" featured in the program.

An Otter Adventure winds up with students back in the classroom where they "build" an otter, then handle living animals that sea otters eat, including crabs, sea stars and snails.



For grades 3-6

In **The Hungry Ocean**, students explore food webs, learning how sea otters, kelp and other ocean plants and animals depend on each other for survival in the sea. (Program materials are also available in Spanish. We'll work with you so you can deliver this program to your Spanish-speaking students.)

New! In the hands-on **Shorelines** lab, students investigate how animals cope with the ever-changing conditions of coastal ocean habitats.



For grades 6-12

In the **Deep Sea Research Lab**, we'll turn your classroom into a lab where you'll explore the inner space of the deep sea. Discover the challenges researchers face in trying to study this vast, dark, unknown world. You'll see deep sea life through the eyes of a scientist descending 2,000 feet in the Monterey submarine canyon...and when the lights come up, you can examine some of the strange specimens netted in the canyon depths.

sessions: 1-4 per day

For students with special needs

New! Fins and Fur introduces students to three major groups of ocean creatures: fishes, mammals and invertebrates. In a program tailored to your group's special abilities and needs, students or teachers dress up as marine mammals, handle sea stars and turban snails, and make fish prints.

Assembly Programs

You can get even more students involved with our dramatic assembly programs. Students take on starring roles as the drama unfolds, then turn their classmates into sea creatures to learn how ocean animals survive.

M-Th

length: 30-45 minutes
limit: 200 students
sessions: 1-2 per day
fees: \$120 each session

For grades preschool-2

Alice in Waterland follows the adventures of Alice as she explores the sandy shore, the rocky shore and a kelp forest, and discovers some fascinating adaptations of sea creatures.

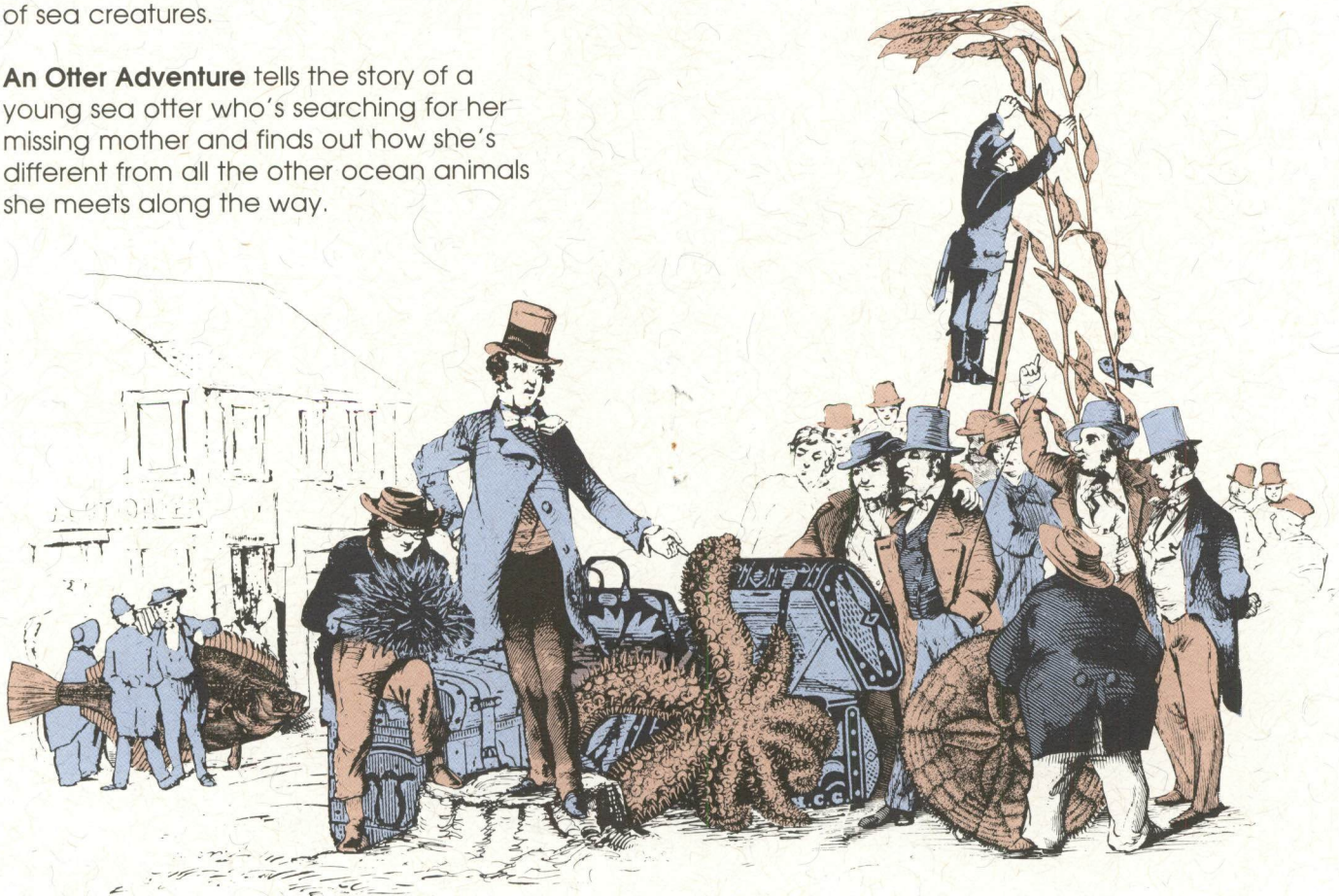
An Otter Adventure tells the story of a young sea otter who's searching for her missing mother and finds out how she's different from all the other ocean animals she meets along the way.

For grades 3-5

Marine Mammals on the Move takes students on an imaginary whale-watching trip where they learn about the lifestyles of gray whales, sea lions and sea otters.

Monterey Bay Habitats sends students off on a tour with Professor Habitat to learn how the residents of local marine environments fit their surroundings.

New! Now you can boo the villain in **The Perils of Pollution!** This ecological melodrama introduces students to the effects of pollution on ocean life, and shows them how they can be heroes by foiling Snidely Spoiler's plan to spoil our oceans and beaches. (Available January 1991.)





MONTEREY BAY AQUARIUM

January 1991

To Whom It May Concern:

Thank you for your interest in programs for teachers. You'll find a table of contents for this information folder on the back of this letter.

- On the left side of the folder, you'll find background information about the aquarium and its education programs.

- On the right side, you'll find information about our five basic types of programs for teachers and samples of some of our support materials.

Since 1987 when the aquarium's Board of Directors created the Teacher Programs Department, 230 teachers have completed our intensive 13 day institutes. Each institute lasts thirteen days and serves 28 teachers at a total cost of about \$2200 per teacher. For each participant space in our institutes we receive an average of 2.5 applications.

A strength of our program has been the mixing of equal numbers of teachers from grades K-12. Our institute teachers are trained to use hands-on methods of sharing the content and process of science with students. They also provide in-service training and support for at least ten other teachers. Together they will continue to multiply our efforts by sharing our curriculum and methods with at least 150,000 students each year.

Please contact me if additional information would be helpful.

Sincerely,

Jeffery S. Bryant
Teacher Programs Coordinator
(408) 648-4835

Monterey Bay Aquarium Teacher Programs Information Folder

Left Pocket Contents:

- I. Monterey Bay Aquarium Information
 - A. Background Information Sheet
 - B. Mission Statement
 - C. Overview
 - D. Visitor's Guide
- II. Education Division Information
 - A. Education Program Fact Sheet
 - B. Outreach brochure (We Deliver!),
On-site brochure (Discover what the bay has to say)
Volunteer brochure (Aquarium volunteers share what's inside.)
- III. Sample materials: Kelp Forest
 - 1. guide manual pp. 137-144
 - 2. education print materials
 - a. Kelp Forests background information
 - b. Kelp Forests glossary
 - c. Kelp Forests caption cards
 - (2) grade 3-5 English
 - (2) grade 3-5 Spanish
 - d. Kelp Forest Habitat slide set captions
 - e. Kelp Forests natural history book cover
 - f. Education Materials order form

Right Pocket Contents:

- IV. Teacher Programs Calendar
- V. Teacher Programs Information
 - A. Program descriptions
 - 1. Teacher Open House
 - 2. Global Issues Symposium/Workshops
 - 3. Marine Studies Workshops (sample schedule)
 - 4. Teacher Expedition
 - 5. Marine Science Institute
 - B. Marine Science Institute Information
 - a. Contents and Assignments
 - b. Schedules
 - c. Evaluation summary with statistics
 - d. Sample Curriculum Product
 - C. Wet Science Project (1991-1994)
 - D. "Aquarium Teacher Training", Current: The Journal of Marine Education. Volume 9, Number 3, 1989, pages 23-26.
 - E. Letters of endorsement
 - a. Teacher
 - b. School Administrator
 - c. Aquarium Director
 - d. University Administrator

Monterey Bay Aquarium Teacher Programs Department

1991 CALENDAR

Teacher Expedition Baja California	12/27/90 - 1/ 2/91
1990-1991 Marine Science Institute July Institute Follow-up II	1/10/91 - 1/12/91
August Institute Follow-up II	1/24/91 - 1/26/91
Marine Studies Workshop for Teachers In Training University of California at Santa Cruz Student Teachers	2/1/91 - 2/2/91
Global Issues Symposium and Workshops	2/23/91
Host: California Science Staff Development and Curriculum Leadership Conference	3/ 5/91
1990-1991 Marine Science Institute July Institute Follow-up III	4/ 4/91 - 4/ 6/91
August Institute Follow-up III	4/18/91 - 4/20/91
Co-sponsor: Monterey County Science Fair	4/11/91 - 4/14/91
Host: Central California Teacher Inservice Programs Providers	5/10/91
1991-1992 Wet Science Institute Advanced Institute	6/17/91 - 7/19/91
Basic Institute	8/11/91 - 8/21/91
Present at: National Marine Educators Association Conference New Brunswick, New Jersey	8/ 6/91 - 8/10/91
Teacher Open House and Camp-in	9/28/91
1991-1992 Wet Science Institute Advanced Institute Follow-up I	10/ 3/91 - 10/ 5/91
Basic Institute Follow-up I	10/24/91 - 10/26/91
Host: California Aquatic Science Education Consortium Confluence	10/11/91 - 10/13/91
Present at: National Science Teachers Association Regional Convention Vancouver, British Columbia	11/21/91 - 11/23/91
Teacher Expedition: Baja California	12/27/91 - 1/ 2/92

1990 Open House

Saturday, October 13...for teachers only
6:30 to 9:30 p.m.

- new program information and previews
- shopping and poster sale until 8:30 p.m.
(cash, VISA, MasterCard and school purchase orders [\$50 or more] accepted)
- all exhibits open
- refreshments and time to meet other teachers

Make your reservations today.

Call our Education Reservationist:

Monday through Friday 8:30 a.m. to 4:00 p.m.

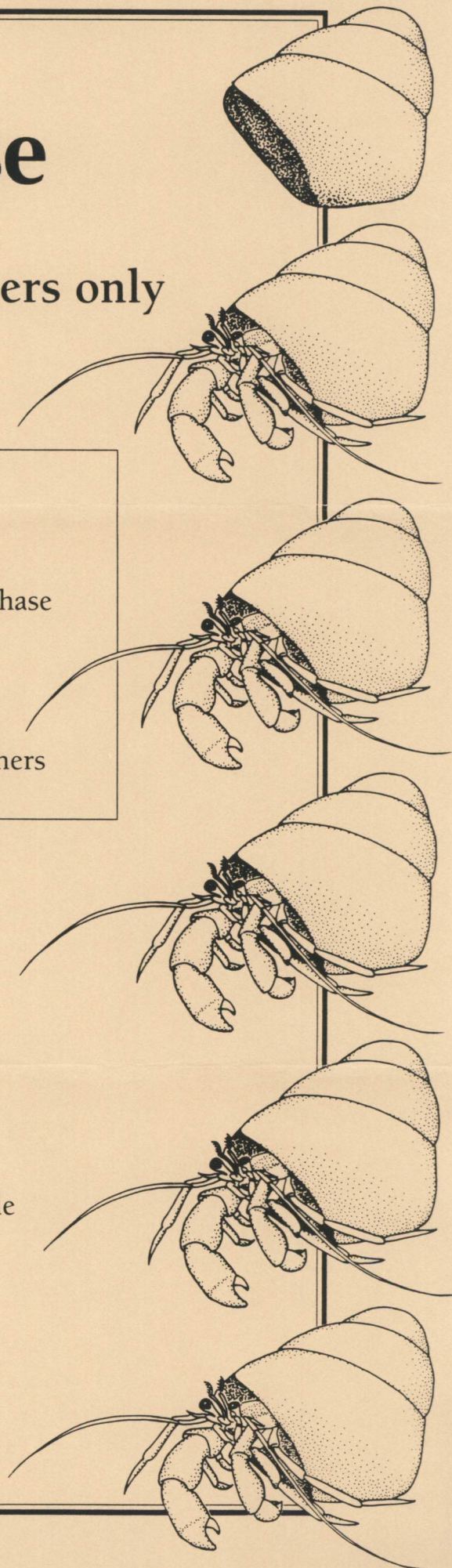
(408) 648-4850

We have room for 50 teachers to camp overnight inside the aquarium. Call for details.



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Monterey Bay Aquarium Teacher Institute
Global Issues Symposium and Workshops

General program description

recent topics:

- 1986 deep sea ecology and technology
- 1987 coastal wetlands
- 1988 threats to the marine environment
- 1989 evolution
- 1990 tropical rain forests
- 1991 human population growth

typical audience composition:

- 180 teachers of Kindergarten through college from Central California with varying levels of knowledge
- 40 students of high school and college
- 10 staff from other institutions which want information on the topic and use our program and resource packet* for their reference and resources libraries

objectives include increasing educators' and others':

- awareness, interest, and ability to teach about the topic
- access to information, curriculum and organizations
- experience using effective methods of teaching about the topic
- contact with scientific and other experts with practical experience and practitioners all off whom can communicate clearly with a lay audience and have been coached regarding the objectives of the program and the background, academic level and public education role of the audience

program description: recent example attached

resource packet contents:

- program schedule and campus map
- speaker information:
 - biographies, presentation outlines or abstracts, suggested readings
- workshop information:
 - biographies, descriptions, samples
- annotated catalog of resources:
 - print and other media, organizations/action groups
- pamphlets, reprints of articles, and teachers guides on the topic from a variety of sources

funding:

- participant registration fees
- financial and other contributions
 - volunteer hours
 - donated materials
 - discounted facilities fees
 - grants

A Global Dilemma



If we want to save the earth, we cannot ignore our own growth. The needs of nature and the needs of people need our attention now.

Human Population Growth and the Environment Symposium and Workshops

For educators and students grades 8-12

Saturday, February 23, 1991 ■ 8:00 a.m. to 4:00 p.m.
Santa Catalina School, Monterey, California

Prepare yourself to help others discover better ways to balance people and nature.

- Learn the basics and current dimensions of our global population/environment dilemma.
- Discuss with experts the issues and choices we face in this crisis.
- Try new hands-on learning activities.
- Receive useful teaching materials.
- Leave knowing how exploding population, poverty, and environmental degradation are related and how education can make a difference.

Reservations are required and space is limited.

To make yours, call the Monterey Bay Aquarium Education Reservationist at (408)648-4850 Monday through Friday 8:30 a.m. to 4:00 p.m.

Fees

\$32 for educators includes symposium, refreshments, lunch, workshops and teaching materials packet.
\$10 for students grades 8-12 includes symposium, refreshments, lunch and workshops.

Credit

0.7 Continuing Education Unit (CEU) will be available from San Jose State University for \$42. Register for credit at the symposium.

Schedule

8:00 a.m. Registration (Reservations are required)

8:30 a.m. Symposium

Keynote Address:

- **Population and Environment: The Global Perspective**
Fred O. Pinkham, Population Program Officer, The David and Lucile Packard Foundation

Case Studies:

Thailand

- Mechai Viravaidya, Secretary General of Population and Community Development for Thailand

Mexico

- Tom McMahon, Board of Directors, Population Environment Balance and Carrying Capacity Network

Central California

- Sandy Lydon, Cabrillo College and KCBA T.V. NEWS

What educators can do:

- Pam Wasserman, Zero Population Growth, Washington, D.C.

12:00 p.m. Lunch

1:00 p.m. Discussions with Speakers

2:00 p.m. Workshops for teachers and students (Choose Two.)

- **Human Growth on Planet Earth**, Kimberly Crews, Population Reference Bureau (grades 6-12)
- **The Environment and You**, Holly White, Planned Parenthood (grades K-8)
- **Population Education**, Pam Wasserman, Zero Population Growth (grades K-12)
- **Population Games**, Ellen Blinderman, Lawrence Hall of Science (grades 3-6)
- **Helping Students Understand and Care about our Exploding Population**, Jeff Bryant, Monterey Bay Aquarium (grades 5-12)
- **Earth Ecology with Computers**, Tom Keating and San Benito High School students (grades 8-12)



MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT

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Dear Colleague,

Teaching about global awareness is a difficult but essential responsibility. Are you prepared to bring one of the world's most important environmental concerns to your classroom?

There are over five billion people on earth today. We are driving other species to extinction, polluting our air and water, exhausting natural resources and exceeding the limits of agriculture, schools and health services. Within our lifetime, the human population will reach ten billion. Learn what we can all do to balance the needs of nature and the needs of people.

Register today, space is limited.



Please copy and distribute this flyer to K-14 teachers in your area, school or organization.

address correction requested



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**The more the merrier,
but 10 billion for dinner?**

Bring the newest thinking from the experts to your K-12 students.

A Global Dilemma



Set between the conflicts of production and preservation, tropical rain forests are caught in a dilemma. The resolution may determine our environmental future.

Tropical Rain Forest Symposium and Workshops

for educators and 9-12 students

Saturday, February 24, 1990 • 8:00 a.m. to 4:00 p.m.
Santa Catalina School • Monterey, California

Prepare yourself to lead others out of the woods.

- Learn the basics and current dimensions (geographical, ecological, social, political and economic) of our global tropical rain forest dilemma.
- Discuss with experts the issues and choices we face in this crisis.
- Try new hands-on learning activities.
- Leave knowing why tropical rain forests are valuable, why they are disappearing and how to help them.

Reservations are required.

To make yours, call the Monterey Bay Aquarium Education Reservationist at (408) 648-4850 Monday through Friday 8:30 a.m. to 4:00 p.m.

Fees

\$30 for educators, includes symposium, refreshments, lunch, workshops and teaching materials packet
\$10 for students in grades 9-12, includes symposium, refreshments, lunch and workshops
\$10 express mailing fee for all reservations made after February 13

Credit will be available.

0.7 Continuing Education Unit (CEU) for teachers from San Jose State University for \$32. Register for credit at the symposium.

Schedule:

8:00 a.m. Registration (Reservations are required.)

8:30 a.m. Symposium

- | | |
|------------------------------|----------------------------|
| ■ Hilgard O'Reilly Sternberg | U.C. Berkeley |
| ■ Jean Langenheim | U.C. Santa Cruz |
| ■ Laura Marsh | Rain Forest Action Network |

12:00 p.m. Lunch

1:00 p.m. Discussions with speakers

2:00 p.m. Workshops (Choose two.)

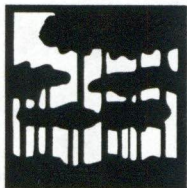
- Earth Games (9-12 students) Earth Club, Santa Catalina School, Monterey
- Global Warming Game (6-9) Lawrence Laboratory, Livermore
- Organizing Student Environmental Action (9-12) Earth Club, Santa Catalina School, Monterey
- Rain Forest Activities (K-12) Marine World Africa U.S.A., Vallejo
- Multidisciplinary Rain Forest Activities (3-8) Stanford University, Palo Alto
- Tropical Rain Forest Education Project (K-12) Rain Forest Action Network, San Francisco



MONTEREY BAY AQUARIUM
EDUCATION DEPARTMENT

Dear Colleague,

Teaching global awareness is a difficult but essential responsibility. Are you prepared to bring one of the world's most immediate concerns to your classroom?



The tropical rain forests are rapidly disappearing and we as educators play an important role in saving them. Spend a day with rain forest experts, rediscover this complex habitat and gain new teaching activities and strategies.

Register today, space is limited.

Please copy and distribute this flyer to K-14 teachers in your area, school or organization.

address correction requested

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MONTEREY BAY AQUARIUM
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Will
tropical rain
forests survive?

Bring the newest thinking from the experts to your K-12 students.



Teaching Evolution Today

Bring the newest thinking from the scientists to your students.

What: Join us for a day with leading thinkers on biological evolution. Explore the history, controversies and cutting edge of the science. Participate in hands-on workshops with other teachers of *kindergarten through high school*. Return to your students with increased knowledge, enthusiasm and exciting classroom activities.

When: Saturday, January 21, 1989

Where: Sister Carlotta Performing Arts Center
Santa Catalina School, Mark Thomas Drive, Monterey

The day's agenda:

8:00 a.m. Late Registration (if space is available)

8:30 a.m. Morning Session

Keynote Address: Evolution Today: Firm Foundations and Remaining Controversies
Dr. Phillip Kitcher, U.C. San Diego

View from the Past: Greatest Hits from the Fossil Record
Dr. James Valentine, U.C. Santa Barbara

Modern Concepts: Evolution at the Molecular Level
Dr. Gerald Lowenstein, U.C. San Francisco

Human Evolution
Dr. Vince Sarich, U.C. Berkeley

Education and Evolution: Science as a Way of Knowing
Dr. John Moore, U.C. Riverside

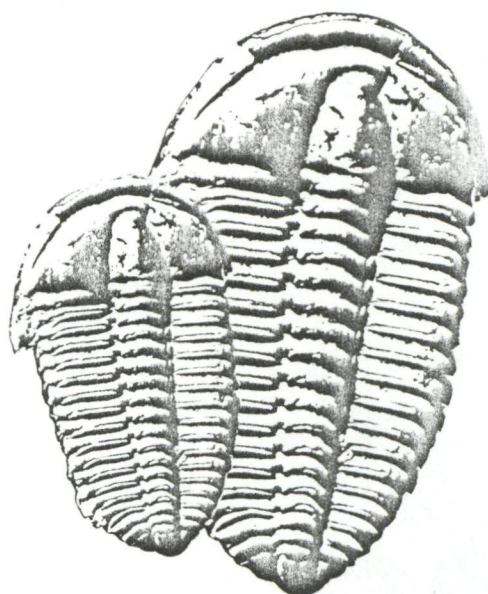
Panel discussion with visiting scientists

1:15 p.m. Lunch (included in fee)

2:15 p.m. Afternoon Session

Grade level workshops (K-12) featuring hands-on activities led by classroom teachers and staff from the California Academy of Sciences, Marine World Africa USA, the National Center for Science Education and Project AIMS.

Educator's Resource Packet containing abstracts, evolution sections from the California Science Framework, materials list, references, A-V list, and pamphlets on evolution content and controversies



Pre-registration required:

Call the Education Reservationist at the Monterey Bay Aquarium
(408) 649-3133

Fee: \$25 includes symposium, lunch, workshops and resource packet

Credit: 0.7 CEU from San Jose State University. \$32.00 payable at symposium.

Sponsored by: Asociacion de Biologos Ambulantes
Elkhorn Slough National Estuarine Research Reserve
Monterey Bay Aquarium
Monterey County Office of Education
Santa Catalina School
University of California Sea Grant

Please copy and post.

More than 80% of California's wetlands have been paved, built up or filled in.

Today, development and pollution threaten the rest.

What and where are our wetlands? Why should we prize them? What does current research tell us, and how can we communicate the critical issues to our students?

Coastal Wetlands Symposium and Workshop for teachers grades K-12

Symposium

Monterey Bay Aquarium
Saturday, Nov. 14
8:00 a.m.-5:00 p.m.

Come meet with scientists, environmental educators, lobbyists, developers and policymakers.

The day includes continental breakfast, aquarium admission, curriculum fair, materials packet and list of wetlands concepts/activities.

SJSU units are available by arrangement.

Workshop

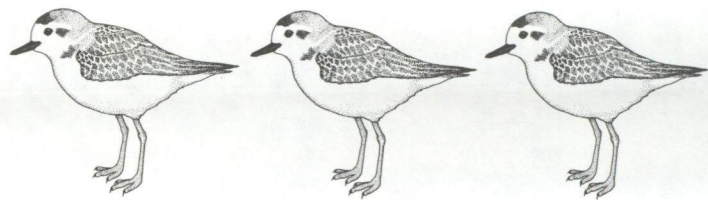
Elkhorn Slough and Bay Area
nature centers

You can attend the follow-up workshop nearest you:

Saturday, Nov. 21
Elkhorn Slough Visitors Center,
Alviso Education Center, Baylands
Center (Palo Alto), Crab Cove Center
(Alameda), Hayward Shoreline Park,
Richardson Bay Audubon (Tiburon),
San Francisco Bay Model (Sausalito)

Saturday, Dec. 5
Coyote Point Museum (San Mateo)

Saturday, Dec. 12
Refuge Visitors Center (Fremont)



The \$15 fee covers both symposium and follow-up workshop.
Enrollment is limited, so call today.
Ask for the Education Reservationist at:

(408) 649-3133

Please post or distribute

Program Marine Studies Workshop for Teachers in Training

Participants (30-35) UCSC Student Teachers and (4) Supervisors
 Contact: Tom Takano, 160 Lawrence Ave, Watsonville 95076
 (408) 724-0224

Date February 1 - 2, 1991

Objectives Using field sites to enrich learning
 Using ecosystem themes to integrate curriculum
 Using concrete (hands-on) activities to introduce
 all content
 Developing self-guided experiences integrating
 science and other disciplines

Content focus Rocky Shores and Kelp Forest Ecosystems

Schedule

Friday, February 1, 1991

1:30 p.m. Register at aquarium Classroom on Hovden Way

1:45 p.m. Introductions and program orientation Classroom

2:15 p.m. Exhibit gallery exploration Deck

20 minute stations: Simulating field research in

- 1. Rocky Shore Ecosystem (Suzanne)
 (deck, gallery, touch tank)
- 2. Kelp Forest Ecosystem (Jeff)
 (deck, exhibit, gallery, lab)

3:00 p.m. Rocky Shore Ecosystem activities Classroom

20 minute stations:

- 1. non-living factors (tide, temperature, light, water, effects of salt, and zones) (Jeff)
- 2. living factors (animals, adaptations, feeding, relationships) (Suzanne)
- 3. design-a-critter (Holly)
- 4. resources (Betty)

4:30 p.m. Field activities: Rocky Shore tidepools

- 1. Testing designed critters
- 2. Tidepool orientation
- 3. Tidepool exploration
- 4. Tidepool wrap-up

6:30 p.m.	Dinner (on your own)	Monterey
8:00 p.m.	Audiovisual presentation Rocky Shore and Kelp Forest Ecosystems	Edu. Bldg. (J. & S.)
9:00 p.m.	Camp-in	Aquarium

Saturday, February 2, 1991

7:30 a.m.	Breakfast	OVCR
8:30 a.m.	Aquarium explorations Waves, Kelp, Adaptations	Exhibit galleries (Jeff)
10:15 a.m.	Kelp Forest Ecosystem activities	Classroom
15 minute stations:		
	1. non-living factors (substrate, temperature, light, water chemistry and motion, distribution)	(Jeff)
	2. living factors (animals, adaptations, feeding)	(Suzanne)
	3. kelp industry and products	(Holly)
	4. resources (print, audiovisual)	(Betty)
	5. creative dramatics?	
11:30 a.m.	Content closure	Classroom
12:00 p.m.	Lunch	Classroom
12:45 p.m.	Defining successful aquarium, museum or field sessions	Edu. Bldg. (J. & H.)
1:15 p.m.	Orientation to curriculum development	Edu. Bldg.
1:45 p.m.	Developing self-guided student activities	Ed.Bldg.&Aquarium
3:15 p.m.	Sharing results	Edu. Bldg. (Suzanne)
3:45 p.m.	End of session evaluation	(Jeff)



MONTEREY BAY AQUARIUM

September 18, 1990

Dear Teacher,

Last year the Teacher Programs Department of the Monterey Bay Aquarium offered its first Teacher Expedition to Baja Mexico. The trip was such a huge success that we're doing it again!

"Teacher Expedition Two" will include seven low cost days of stimulating professional growth experiences in the natural and cultural history of Baja California. The group will depart from the San Diego airport at 9:00 a.m. on December 27, 1990, and return in the late afternoon on January 2, 1991. An itinerary and trip description are enclosed. Total cost exclusive of travel between your home and San Diego will be \$595.00.

Staff will include well informed and personable leaders, each of whom has experience in natural history and education. Aquarium staff will be accompanied by naturalists Greg Meyer and Roger Luckenbach, Baja California specialists. Participants and staff will discuss effective ways to share a natural history experience with students in the classroom. We're committed to helping everyone have fun, be comfortable and fulfill their personal learning objectives.

There is room for the first 25 teachers who send us their registration form and deposit. The registration deadline is October 22, 1990. Academic credit is being arranged with San Jose State University.

For more information call me at (408) 648-4863.

Sincerely,

Suzanne Sawyer

Suzanne Sawyer
Teacher Programs Department

P.S. Join Greg Meyer at the Aquarium for a free preview of the trip during the Teacher Open House on Saturday Oct. 13th from 6:30-9:30. Call (408) 648-4850 for a reservation.



MONTEREY BAY AQUARIUM

886 Cannery Row Monterey, CA 93940-1085

Non-profit organization

U.S. postage

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Permit no. 290

Monterey, CA 93940-1085

Address correction requested

Forward and return postage guaranteed

Join us on a journey to Mexico's secret sea - the Sea of Cortes!

This rich body of water is home to an enormous array of marine invertebrates, endemic fish, seabirds and marine mammals!

Based in the small village of Bahia de Los Angeles, our excursion will explore the pristine and isolated Midriff Islands region. These islands are famous for their endemic animal and plant life and for the large numbers of whales and dolphins which inhabit the surrounding waters. The islands also provide nesting and roosting habitat for numerous species of seabirds. Offshore, rocky reefs teem with temperate and tropical fish.

While staying at a comfortable field station, local fishing boats will take us out on daily excursions. Our days will be full with island hopping adventures, snorkeling trips, desert hikes and time for just beach combing. As a special highlight we will feature two days of whalewatching, looking for wintering fin and blue whales as well as dolphins and sealions.

TRIP SPECIFICS

Travel

Beginning in San Diego, we will travel by comfortable air conditioned bus. To ensure our comfort we will stop frequently to enjoy Baja's diverse scenery. In Bahia, local guides will take us on daily excursions in traditional fishing boats.

Lodging

During our stay on the Sea of Cortez, we will be using a large field station, Campo Caguama. Recently built, the station has showers, dormitories, a large central meeting house and a well stocked library. Best of all, it is situated on the beach with a veranda overlooking the Bay of Angels.

Meals

All meals will be provided except for one dinner. Because of the communal nature of the field station, participants will be asked to help with preparation and clean up of meals.

Weather

Baja stretches between the temperate and tropical zones. Because of this, weather patterns can be volatile and unpredictable. We reserve the right to adjust the itinerary to ensure a safe trip and to take advantage of any unforeseen opportunities. Days will be warm with highs in the 80's and cool nights. December is usually a dry and mild month.

Itinerary

- Day 1: Meet at San Diego Airport West Terminal Baggage Claim by 9 am. Leisurely drive down Baja's Pacific coast, camping south of Ensenada. Sunset walk and evening campfire.
- Day 2: Drive to Bahia de Los Angeles, on the shores of the Sea of Cortes. In route, we will stop in the Central Desert National Park and visit a pre-Columbian cave painting site.
- Day 3 - 6: Bahia. Daily activities will include snorkeling, island exploration, whale watching, desert hikes and marine science activities. Evenings will be relaxing with barbeques, a seafood dinner at a local restaurant and slide shows and videos on the Gulf of California and Baja.
- Day 7: Early morning departure for the United States. Shopping and lunch in Ensenada. 5 pm return to the San Diego airport.



Marine Science Institute at the Monterey Bay Aquarium

Session I:

Saturday, July 7 to Saturday, July 14, 1990

with follow-up workshops:

6:00 p.m. Thursday to
3:00 p.m. Saturday
October 4-6, 1990
January 10-12, 1991
April 4-6, 1991

Session II:

Sunday, August 12 to Sunday, August 19, 1990

with follow-up workshops:

6:00 p.m. Thursday to
3:00 p.m. Saturday
November 1-3, 1990
January 24-26, 1991
April 18-20, 1991

This intensive and popular program is for teachers of kindergarten through 12th grade.
Apply for either session.

We encourage application by multigrade-level teams, but you may apply as an individual.
If you teach science only, consider applying with a non-science teacher in your school.

You will

- meet and work with scientists, do field studies and use the aquarium's exhibits and labs
- visit major natural communities of Monterey Bay to become familiar with basic physical, biological and social marine science topics
- learn to use a variety of curriculum materials
- discover an ecological approach to studying and teaching science anywhere
- gain an overview of the 1992 California Science Framework
- return to your school with the new knowledge, enthusiasm and activities for integrating more science into your classes
- acquire presentation skills in classroom and in-service teaching.

You will be expected to

- live at the institute
- participate in the scheduled summer events and all three follow-up weekends (Room and meals will be provided.)
- work with others to prepare marine science curriculum which conforms to the new California Science Framework and meets your needs
- pilot new activities in your classroom and report on their effectiveness
- conduct an in-service workshop on hands-on, science process based teaching integrating physical earth, life and social sciences for your district's teachers during the 1990-91 year.

Application postmark deadline: April 23, 1990

To apply: Complete and mail forms A, B, C and D.

Fee: There is no fee for this program.

Optional credit: from San Jose State University

Enrollment limit: 28 teachers (kindergarten through 12th grade) per session

Selection decisions will be mailed May 11, 1990.

Form A: Participant's application

(Please photocopy this form as needed and complete a separate form for each session.)

Marine Science Institute Check one: ____ Session I July 7-14, 1990
____ Session II August 12-19, 1990

Name: _____ Home phone: (____) _____

Home address: _____

Street City State Zip

Name of school and county: _____

School district: _____ Work phone: (_____) _____

Current position title(s): _____ Total years in teaching: _____

Teaching grade/subject(s) in 1990-91: _____

List educator training programs with a duration of more than three days which you have attended in the last five years:

Please answer briefly the following questions on the back of this page.

Why would you like to attend this program?

How will you use this experience to benefit your students and fellow teachers?

If applying as a team:

a) Team member's name: _____

b) List your plans for implementing what you'll learn together.

Please initial each of the following statements to indicate that you have read and agree to them.

— I will attend the full program and complete all program requirements as listed in the program description.

— I have provided my school principal and district superintendent with copies of the program description and have attached their written statements of support (forms B and C).

— I have provided one of my peers with a copy of the program description and have attached his/her written statement of support (form D).

Application postmark deadline: April 23, 1990

Mail to: Teacher Programs
Monterey Bay Aquarium
886 Cannery Row
Monterey, CA 93940

For more information call Becky Garcia at (408) 648-4845.

Form B: Principal's statement of support

Dear Principal,

_____ is applying to participate in the Monterey Bay Aquarium's Marine Science Institute and follow-up workshops on the following dates:

If it is not attached, please request a copy of the program description from the applicant.

We want to recruit motivated, enthusiastic educators who are excellent classroom teachers, have strong cooperative and peer leadership capabilities, and have time to commit to improving science education.

If the applicant is selected, we would like a commitment from your school to provide adequate support to enable the teacher to participate in all institute activities and complete all program requirements including an in-service workshop on hands-on, science process based teaching.

Please initial each of the statements below to indicate that you have read them and agree to them.

- _____ I will release the participating teacher and provide a substitute teacher on all scheduled institute follow-up dates (three days) during the 1990-1991 school year.
- _____ I will release the participating teacher to do an in-service workshop (minimum of two hours) for our teachers during the 1990-91 school year on skills and activities covered in this program.
- _____ I will release or pay stipends to teachers who wish to attend the participating teacher's in-service workshop.

Please write two short paragraphs on the back of this page describing your applicant's and your school's abilities to fully participate in and benefit from this program.

If you wish to discuss how this program might best serve your staff and curriculum development needs, please call Jeff Bryant at (408) 648-4835.

Principal's signature: _____ Date signed: _____

Name (print): _____ Title: _____

School: _____

Address: _____
Street City State Zip

Phone: (____) _____

Please return this form to the applicant before the April 23, 1990 deadline.

Thank you for your support.

For more information call Becky Garcia at (408) 648-4845.

Form C: Superintendent's statement of support

Dear Superintendent,

_____ is applying to participate in the Monterey Bay Aquarium's Marine Science Institute and follow-up workshops on the following dates:

If it is not attached, please request a copy of the program description from the applicant.

We want to recruit motivated, enthusiastic educators who are excellent classroom teachers, have strong cooperative and peer leadership capabilities, and have time to commit to improving science education.

If the applicant is selected, we would like a commitment from your school to provide adequate support to enable the teacher to participate in all institute activities and complete all program requirements including an in-service workshop on hands-on, science process based teaching.

Please initial the statements below to indicate which you will agree to.

___ I will help the participating teacher publicize his/her in-service workshop throughout the school district.

___ I will assist the participating teacher with his/her institute related travel expenses.

Please attach a statement on your official letterhead. Include two short paragraphs describing the applicant's school's and your district's abilities to fully participate and benefit from this program.

If you wish to discuss how this program might best serve your staff and curriculum development needs, please call Jeff Bryant at (408) 648-4835.

Superintendent's signature: _____ Date signed: _____

Name (print): _____ Title: _____

School: _____

Address: _____
Street City State Zip

Phone: (____) _____

Please return this form to the applicant before the April 23, 1990 deadline.

Thank you for your support.

For more information call Becky Garcia at (408) 648-4845.

Form D: Colleague's statement of support

Dear Colleague,

_____ is applying to participate in the Monterey Bay Aquarium's Marine Science Institute and follow-up workshops on the following dates:

If it is not attached, please request a copy of the program description from the applicant.

We want to recruit motivated, enthusiastic educators who are excellent classroom teachers, have strong cooperative and peer leadership capabilities, and have time to commit to improving science education.

Please write two short paragraphs on the back of this page describing how and why you expect teachers and students to benefit from the applicant's participation in the institute and the in-service workshop(s) he/she will offer in your district.

Colleague's signature: _____ Date signed: _____

Name (print): _____ Title: _____

School: _____

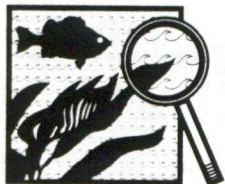
Address: _____
Street City State Zip

Phone: (____) _____

Please return this form to the applicant before the April 23, 1990 deadline.

Thank you for your support.

For more information call Becky Garcia at (408) 648-4845.



Dear colleague,

The Monterey Bay Aquarium offers unique opportunities for science and non-science teachers to spend time with scientists and educators exploring marine science in the field, the aquarium, the lab and the classroom.

Look inside, choose the session for you and register today--space is limited.

Please copy and distribute this flyer to science teachers and elementary school teachers in your area, school or organization.



MONTEREY BAY AQUARIUM®

886 Cannery Row Monterey, CA 93940-1085

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Please post

CONTENTS

- I. Marine Science Content
- II. Process of Science Skills/Tools
- III. Process of Teaching Skills/Tools

I. Marine Science Content

A. Ecological Systems

- SU 1. Levels of Organization and Marine Examples
- SU 2. Non-living Components and Interactions
- SU 3. Living Components: Roles, Adaptations, Interactions
- SU 4. Dynamic Interactions: Stability and Change

B. Geology

- F 1. The Earth's Interior and Surface Features
- F 2. Earth Materials: Distribution, Chemistry, Cycles
- F 3. Dynamic Interactions: Stability and Change
- F 4. California Geology
- F 5. Monterey Bay Geology
- F 6. Submarine Canyon
- F 7. Hydrothermal and Hydrocarbon Vents
- F 8. Coastal Geological Processes

C. Astronomy

- SU 1. Sun's Affects: insolation and gravitation
- SU 2. Moon's Affects: gravitation
- SU 3. Density Sorting of Matter into Orbits and Layers
- SU 4. Earth's Orbit and Seasons

D. Oceanography and Meteorology

- SU 1. Physical and Chemical Properties of Water
- SU 2. Physical and Chemical Properties of Sea Water
- SU 3. Hydrologic Cycle
- SU 4. Global Circulation of Atmosphere and Ocean
- SU 5. Ocean Water Movement:
 - tides, waves, currents, upwelling
- SU 6. Regional Currents
- SU 7. Regional Climate

E. Living Components

- SU 1. Distribution/Zonation: Planktonic, Nektonic, Benthic
- FA 2. Bacteria, Virus, Fungi
- SU 3. Plants and Algae
- SU 4. Invertebrate Animals
- SU 5. Fish
- F 6. Birds
- WI 7. Mammals
- SU 8. Evolution

F. Natural Communities

- SU/F 1. Shores:
 - a. Rocky
 - b. Sandy
 - c. Dune
 - d. Other: ie. Wharf/Harbor
- SU 2. Coastal Wetland:
 - a. Mudflat
 - b. Eelgrass
 - c. Saltmarsh
 - d. Other: ie. Mangrove
- SU 4. Subtidal:
 - a. Kelp Forest
 - b. Rocky Reefs
 - c. Sandy Seafloor
 - d. Other: ie. Coral Reef
- WI 5. Open Ocean:
- WI 6. Deep Sea:
 - a. Submarine Canyon
 - b. Vents (hydrothermal, hydrocarbon)

SP G. Humans Impacts

- 1. Human Needs, Uses, Technology, Impacts
- 2. Global Systems Threats and Management
 - a. Global Warming
 - b. Pollution and Debris
 - c. Sustainable Yields
 - d. Bio-diversity
 - e. Ethics

____ Teacher in Marine Science

II. Process of Science Skills/Tools/Resources

SU A. Science Definitions

SU B. Scientific Process

1. Question or problem
2. Background research and observations
 - a. clarify variety of appropriate sources:
library, interview, video, newspapers
 - b. clarify difference between observation and
interpretation, inference, or conclusion
- SU 3. Possible answer to question
(hypothesis, prediction)
- SU 4. Design experiment or model
 - a. health and safety risk management
 - b. controls and limited variables
 - c. responsibility to environment and living
things
- SU 5. Data collection and analysis
 - a. sampling methods
 - b. organizing and presenting data
 - c. graphing, central tendencies and simple
analysis
 - d. honesty and ethics
- SU 6. Interpretation of results (describe patterns)
- SU 7. Communication of Conclusions
 - a. relate conclusion to hypothesis
 - b. support conclusion with data
 - c. discussion of applications, extensions,
actions
- SU 8. Peer review and feedback

ALL D. Resources*

1. Field Sites and Data
2. Print
3. Lab and Field Hardware
4. Software
5. Scientists
6. Other: ie. photography/video

*(see also framework ch 7 & 8)

III. Process of Teaching Skills/Tools

FALL A. Humans as learners:

Developmental/Learning Cycle Approach
Appropriately Leveled Behavioral Objectives
Questioning Strategies and Levels of Thinking
Learning Styles and Handicaps (Science for All)
Cooperative Learning

FALL B. Methods of teaching:

Teaching Styles and Diversification
Elements of Effective Instruction
Construction of Concepts
Thematic Approach to Multidisciplinary Integration

ALL C. Hands-on Process Based Science Curriculum Development
Using Habitat Themes

Key Idea to Behavioral Objective to Hands-on Activity

SP D. Implementing a Strong Science Program*

Science Education System Analysis
Science Education Promotion
Inservice Workshop Leadership
Politics of Change
Peer Coaching

ALL Science Teaching Resources

Collecting and Maintaining Specimens and Artifacts
Managing Classroom Aquaria

ALL Networks

E. Other:

* Framework Ch. 7, NSTA tools, Cal Dept Edu publications

Reading Assignments

Reading assignments have been selected to provide background and reference information on the content we will cover during the institute. Most items produced by the aquarium contain a glossary. Mastery is not expected until after you have completed additional learning activities at the aquarium.

- The aquarium will provide you with all required reading materials except the National Geographic article for Fall and the Steinbeck books listed for Spring. All others are available in libraries.

- Please bring all required reading materials to the session for which they are assigned.

A. Summer Session Readings:

1. prior to arrival: (materials will be mailed)
 - a. Monterey Bay Aquarium. Volunteer Guide Training Manual pp. 1-7, 17-29, 30-53, 85-89, 91-108, 118-126, 133-136 and the Glossary as needed
 - b. Connor & Baxter. Kelp Forests, Monterey Bay Aquarium, 1989.
 - c. Silberstein & Campbell. Elkhorn Slough, Monterey Bay Aquarium, 1989.
 - d. "Between Monterey Tides," National Geographic Magazine, February 1990.
2. during and after session: (materials will be handed out)
 - a. Monterey Bay Aquarium Education Materials
 - b. All handouts from the session
 - c. Lowery, Lawrence. The Everyday Science Sourcebook, Dale Seymour, 1985, pp. 3-14.
 - d. "Executive Summary" Science Framework Draft, September, 1989, pp.ii-vii.

B. Fall Session Readings:

1. prior to arrival:
 - a. Monterey Bay Aquarium. Volunteer Guide Training Manual pp. 8-16, 54-66, 127-132 and reread 118-126
 - b. "Earthquake-Prelude to the Big One?" National Geographic Magazine, May 1990.
2. during and after session:

All handouts from the session

(OVER)

C. Winter Session Readings:

1. prior to arrival:
 - a. Monterey Bay Aquarium. Volunteer Guide Training Manual
pp. 67-84, 109-117
 - b. "Monterey Bay and its Astonishing New Aquarium", Sunset Magazine, November, 1984.
2. during and after session:
All handouts from the session

D. Spring Session Readings:

1. prior to arrival:
 - a. Monterey Bay Aquarium. Volunteer Guide Training Manual
pp. 137 - 144.
 - b. Steinbeck, John. Cannery Row.
 - c. Steinbeck, John. Sweet Thursday.
 - d. Steinbeck, John. Travels with Charlie, pp. 193+ to 206+/-*

*Read from chapter beginning: "I find it difficult to write about my native place, northern California."
Continue for two chapters ending with: "I printed it once more on my eyes, south, west, and north, and then we hurried away from the permanent and changeless past where my mother is always shooting a wildcat and my father is always burning his name with his love."

2. during and after session:
All handouts from the session

Monterey Bay Aquarium Institute 1990-1991

Guidelines for final individual presentations

Due: April 4, 1991 (for July '90 participants)
April 18, 1991 (for August '90 participants)

Please arrive on the date listed above with everything you need to make a ten minute presentation of the best or most successful original marine science activity you used with your students this school year. It must be an activity which you developed as a result of participating in the institute. Your presentation and handout should include each of the following:

- your name and phone number
- the grade level you used this activity with
- brief descriptions of
 - your students' abilities range,
 - the topic of the unit in which the activity occurred
 - the setting/place where the activity was carried out
- the behavioral and content objectives of the activity
- a demonstration & handouts from key parts of the activity
- a statement of how you evaluated student mastery of the objectives
- samples of student work if available

Please bring **33 copies** of the handout(s). Call us by:

March 22, 1991 if you need any audio-visual equipment.

The presentations will be scheduled throughout Friday and Saturday morning. Sign up for your ten minute block when you arrive at the classrooms on Thursday evening.

Guidelines for final reports on in-service workshops

Due on or before*: April 4, 1991 (for July '90 participants)
April 18, 1991 (for August '90 participants)

The report should be sent to the aquarium teacher programs department and should include the following:

- copies of all publicity distributed prior to the in-service
- copies of all handouts provided during the in-service
- a detailed copy of your schedule for the in-service session
- your comments based on reflecting on your in-service experience from the time it was assigned in July or August 1990:
 - a. What went well or did you find satisfying about doing your in-service workshop?
 - b. What suggestions do you have for others facing similar tasks in the future?

On a separate piece of paper:

- a. Please print the names, titles and addresses of your principal and superintendent. We will send letters reporting your completion of the institute.
- b. Please print your name as you want it spelled on your certificate. Certificates will be mailed following our receipt of your final presentation, final in-service report, post-institute assessment forms, and any other individual assignments.
- c. Please print the name and mailing address of the local news paper to which you would like the aquarium to mail a press release announcing your successful completion of the institute and a description of the institute.

*Refer to the commitment you and your principal submitted in May, or call Becky (408)648-4845 if you have any date problems. All extensions must be negotiated.

Monterey Bay Aquarium
1990 Marine Science Institute

In-service Plan

Teacher's Name: _____

Principal's Name: _____

School: _____

District: _____

Superintendent's Name: _____

In-service date (please consult school calendar): _____

Time In-service will begin: _____ end: _____

Number of participating teachers (projected): _____

*****RETURN UPPER PORTION *****

As a requirement for admission, all participating teachers, principals and superintendents signed statements indicating that they would each respectively conduct, support and help publicize the required in-service workshop.

During the summer institute participants will receive training and sample materials from the aquarium to assist them with their workshops.

Workshop Guidelines:

Each teacher participating in the institute will produce an in-service workshop lasting at least two hours and serving at least ten peers. The workshop should be based on marine science content and include skills and activities gained during the summer institute session. The workshop must be completed by April 30, 1991.

The workshop should:

- take place during release time or participating teachers should be paid a stipend
- be effectively publicized
- use graphics for effective organization and communication
- involve participants in at least one hands-on activity
- include one or more hands-on activity (including materials) for participants to take back to their classrooms and use
- encourage integration of science with other subjects
- demonstrate how marine science fits into the State Science Framework and local school curriculum
- include a bibliography list of sources including literature, field sites, curriculum and activities guides
- provide participants with evaluation forms

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 1:
Saturday, July 7, 1990

2:00 pm	Registration and refreshments *Linda Hagerty and David Cobb	Douglas Hall
2:30 pm	Orientation: Campus *Frank Keith People (name activity) *Linda Hagerty Program and Schedule *Rita Bell	Douglas Hall
4:45 pm	History of Monterey Bay Aquarium *Betty Allen	Science Lecture Hall
5:00 pm	Monterey Bay: Natural Communities Approach *Jeff Bryant, Monterey Bay Aquarium	Science Lecture Hall
6:15 pm	Dinner	Dining Hall
7:15 pm	Dorm Orientation and Moving In *Suzanne Sawyer	Wilson Lounge
8:30 pm	Resource Room Orientation *Betty Allen	Wilson Lounge
9:00 pm	Closing Activities *Rita Bell	Wilson Lounge

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 2:
Sunday, July 8, 1990

7:00 am	Breakfast	Dining Hall
7:45 pm	Vans leave for aquarium	Front Parking
8:00 am	Exploring Monterey Bay Natural Communities *Suzanne and Jeff	Classrooms and Aquarium
9:00 am	Marine Science Exploration I (waves) *Jeff	Aquarium
10:00 am	Introduction: Climate and Currents *David	Classrooms
10:15 am	Global Climate and Ocean Currents *Eugene Haderlie, Hopkins Marine Station	Classrooms
12:00 am	Lunch	
1:00 pm	Activities I: Physical Oceanography *David	Classrooms
3:15 pm	Closure: Physical Oceanography *Rita	Classroom
4:00 pm	Introduction: Rocky Shore *Betty	Classrooms
4:15 pm	Rocky Shores Community *Jeff	Classrooms
5:45 pm	Vans leave for RLS	Bus Loop
6:00 pm	Dinner	Dining Hall
7:15 pm	Field equipment assembly & use *Jeff	Wilson Lounge
8:30 pm	Tidepool Safety & Closing *Suzanne	Wilson Lounge

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 3:
Monday, July 9, 1990

5:45 am	Vans leave for tidepools	Front Parking
6:00 am	Tidepooling *Staff	Carmel
8:30 am	Vans leave for RLS	
8:50 am	Breakfast & change clothes	Dining Hall
11:00 am	Vans leave for aquarium	Front Parking
11:15 am	Discussion: Field trips (strengths, weaknesses, solutions, resources) *Linda	Classrooms
12:00 pm	Lunch	
1:00 p.m.	Activities II: Biological Marine Science (General, Rocky Shore, Wetland, Kelp) *Linda	Classrooms
3:15 pm	Closure: Rocky Shore Community *Rita	Classrooms
4:00 pm	Discussion: Scientific Research (examples, elements, definitions, teaching) *Suzanne and Betty	Classrooms
4:45 p.m.	Field Research Simulation *David	Classroom
5:45 pm	Vans leave for RLS	Bus loop
6:00 pm	Dinner	Dining Hall
7:00 pm	Introduction: Kelp Forest Community *Linda	Science Lecture Hall
7:15 pm	Kelp Forest Community and Research *Chris Harrold, Monterey Bay Aquarium	Science Lecture Hall
9:00 pm	Closing *David	Wilson Lounge

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 4:

Tuesday, July 10, 1990

7:00 am	Breakfast	Dining Hall
7:45 am	Vans leave for aquarium	Front Parking
8:00 am	Kelp Forest Exploration *Linda	Aquarium
9:00 am	Marine Plants *Judith Connor, Monterey Bay Aquarium Activities III: Marine Plants *Betty	Classrooms
12:00 pm	Lunch (STAFF: gather field equipment)	
1:00 pm	Closure: Marine Plants and Kelp Forest *Suzanne	Classrooms
2:00 pm	Sampling Methods Activity *Suzanne	Classrooms
2:45 pm	Introduction: Coastal Wetland Community *David	Classrooms
3:00 pm	Coastal Wetland Community and Research *Mark Silberstein, Elkhorn Slough Reserve	Classrooms
4:30 pm	Introduction to Field Research Day *Jeff: communities, sites, gear (discuss collecting specimens) *Rita: selecting communities and teams	Classrooms
6:00 pm	Vans leave for RLS	Bus loop
6:15 pm	Dinner (Pack lunch for the field.)	Dining Hall
7:15 pm	Field research planning *Teams	Wilson Hall
8:30 pm	Closing *Linda	

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 5:
Wednesday, July 11, 1990

6:00 am	Vans leave for Moss Landing			Front Parking
	Group #1	Group #2	Group #3	Group #4
7:00am	Bay	Wharf	Slough	Island
9:00am	Wharf	Slough	Island	Bay
11:00am	*****Lunch Break*****			
11:30am	Slough	Island	Bay	Wharf
1:30pm	Island	Bay	Wharf	Slough
	STAFF: Save some fish, inverts, plankton			
3:45 pm	Put away field gear *Teams			Parking lot
4:00 pm	Vans leave for RLS			Parking lot
4:45 pm	Compile Field Data and Design Presentation *Teams			
6:00 pm	FREE EVENING...Dinner will not be served.			

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 6:

Thursday, July 12, 1990

7:00 am	Breakfast	Dining Hall
7:45 am	Vans leave for aquarium	Front Parking
8:00 am	Marine Science Exploration III (adaptations) *Jeff	Aquarium
8:40 am	Activities V: anatomy (4) 20-minute stations: - misc. invertebrates - squid - shark - fish *Dave	Classrooms
10:15 am	Model: In-service Workshop *Rita	Classrooms
12:15 pm	Lunch: Grade level groups review FORSEA manuals	
1:15 pm	Creative Dramatics & Puppet making *Pat Rutowski, Monterey Bay Aquarium	Classrooms
3:30 pm	Marine Animals Key *Mike Guardino, North Salinas High School	Classrooms
5:00 pm	Vans leave for RLS	Bus loop
5:15 pm	Prepare Research Presentations *Teams	Wilson
6:15 pm	Dinner	Dining Hall
7:00 pm	Prepare Research Presentation *Teams	Wilson
8:00 pm	Research Reports and Feedback *Teams	Wilson Lounge
9:00 pm	Closing *Becky	Wilson Lounge

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 7:
Friday, July 13, 1990

7:00 am	Breakfast	Dining Hall
7:45 am	Vans leave for aquarium	Front Parking
8:00 am	Closure Marine Life: Hunting Parties Find Phyla *Rita	Aquarium
8:45 am	Activities VI: Evolution -Teaching Evolution Today activities *Jeff	Classrooms
11:00 am	Behind the Scenes Video and Tour *Betty, Suzanne and Jeff	Classrooms
12:15 pm	Vans leave for lunch at RLS *Return vans: Dave, Rita, Suzanne, car: Becky	Bus loop
12:30 pm	Lunch	Dining Hall
1:30 pm	Closure and Key Ideas Kelp Forest, Coastal Wetlands, Bay and Sandy Seafloor, Wharf, Research *Linda and Betty	Wilson Lounge
2:30 pm	The 1992 State Science Framework *Jeff	Wilson Lounge
3:00 pm	Interdisciplinary Curriculum Development: Integrating Marine Science into Your Curriculum *Rita	Wilson Lounge
4:00 pm	Marine Studies Unit Development *Grade Level Groups	Leaders' Rooms
6:15 pm	Dinner	Dining Hall
7:15 pm	Continue working on interdisciplinary units	Leaders' Rooms
8:45 pm	Closing *Rita	Wilson Lounge

Monterey Bay Aquarium
Schedule: Session I

1990 Marine Science Institute

Day 8:
Saturday, July 14, 1990

7:00 am	Breakfast	Dining Hall
8:00 am	Progress Reports: Interdisciplinary Marine Studies Units *Grade Level Groups	Wilson Lounge
9:00 am	Marine Studies Resources and Networks *Betty and All	Wilson Lounge
9:45 am	Participant Concerns and Needs: In-service workshops and Best of the Best -review contract and guidelines Follow-ups *Rita, Becky and Jeff	Wilson Lounge
10:45 am	Final Evaluations (aquarium and SJSU) SJSU registration and fees *Becky and All	Wilson Lounge
12:00 pm	Lunch	
1:00 pm	Check-out Closing *Rita and All	Wilson Lounge

Days 9-11:

Follow-up 1, October 4-6, 1990

Geology, Sand

Communities: Sandy Beach, Mudflat(?)

Reports: Marine Studies Unit Development (grade level groups)
3-5 pm, Fri., Oct 5, The Classroom Aquarium w/ Mark Ferguson

Days 12-14:

Follow-up II, January 10-12, 1991

Conservation

Communities: Open Ocean (plankton to mammals), Deep Sea

New: Sharks exhibit

Days 15-17:

Follow-up III, April 4-6, 1991

Best of Best, History (Hopkins, Row, Ricketts Lab)

Thursday, October 4, 1990

2:00 p.m. (or later) check-in to Days Inn, Seaside

6:00 p.m. Check-in at aquarium (classrooms)
 *Pick up schedule, nametags
 and sign-up for sharing time
 *Get your photo taken--Pose for the camera!

6:30 p.m. Dinner (Portola Cafe)

7:30 p.m. Monterey Bay Geology, Dr. Haderlie

9:00 p.m. End

****NOTE: THE MEETING ROOM AT THE DAYS INN CAN BE USED AS A COMMONS
AREA AND HAS BEEN RESERVED FOR TONIGHT AND FRIDAY NIGHT.
PLEASE FEEL FREE TO MEET AND SOCIALIZE.**

Friday, October 5, 1990

7:30 a.m. Vans leave hotel (to aquarium)
 *****BRING SAND SAMPLES, BINOCULARS AND FIELD KIT*****

8:00 a.m. Breakfast (Portola Cafe)

8:30 a.m. Free time

9:30 a.m. Film: Beach a River of Sand (classrooms)

10:00 a.m. Sand Activities (classrooms)
 *Beach in a Pan and
 sorting and describing sediments
 *Trading sand samples and "Sand Biographies"

11:30 a.m. Lunch (classrooms)

12:30 p.m. Vans leave to New Brighton State Beach

1:30 New Brighton State Beach
 *fossils

3:00 p.m. Vans leave to Salinas River State Beach

5:00 p.m. Vans leave to mudflats (Elkhorn Slough)

5:30 p.m. Elkhorn Slough

6:30 p.m. Vans leave to Days Inn

******YOU'LL NEED TO CARPOOL BACK TO THE AQUARIUM AND
BRING ANY SHARING RESOURCES*******

7:30 p.m. Dinner (Portola Cafe)

8:30 p.m. Resources and Slides Sharing

Saturday, October 6, 1990

7:30 a.m.	Hotel check-out	
8:00 a.m.	Breakfast and free time	(Portola Cafe)
10:00 a.m.	Marine Research *Don Livermore	(classrooms)
noon	Lunch	(classrooms)
2:00 p.m.	Wrap-up *SJSU registration and payment *Session and SJSU evaluations *Announcements	

Monterey Bay Aquarium
Marine Science Institute I Follow-up II

January 10-12, 1991

Thursday, January 10, 1991

after 1:00 p.m.	Check in at Days Inn 1400 Del Monte Blvd. Seaside, CA 93955 (408)394-5335	
6:00 p.m.	Social time -pick up schedule -sign up for sharing	(classrooms)
6:30 p.m. - 7:30 p.m.	Dinner	(Portola Cafe)
7:30 p.m. - 8:30 p.m.	Marine Mammals Labs	(classrooms)
8:30 p.m. - 8:45 p.m.	Deep Diving Physiology <u>Scientific American</u> video	(classrooms)

Friday, January 11, 1991

7:30 a.m.	Breakfast	(Portola Cafe)
8:30 a.m.	Fish mapping - Rita	(classrooms)
9:30 a.m.	MBARI Link - Jeff	(auditorium)
10:30 a.m.	Activities -local canyon, geology - Jeff -pressure activities - Betty & Suzanne -light lab - Linda Hagerty -preserved specimens - Rita	(classrooms)
12:00 p.m.	Lunch	(classrooms)
1:00 p.m.	Activities -World's Smallest Ocean & Packages Linda Hagerty -Resources - Betty -Bradycardia & (Don) Moon's oil - Rita -Hot vents, <u>Discovery</u> video - Suzanne	(classrooms)
2:30 p.m.	Leave to Moss Landing	
3:30 p.m.	MBARI tour	

Friday, January 11, 1991 (continued)

6:00 p.m.	Leave to the aquarium	
6:30 p.m.	Dinner	(Portola Cafe)
7:30 p.m.	Sharks program - Suzanne	(auditorium)
8:30 p.m.	Sharing time	(classrooms)
9:00 p.m.	Schooling Fishsticks - Linda	(classrooms)

Saturday, January 12, 1991

7:30 a.m.	Breakfast	(Portola Cafe)
8:30 a.m.	Bat ray feeding - Suzanne	(Aquarium)
9:00 a.m.	Deep Sea Ecology & Technology *Dr. Robison or Mary Silver	(classrooms)
10:30 a.m.	Activities -plankton key - Linda -Sinking slowly - Betty -Lifestyles of Marine Organisms - Rita	(classrooms)
12:00 p.m.	Lunch	(classrooms)
1:00 p.m.	Open Closure - Rita	(classrooms)
1:30 p.m.	Wrap-up Announcements/SJSU registration and checks/ Evaluations/April assignments	

Saturday afternoon option: Point Lobos at 3:00 p.m.

Sunday morning option: whale watching

Monterey Bay Aquarium Teachers Institute

1989 Monterey Bay Habitats Institutes

Schedule for Follow-up Workshop III: April 26-28, 1990

Thursday, April 26, 1990

- 2:00 pm or later check-in at Days Inn, Seaside, (408) 394-5335
- 5:30 pm Check-in at aquarium classrooms
Sign up for time slots to share activities
Pick up schedule/SJSU forms, etc.
- 5:45 pm Dinner in the classrooms
- 6:30 pm Conservation Forum & Workshops
- 9:00 Social in classrooms

Friday, April 27, 1990

- 8:00 am Hand-in 33 copies of your "presentation handout set" to the staff member in the classroom.

Put your other 2 copies in an envelope (envelope will be provided). After your scheduled presentation, place any additional materials you are delivering to the aquarium in this envelope and give it to Becky

Breakfast in the Portola Cafe

- 8:30 am Free time in the aquarium
- 8:45 am Bat Ray Feeding
- 9:15 am Assemble your packet of everyone's handout sets in classroom
- 9:30 am to Activity presentations in the classrooms (13)
- 12:30 pm (Lunch will be served around 11:45 am.)
- 12:45 to Field Exercises: Human Impacts on Monterey
- 3:00 pm

(OVER)

Field Schedule for Friday, 4/27/90 12:45 to 3:00 p.m.

Field Sites:

Hopkins Marine Station (LAB) with Judith Connor
Begin and end at Hovden Way gate.

Cannery Row (ROW) with Betty Allen
Begin and end at Hovden Way gate.

Each group will have 50 minutes per site and 15 minutes transit time between sites. MEET EACH GROUP AT THE PRE-ARRANGED LOCATIONS AND WALK THEM BACK TO THEIR NEXT PICK-UP POINT.

3:00 pm Free Time
3:15 Discussion: Review/Feedback of MBA education materials
5:00 pm Original Curriculum Unit in small groups
6:00 pm Doc Ricketts Lab with Morgan Stalk
6:30 pm Dinner in the Portola Cafe
7:30 pm A Backward Glance from China Point with Tom Takano

Saturday, April 28, 1990

7:30 am Check-out of Days Inn
8:00 am Breakfast in the Portola Cafe
8:45 am Activity presentations in classroom (13)
11:45 am Lunch
12:30 pm Complete and turn in:
MBA and SJSU evaluation forms
SJSU registration forms and checks
Individual assessment
MBA content review
2:00 pm-2:30 pm
Closing session sharing personal statements

Note: Staff meeting 2:00 p.m.-3:00 p.m.

1990 MONTEREY BAY AQUARIUM TEACHER INSTITUTE

Marine Science Institute Summer Session

Evaluation Summary

R = Number of respondents

Date: Aug. 19, 1990

() = Percentage

R

25 1. What grade(s) do you teach? K-2 3-5 6-8 9-12
6 6 7
(24) (24) (24) (28)

28 2. Which statements best describe your science background?

6 Little or no college level science education (21)

4 Science minor or equivalent (14)

11 Degrees in science (40)

7 Teach science classes (25)

17 3. If you had a science minor, or a degree in science, what was your area of study? Life Sciences 5 (29)
Biology 9 (53)
Natural Sciences 3 (18)

22 4. Please circle your overall rating for this program in comparison to similar programs in which you have participated.

21 (95)	0	0	0	0	1 (5)
much better	somewhat better	very similar	somewhat worse	much worse	N/A

22 5. This institute fulfilled my general expectations for an educational workshop.

19 (86)	3 (14)	0	0	0
strongly agree	agree	disagree	strongly disagree	does not apply to me

22 6. The objectives of this institute were clearly defined.

In pre-program materials	yes	19 (86)	usually	3 (14)	no	0
During orientation	yes	20 (91)	usually	2 (9)	no	0
In class sessions	yes	19 (86)	usually	3 (14)	no	0

22 7. What was promised to me in this program was delivered.

20 (91)	2 (9)	0	0	0
strongly agree	agree	disagree	strongly disagree	does not apply to me

22 8. The institute has strengthened my interest in teaching of science.

21 (95)	1 (5)	0	0	0
strongly agree	agree	disagree	strongly disagree	does not apply to me

- 22 9. The institute has increased my ability and my resources for teaching hands-on (activity based) science.
- | | | | | |
|----------------|-------|----------|-------------------|----------------------|
| 21 (95) | 1 (5) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 10. This institute provided opportunities for interactions between teachers and scientists.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 16 (73) | 6 (27) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 11. The institute helped me become more capable of providing in-service training in science teaching for my peers.
- | | | | | |
|----------------|---------|----------|-------------------|----------------------|
| 11 (50) | 10 (45) | 1 (5) | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 12. I am more confident, following this institute, that I can meet State Science Framework objectives using marine science content.
- | | | | | |
|----------------|---------|----------|-------------------|----------------------|
| 8 (36) | 12 (55) | 0 | 0 | 2 (9) |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 13. The institute has increased my ability to teach my students to use scientific processes to answer research questions.
- | | | | | |
|----------------|---------|----------|-------------------|----------------------|
| 11 (50) | 10 (45) | 0 | 0 | 1 (5) |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 14. The institute improved my skills as a scientist both in the field and in the laboratory.
- | | | | | |
|----------------|---------|----------|-------------------|----------------------|
| 11 (50) | 10 (45) | 0 | 0 | 1 (5) |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 15. The institute increased my knowledge of marine science (physical, biological and ecological) facts, concepts and themes.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 16 (73) | 5 (23) | 0 | 0 | 1 (4) |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 16. The process of developing a unit to integrate marine science into my school's curriculum was productive and worthwhile.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 17 (77) | 4 (18) | 0 | 0 | 1 (5) |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |

- 22 17. The resource materials that were given to me and provided in the resource room were useful.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 16 (73) | 6 (27) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 17a. I would like to see the following items (or types of items) added to the resource room: (See attached)
- 22 18. I found the institute well organized.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 17 (77) | 5 (23) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 19. The dorm rooms in Wilson Hall at RLS were satisfactory.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 15 (68) | 7 (32) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 20. The food was satisfactory.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 13 (59) | 9 (41) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 21. The van transportation was satisfactory.
- | | | | | |
|----------------|--------|----------|-------------------|----------------------|
| 15 (68) | 7 (32) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 22. The lounge/meeting room in Wilson Hall at RLS was satisfactory.
- | | | | | |
|----------------|---------|----------|-------------------|----------------------|
| 11 (50) | 11 (50) | 0 | 0 | 0 |
| strongly agree | agree | disagree | strongly disagree | does not apply to me |
- 22 23a. The activities using aquarium exhibits and galleries were
- | | | | | | |
|--------------|---------------------------|--------------------------|----------------|------------------------|---------------|
| Instructive: | 17 (77)
strongly agree | 5 (23)
somewhat agree | 0
agree | 0
somewhat disagree | 0
disagree |
| Useful: | 17 (77)
strongly agree | 5 (23)
somewhat agree | 0
agree | 0
somewhat disagree | 0
disagree |
| Challenging: | 14 (64)
strongly agree | 7 (32)
somewhat agree | 1 (4)
agree | 0
somewhat disagree | 0
disagree |
| Enjoyable: | 17 (77)
strongly agree | 5 (23)
somewhat agree | 0
agree | 0
somewhat disagree | 0
disagree |
- My most favorite was: (See attached.)
- My least favorite was: (See attached.)

22 23b. The hands-on activities in the classroom were

Instructive:	20 (90) strongly agree	1 (5) somewhat agree	0 agree	1 (5) somewhat disagree	0 disagree
Useful:	21 (95) strongly agree	1 (5) somewhat agree	0 agree	0 somewhat disagree	0 disagree
Challenging:	18 (82) strongly agree	3 (14) somewhat agree	0 agree	1 (4) somewhat disagree	0 disagree
Enjoyable:	21 (95) strongly agree	1 (5) somewhat agree	0 agree	0 somewhat disagree	0 disagree
My most favorite was: (See attached.)					
My least favorite was: (See attached.)					

22 23c. The field trips were

Instructive:	18 (82) strongly agree	4 (18) somewhat agree	0 agree	0 somewhat disagree	0 disagree
Useful:	18 (82) strongly agree	3 (14) somewhat agree	1 (4) agree	0 somewhat disagree	0 disagree
Challenging:	15 (68) strongly agree	6 (27) somewhat agree	1 (5) agree	0 somewhat disagree	0 disagree
Enjoyable:	20 (91) strongly agree	2 (9) somewhat agree	0 agree	0 somewhat disagree	0 disagree
My most favorite was: (See attached.)					
My least favorite was: (See attached.)					

21 23d. The field research projects were

1 N/A

Instructive:	7 (33) strongly agree	8 (38) somewhat agree	5 (24) agree	1 (5) somewhat disagree	0 disagree
Useful:	7 (33) strongly agree	7 (33) somewhat agree	5 (24) agree	2 (10) somewhat disagree	0 disagree
Challenging:	8 (38) strongly agree	6 (29) somewhat agree	6 (29) agree	1 (4) somewhat disagree	0 disagree
Enjoyable:	13 (62) strongly agree	2 (9) somewhat agree	4 (20) agree	2 (9) somewhat disagree	0 disagree
My most favorite part was: (See attached.)					
My least favorite part was: (See attached.)					

20 24. Group Discussions on (Field Trips, Science Research) were

2 N/A

Instructive:	12 (60) strongly agree	5 (25) somewhat agree	2 (10) agree	1 (5) somewhat disagree	0 disagree
Useful:	13 (65) strongly agree	5 (25) somewhat agree	2 (10) agree	0 somewhat disagree	0 disagree
Challenging:	9 (45) strongly agree	7 (35) somewhat agree	3 (15) agree	1 (5) somewhat disagree	0 disagree
Enjoyable:	14 (70) strongly agree	6 (30) somewhat agree	0 agree	0 somewhat disagree	0 disagree

22 25. The lectures were

Instructive:	20 (91) strongly agree	2 (9) somewhat agree	0 agree	0 somewhat disagree	0 disagree
Useful:	16 (73) strongly agree	6 (27) somewhat agree	0 agree	0 somewhat disagree	0 disagree
Challenging:	16 (73) strongly agree	5 (23) somewhat agree	1 (4) agree	0 somewhat disagree	0 disagree
Enjoyable:	19 (86) strongly agree	3 (14) somewhat agree	0 agree	0 somewhat disagree	0 disagree

My most favorite part was: (See attached.)

My least favorite part was: (See attached.)

22 26. The evening/end of the day closing times were

Instructive:	6 (27) strongly agree	8 (36) somewhat agree	3 (14) agree	5 (23) somewhat disagree	0 disagree
Useful:	8 (36) strongly agree	7 (32) somewhat agree	5 (23) agree	2 (9) somewhat disagree	0 disagree
Challenging:	5 (23) strongly agree	6 (27) somewhat agree	4 (18) agree	4 (18) somewhat disagree	3 (14) disagree
Enjoyable:	11 (50) strongly agree	5 (23) somewhat agree	5 (23) agree	1 (5) somewhat disagree	0 disagree

22 27. The staff was

Knowledgeable:	22 (100) strongly agree	0 somewhat agree	0 agree	0 somewhat disagree	0 disagree
Helpful:	22 (100) strongly agree	0 somewhat agree	0 agree	0 somewhat disagree	0 disagree
Accepting:	22 (100) strongly agree	0 somewhat agree	0 agree	0 somewhat disagree	0 disagree
Pleasant:	22 (100) strongly agree	0 somewhat agree	0 agree	0 somewhat disagree	0 disagree
Inspiring:	22 (100) strongly agree	0 somewhat agree	0 agree	0 somewhat disagree	0 disagree

A major strength of the staff was: (See attached.)

A major weakness of the staff was: (See attached.)

28. Please list at least five things you have learned during the course of the institute. (See attached.)

29. List any things you would change about the institute. (See attached.)

Responses to open-ended questions.

17. The following items (or types of items) added to the resource room:

Harbinger file
 videos
 lab data
 charts
 maps
 supporting software
 State Science Framework

- 23a. Most favorite activities using aquarium exhibits and galleries were:

9 kelp forest
 3 freetime at exhibits before opening
 2 treasure hunt
 1 behind the scenes
 7 N/A

Least favorite:

18 none
 1 phylum activity
 1 dissection
 1 behind the scenes
 1 distribution sheets

- 23b. Most favorite hands-on activity in the classroom:

4 black oil
 2 Mike's classifications
 2 sand lab
 2 oyster and apple intros
 2 keying animals
 1 fish printing
 1 squid dissection
 1 algae pressing
 1 density
 1 hydrometer
 1 clam dance
 1 marine biology
 3 N/A

Least favorite:

6 None
 6 dissection
 1 activities only applicable to younger age levels
 1 plankton study
 1 password
 1 final exam
 1 clay boats
 1 hydrometers
 1 fish printing

23c. Most favorite field trip:

- 15 bay excursion
- 12 Elkhorn Slough
- 7 wharf
- 3 beach dunes
- 1 Moss Landing
- 1 N/A

23c. Least favorite field trip:

- 8 N/A
- 7 dunes
- 1 wharf
- 1 marsh

23d. Most favorite part of field research project:

- 5 collecting data
- 3 finding our hypothesis to be true
- 2 creative colleagues
- 2 presentations
- 2 observing nature
- 1 water data on slough boats
- 1 bay organism exam
- 1 open sea
- 5 N/A

Least favorite:

- 8 N/A
- 2 presenting
- 1 too much time
- 1 needed more time
- 1 beach/plant identification
- 1 listening to lengthy lectures
- 1 wondering whether our hypothesis might be affected by unknown variables made us insecure about our findings
- 1 boat on the bay
- 1 choosing a topic

25. Most favorite part of lectures:

- 9 Judith Connor
- 4 Mr. Livermore
- 3 Dr. Watanabe
- 1 clam anatomy
- 1 taxonomy
- 1 crab dance
- 1 aquarium tips
- 1 closure/ key ideas
- 2 N/A

Least favorite:

- 7 N/A
- 5 Ferguson/lecture explaining how to set up aquarium
- 3 Dr. Haderlie
- 2 Dr. Watanabe
- 1 kelp forest
- 1 algae

27. A major strength of the staff was:

- 15 helpful and positive
- 4 flexibility
- 3 diversity of personalities
- 5 accessible and interactive
- 3 knowledgeable

A major weakness of the staff was:

- 13 none
- 2 not keeping group focused
- 1 could be more prepared at times

28. Please list at least five things you have learned during the course of the institute.

- 22 Physical Oceanography
- 19 teaching strategies and activities
- 7 marine science and research
- 7 interdependence of ecosystems
- 3 importance of classification

29. List any things you would change about the institute.

more time to meet with scientists and ask them questions
 program geared to grade level
 access to library and xeroxing
 free time outside each day
 more time first night to develop questions/orient ourselves
 reduce time spent on field research projects
 more technology-related activities: VCR, video disc, computer
 shorter days
 teach more taxonomy at beginning of institute

A:®90POST.DOC



DEEP SEA ! DISCOVERIES !

Moderator: Steven Webster
Monterey Bay Aquarium

Deep Sea Ecology and Technology

Bruce H. Robison
Senior Scientist
Monterey Bay Aquarium Research Institute

Abstract

What we know about something is usually a function of how we learned it. When it comes to the animal life of the deep sea, what we know has been very strongly influenced by the fact that most of it has been learned indirectly. For more than a century, our principal means of obtaining samples and data from the deep sea has been with nets and instruments lowered into the ocean at the end of long steel cables. This arrangement meant that the scientists who collected the information and were charged with interpreting it had to do so out of context because they were stuck at the surface of the sea on the deck of a ship.

Twenty-five years ago, the first real technological improvement of this situation came about with the construction of *ALVIN*, a deep-diving, three-person research submersible that provided oceanographers with direct access to the deep sea floor. The availability of *ALVIN* led to a number of breakthrough discoveries about the geology and biology of the deep sea habitat. While the ability to work at the bottom of the ocean has greatly improved our understanding of benthic ecology, until very recently we lacked the means to directly study the water column that separates the sea surface and the deep sea floor.

The oceanic water column is where about ninety percent of oceanic animals live and, because it is a truly three-dimensional habitat (in the sense that there is no single spatial plane against which most ecological patterns are based), it presents a considerable challenge to those who would study it directly. In the 1980s, a

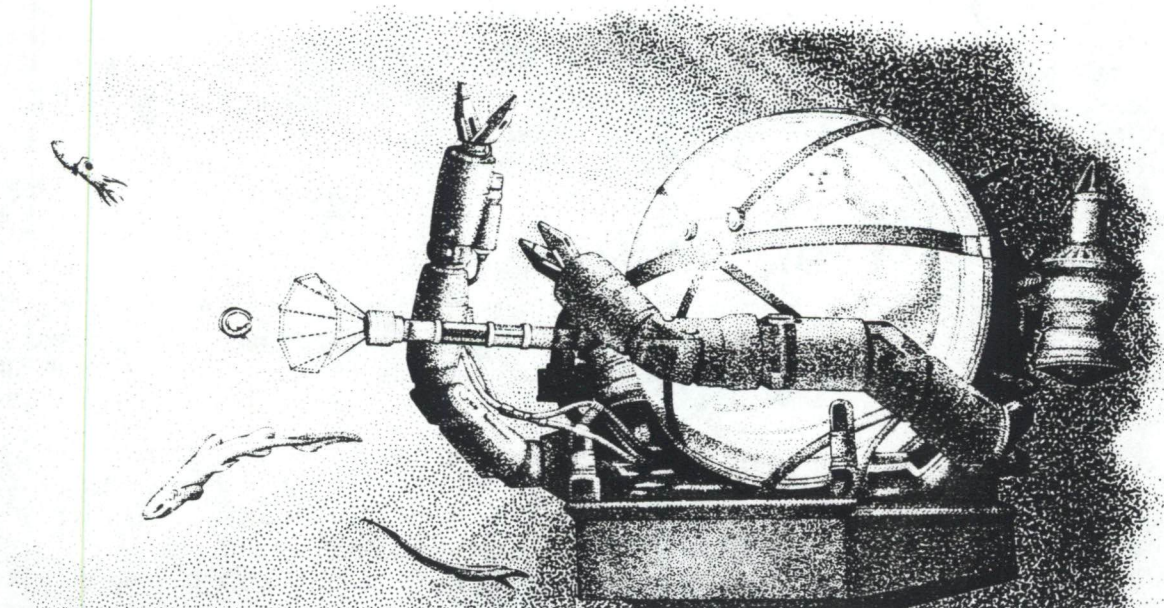


Illustration © Monterey Bay Aquarium

small group of researchers has begun to study the animals of the deep sea water column directly, using technology that was developed principally for the offshore oil industry. This technology consists of both manned and unmanned submersibles.

What we are learning from this new perspective is revolutionizing our understanding of deep sea ecology. For example, recently acquired data suggests that we may have underestimated the abundance of small fishes and squids by an order of magnitude. The reason for this is that the animals were easily able to avoid the slow-moving nets we dragged behind our ships. Likewise, another group of animals, the gelatinous zooplankton, have been grossly underestimated because they are so fragile that our nets destroyed them during capture.

The new submersible technology has also allowed us to focus our observations with much better resolution and thus to resolve ecological patterns in the deep sea

on a much finer scale. In addition, we can now go beyond the mere structural elements of deep sea ecology and begin to study the dynamic aspects of these systems, such as behavioral patterns and physiological processes. Two research topics of particular importance which did not yield to conventional methods are the role of bioluminescence and the study of interactions between benthic and pelagic communities. Both are now practical lines of research.

Deep sea ecology is at the brink of a major evolutionary change in the way that research is conducted. The technology we are developing now will provide the standard tools of the next generation of oceanographers, and it is our responsibility to properly develop the thought processes and methodologies necessary to use them well.



Deep Sea Structure and Food Webs

Mary W. Silver
Professor of Marine Sciences
University of California, Santa Cruz

Abstract

Communities in the deep sea differ from almost all others on earth because they function in darkness and hence without photosynthesis. Thus, the food of the communities is derived mostly from external sources. On the one hand, active animals, especially at depths of a few hundred meters to a thousand meters or so, swim nightly to overlying waters. Here they feed in the darkness on populations that are lit by the sun during the day. On the other hand, non-migrators at depth must feed on one another or on the decomposing materials that drift down from overlying waters.

The goal of this talk is to briefly review the characteristics of the deep sea organisms and communities, paying special attention to their food sources. Recent discoveries will be discussed that result from applications of new technology used in an internationally sponsored, global monitoring program, a program concerned with cycles of natural and man-made substances in the sea.

References

- Marshall, N.B. 1979. *Deep-Sea Biology, Developments and Perspectives*. Garland STPM Press, New York, 566 pp.
- Rowe, G.T. (ed.) 1983. *Deep-Sea Biology*. Vol 8, *The Sea*. Wiley-Interscience Pub., John Wiley & Sons, New York, 560 pp.

Drugs from the Deep

Judith L. Connor
Monterey Bay Aquarium
and Hopkins Marine Station

Abstract

Many drugs currently used in medicine are derivatives of terrestrial plants and soil microorganisms. Scientists are now looking to the marine environment as a source of potential drugs.

Many chemical compounds from sponges, sea squirts, algae and other marine organisms exhibit antibiotic activity against bacteria, fungi, viruses or cancer cells.

The search for pharmaceuticals from marine organisms has been a catalyst for deep sea exploration. Funded by the National Cancer Institute and a private pharmaceutical company, a team of marine biologists, microbiologists, immunologists and chemists studied marine organisms from the eastern Caribbean, Central

America, Cocos and the Galapagos Islands. Using the Johnson Sea-Link submersible, we collected and examined organisms from depths of 350 to 2,360 feet.

Although the primary goal of these cruises was applied research on pharmacology, we continued to address basic scientific questions on evolution and ecology of deep sea organisms. What are the geographic patterns of species diversity in deep sea benthic communities? How much does community structure change with depth?

We were especially interested in the deep Galapagos collections where the deep sea fauna is geographically isolated and relatively unexplored. Perhaps the richest sites were the windward shores of the western Galapagos islands, Isabela and Fernandina, where upwelling provides cold, nutrient-rich water. New species of sponges, sea squirts and corals were collected from rich, benthic communities on the deep volcanic slopes. Sea cucumbers dominated the soft

benthos of the deep, horizontal plains. The photographs, videos and specimens collected during these cruises continue to provide data for study of deep sea organisms, their taxonomy, biomechanics of locomotion, distributions and community structure.

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CURRICULUM DEVELOPMENT

Deep Sea Discoveries

Grades K-2

Main Ideas

- A. Deep sea creatures have unique characteristics by which they can be described and identified. (biological)
- B. Animals living in the deep sea have special body parts and actions that help them survive. (biological)
- C. The ocean gets darker and colder as it gets deeper. (physical)
- D. Scientists learn about the deep sea with nets, submarines and other equipment. (human impact)
- E. A deep sea animal must eat and avoid being eaten. (biological)
- F. Deep sea animals use senses of touch, smell and sight to catch food. (biological)

Activities

1. Show a picture of a deep sea animal. Discuss one of its interesting features (such as big eyes or a lure). How might this body part help the animal survive in the deep sea? What could you see with eyes that big? Have students find a picture of another animal with a similar body part. (Concepts A & B)

2. Ask students to describe a deep sea creature and see if other classmates can point out its picture. (Concept A)
3. Provide each student with a page of body parts from which they create a creature adapted to the deep sea environment. (Concept B)
4. Give each student one of three fish body shapes (lantern fish, eel or hatchet fish), and have them add other body parts to help it survive in the deep sea. Add each fish to a mural showing different ocean zones. (Concept B)
5. Prepare and produce a deep sea puppet show called "A Day in the Life of Josie the Jellyfish." Students show what its like in the cold, dark, deep sea and include Josie's prey and predators. (Concepts A, B, C, and D)
6. Display pictures of deep sea creatures as you explain their roles in the food web, then ask students to guess how each catches its food and avoids being eaten. Create a food web with the pictures. (Concepts A, B, E & F)

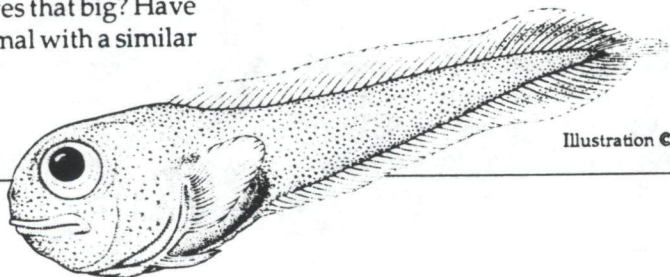
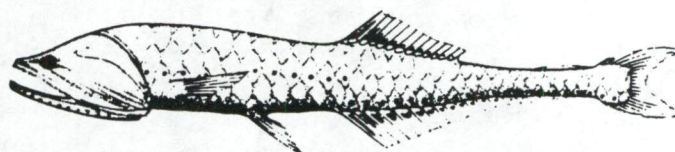


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7. Students draw an imaginary deep sea fish, then write a description that tells how its features help it survive. (Concept A)

8. Produce a play highlighting exploration of the deep sea by a scientist in the one-person submarine *Deep Rover*. The pilot can describe decreasing light and increasing cold and the strange creatures encountered during their descent. Other students can act out or display pictures of the marine life described by the pilot. (Concepts C & D)

9. Observe four different foods (almonds, lemon, peppermint, and chocolate) and discuss your favorites. Have students find their favorite food using only their sense of smell by giving them four cups containing a cotton ball saturated with a different flavoring). (Concept F)



Deep Sea Discoveries

Illustration © Monterey Bay Aquarium

Grades 3-5

Main Ideas

A. As the ocean gets deeper, it gets colder and darker and water pressure increases. (physical)

B. Scientists define three ocean zones based on light levels: the **sunlight zone**, where enough sunlight penetrates for plants to make food or photosynthesize (surface to about 200 meters deep); the **twilight zone**, where weak sunlight is insufficient for photosynthesis (200 to 600 meters), and the **dark zone** where no sunlight penetrates (below about 600 meters). The exact depths of these zones are determined by the clarity of the water. (biological & physical)

C. Only the blue colors of the sunlight rainbow penetrate into the **twilight zone**. The red end of the sunlight rainbow is absorbed within a few meters of the surface. (physical)

D. The Monterey Submarine Canyon is similar in size and shape to the Grand Canyon. (physical)

E. Deep sea animals have special body parts and for feeding, avoiding predators and finding mates. (biological)

F. Many deep sea animals create their own light, or "bioluminescence" (usually blue or green light). (biological)

G. Many deep sea animals are either red or black. In the darkness of the deep sea (where no red light penetrates) red animals are as hard to see (camouflaged) as black animals. (biological)

H. Scientists have discovered who eats whom (food webs) in the deep sea. (biological & human impact)

I. Particles of decomposing material called marine snow drift down through the deep sea, providing food and constantly changing physical structure. (biological)

J. New methods of exploring the ocean, such as underwater cameras, submarines, and unmanned submersibles, give scientists a new, more complete understanding of the deep sea than previous collect-

ing methods using nets and bottles dragged by boats. (human impact)

K. As new information is gathered, scientists challenge and revise existing theories about the deep sea. (human impact)

Activities

1. Describe the ocean's three light zones, then scatter colored toothpicks (representing red, yellow, blue, green, and black fishes) on a dark surface. Students act as predators in the sunlight zone. Time how many toothpicks they can pick up (one by one) in fifteen seconds. Record the number of each captured color. Now darken the room and have students look through a blue filter as they capture prey in the twilight zone. Try again, this time students wear blindfolds to simulate conditions in the dark zone. Compare the numbers and colors of prey captured in each zone and discuss the importance of color in deep sea animals. (Concepts A, B, and C)

2. Lead an imaginary deep sea descent (using video or slides if possible). After the dive, students work in pairs to present a news interview; one partner plays the reporter and the other plays the deep sea explorer. (Concept I)

3. In a dark, cool, quiet place, use guided imagery to help students experience the conditions of the deep sea. Then spread out in the dark and use a prearranged signal to find another of your species while avoiding an identified predator. (Concepts A & E)

4. Students make a picti-nary illustrating deep sea vocabulary such as submarine canyon, bioluminescence, submersible, lanternfish, etc. (Concepts A, D, E and I)

5. Use contour maps to compare the Monterey Submarine Canyon to the Grand Canyon. Discuss similarities and differences. Ask students to construct models of each. (Concept D)

6. Hide candy around the room, then darken the room and send students off on a search for the hidden candy. Discuss what adaptations would help you gather food in a dark environment such as the deep sea. (Concepts A and E)

7. See if students can find a "mate" in the dark by smell. Each mate will be wearing the same perfume applied to the scent card a "partner" is holding. (Concept E)

8. Using small pen lights, students try to find a mate in the dark by matching signals. Watch out for a mimicking predator. Discuss problems involved in finding mates in the deep sea and how adaptations like bioluminescence and scent help overcome these difficulties. (Concept E)

9. Sit in a tight circle with a picture card of a deep sea animal on a string around each student's neck. A ball of yarn is passed from prey to predator forming a deep sea food web. (Concept H)

10. Discuss how the deep sea compares to a shallow water habitat. Then dress a student up as an angler fish, adding body parts as classmates suggest needs, and adaptations that resolve them. (Concept E)

11. Each student acts out a description of an adaptation displayed by a deep sea creature. Classmates name the adaptation and tell how it aids in deep sea survival. (Concept E)

12. As a class, sort a set of deep sea fish pictures into groups based on observable characteristics. Discuss how the different adaptations help the fishes survive. (Concept E)

13. Take the students on an imaginary journey to the deep sea. Discuss what you'll need in order to survive. Describe the physical conditions of each zone and how it feels to be there. (Concepts A and B)

14. Brainstorm a list of materials that will simulate marine snow in a gallon jar of water (for example, diatomaceous earth, ground up seaweed, talcum powder, cereal, etc.). (Concept I)

15. After discussing the value of photography in deep sea studies, explore the difficulties of photographing deep sea creatures by taking pictures of a fish model or photo in a darkened room. Have the first group use no flash or other light source. The next group can use a flash but no other light source. The last photo team can use a flashlight to find the fish and shoot again. Compare results and discuss problems and solutions to photography in the deep sea. Use an underwater camera to try photographing a fish in an aquarium. (Concept J)

16. Display photographs of submarines used in the study of the deep sea. Discuss the functions of different parts. Then, using juice bottles, wood scraps, bottle caps, straws, etc., students can build a model submersible. Ask each student to explain some of the most interesting features of the sub to the rest of the class. (Concept J)

17. Watch for news stories about new discoveries disproving existing theories. Discuss the new technologies that help lead to new ideas. (Concept J)

Deep Sea Discoveries

Grades 6-8

Main Ideas

A. As you go deeper in the sea, pressure increases while light level and temperature decrease. (physical)

B. Deep sea animals have structural and behavioral adaptations to the deep sea environment. (biological)

C. Many deep sea animals have light organs called photophores and can produce their own light (bioluminescence). (biological)

D. Deep sea animals can be classified according to their physical characteristics. (biological)

E. Scientists divide the deep sea into zones determined by physical conditions such as depth, temperature and light level. (physical & biological)

F. Due to very different physical surroundings, mid-water animals or open-water animals are very different from benthic or bottom-dwelling animals. (physical & biological)

G. Most deep sea animals depend on food energy resulting from photosynthesis in the sunlit zone. (physical & biological)

H. Scientists and engineers use modern technology to help them learn about the deep sea. (human impact)

I. Human activities may threaten deep sea habitats. (human impact)

Activities

1. Direct students to place one hand in a plastic bag and submerge it in a bucket of water to see and feel the affect of water pressure. Discuss any other affects of water pressure, such as ear squeeze when diving to the bottom of a swimming pool. (Concept A)

2. Look at pictures of deep sea animals and discuss how their physical features might help them survive in the deep sea environment. Create a deep sea bulletin board by placing pictures of deep sea life on a

black background with descriptions of their adaptations. (Concept B)

3. Using pictures of deep sea creatures, index cards, markers and large sheets of paper, have students design Venn diagrams to categorize various characteristics of deep sea animals. Share and decode each other's diagrams. (Concept D)

4. View slides or video about the deep sea, then participate in a guided fantasy dive into the deep sea environment. (Concepts A & B)

5. Brainstorm ways deep sea animals use bioluminescence. Give students flashlights to role-play being lanternfishes. Each tries to find a mate (someone blinking the same code letter) before being eaten by secretly designated predators who mimic others' flashes. (Concept C)

6. Research and discuss the colors best suited for survival in the deep sea. One team colors cut-outs of deep sea animals and tapes them to dark surfaces around the room. Another team acts as predators. Using blue-tinted flashlights in the dark, the predators catch as many prey as possible in one minute. Reverse roles. Discuss which colors were easiest to detect. (Concept B)

7. Discuss how environmental conditions affecting a benthic animal living on the deep sea floor would be different from those affecting a midwater animal. Ask students to design a well-adapted benthic organism and a well-adapted midwater organism. Discuss how each creature's features help it survive in a deep sea environment. (Concepts A, B, & E)

8. Work in teams to design deep sea live-in research labs. One team designs a lab that would allow them to live for a month on the deep sea floor at a depth of 5,000 meters. The other team designs a lab that would allow them to live for a month in midwater at a depth of 1,000 meters. Compare problems confronting each team and discuss solutions. (Concepts A, E, F, & H)

9. Have students role-play a public hearing to decide whether to allow sewage dumping in a deep water submarine canyon that is close to shore as a low cost solution to increasing sewage disposal needs. Be sure to include an oceanographer, engineer, concerned taxpayer, environmentalist, sewage disposal expert and a panel of supervisors who will decide whether or not to go through with the plan. (Concept I)

Deep Sea Discoveries

Grades 9-12

Main Ideas

A. Deep sea organisms have evolved unique adaptations to the deep sea environment. (biological)

B. Scientists divide the deep sea into zones based on a number of variables like light, depth and temperature. (physical & human impact)

C. Most deep sea animals ultimately depend upon the energy resulting from photosynthesis in the shallow photic zone. (biological)

D. Different sampling technologies have different advantages and give us different views into the deep sea. (human impact)

E. Many deep midwater creatures are vertical migrators (biological).

Activities

1. Study pictures of deep sea animals. List similarities and discuss how features are adapted to environmental conditions. (Concept A)

2. Ask students to draw an imaginary organism that could live in the deep sea and write a story about its life. (Concept A)

3. Bring in scrap materials for students to create a working model of a real or imaginary deep sea animal (possible materials: foam, popsicle sticks, tooth picks,

straws, pipe cleaners, paper cups, Christmas lights, balloons, etc.) Have them build an exhibit box (with or without lights) to demonstrate how their animal feeds, avoids predators and locates mates. (Concept A)

4. Ask students to modify a basic fish outline to suit different deep sea environmental conditions, and explain the value of the added structural adaptations to the class. (Concept A)

5. As you descend during a simulation dive into the deep sea, changes occur in depth, light level and spectrum, temperature, oxygen concentration, etc. Working in teams, suggest zones based on these different physical conditions. Graph other variables against depth, labeling zones. Students then conduct library research on the deep sea to compare their zones to those suggested by other scientists. (Concept B)

6. Brainstorm mechanisms by which deep sea organisms could access food energy generated in surface waters. Students can conduct library research to find out about scientific discoveries involving the transfer of food energy to the deep sea (for example, vertical migration, marine snow, raining fecal pellets, chemosynthesis, etc.). Have students construct and compare food webs for shallow water and deep sea environments (include energy source, producers, consumers and decomposers). (Concept C)

7. Set up a classroom aquarium with rocks and hardy aquatic plants and animals. Brainstorm effective ways to sample underwater environments. Bring materials from home to create devices for remotely sampling your aquatic environment. Live creatures must be collected humanely and with a minimum of stress. Discuss the advantages and limitations of your sampling devices and compare them to those used by scientists. Discuss the advantages and disadvantages of manned submersibles and remotely operated devices for gaining an accurate view of the deep sea. (Concept D)

8. In a group, list as many migratory animals as possible, suggesting advantages to their migratory behavior. Discuss advantages to vertically migrating deep midwater animals. Plot imaginary net counts (or actual data from the scientific literature, or from a marine scientist) from different depths and times to create a bar graph showing the depth distribution of a lanternfish school over a twenty-four-hour period. (Concept E)

Deep Sea Discoveries

Informal Education

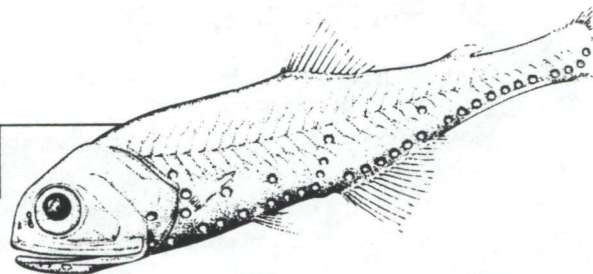


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Main Ideas

- A. Deep sea animals have unique chemical and behavioral adaptations to the deep sea environment. (physical & biological)
- B. Some chemical reactions produce light. (physical)
- C. Scientists believe that bioluminescence plays an important role in the survival of deep sea organisms. (biological)
- D. Scientists have described deep sea food webs. (biological & human impact)

Activities

- 1. Learners mix chemicals to create light (for example, squeeze cylum sticks). Discuss how light energy is released in some chemical reactions and the importance of these reactions to bioluminescent organisms. (Concept B)
- 2. Observe videos of bioluminescing deep sea organism and examine luminescent organisms on preserved specimens. Discuss possible functions of bioluminescence in deep sea organisms. (Concept A & C)

3. Role-play interactions involving bioluminescence among deep sea creatures. Each player gets an instruction card with a description of their character, predators and prey. Cylum sticks or other lights represent photophores in varying patterns depending on the role (prey or predator, male or female). Use guided imagery in a darkened room to set the stage for a deep sea descent. Then proceed to catch prey, avoid predators, and find a mate. (Concept A, C & D)

4. Present a deep sea food web skit. One interpreter portrays a researcher amazed by the "marine snow" in the water. Another interpreter enters portraying marine snow, and explains how mucus and larvacean nets can pick up bioluminescent bacteria. A small fish enters and laments the difficulty of finding food in the deep sea. The fish locates the marine snow and eats it. The skit ends with the entrance of a learner dressed as a deep sea anglerfish. The small fish is attracted by the lure, thinking it's marine snow, and is eaten by the anglerfish. (Concepts D, F, & G)

Deep Sea Discoveries Curriculum Development Participants

K-5: Charlotte Aldrich, Terri Belicha, Bud Camp, Lee Campbell, Penny Chesluk, Sallie Craig, Lynn Dailey-Vondracek, Savina Fazio, Barbara Fuchs, Pat Gotch, Sara Halaj, Elizabeth Haywood, Kathleen Heide, Carol Keiper, Ingrid Lindsay, Liz Love, Joe MacQuade, Philip McLaren, Michael Marzolla, Barbara Moore, Kit Muhs, Vicki Osis, Doug Peterson, Barbara Reitz, Phyllis Schmitt, Kim Straughn, Gail K. Zeiba

Grades 6-8: Joe Benoit, Ruth "Bubbles" Berman, Barry Calleson, Elsie Jones, Paula Keener, Barbara Leighton, Joanne Oien, Jim Snyder, Susan Snyder, Whitney Thwaite, John Trapani, Karen Wallingford, Ralph White,

Grades 9-12: Mary Pat Anderson, Emma Batts, Terri Berry,

Karen M. Blyler, Kay Carlino, Sallie Craig, Joe Dankert, Mercy Heath, Annie Holte, Barbara Klemm, Mary Jo Kuhn, Maryanne Mognoni, Wanda Pagonis, Donna Potter, Rob Spivalk, Maria Stone, Tim Tindol, George Tinker, Don Thompson, Nathan Veatch, Ken Watkins

Informal: Jean Adams, Cy Adler, Valerie Chase, Fred Clerici, Leslie Grella, Edward Rock, Deb Hall Sandler.

Facilitators:

Jeff Bryant, coordinator
Steve Christiano, coordinator
Becky Garcia, coordinator
Christy Lens, grades K-5
Rita Bell, grades 6-8
Holly Shewbridge, grades 9-12
Betty Allen, informal education
Linda Hagerty, informal education

Main Ideas Editors:

Betty Allen, Jeff Bryant, Bruce Stewart, Craig Strang

Activities Editors:

Laurie Dumdrie, grades K-2, 3-5, informal education

Rita Bell, grades 6-8

Michael Gardino, Holly Shewbridge, grades 9-12,

Jeff Bryant, Bruce Stewart, Craig Strang: all

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Compiled by Betty Allen

*Appropriate for elementary readers

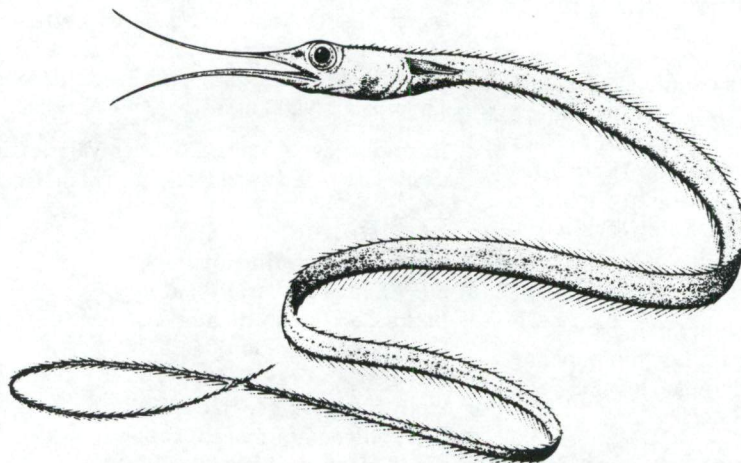


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Monterey Bay Aquarium
Education Division
Teacher Programs Department

Wet Science Project

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Summary

The Monterey Bay Aquarium's education programs model hands-on, process-based science teaching, which we call "wet science." Our three-year Wet Science Project is designed to improve the scientific literacy of 7th -12th grade teachers, strengthen their science-teaching skills, and develop support systems for hands-on science in their districts. This project will train 120 teachers from 13 school districts. With each participant conducting one in-service for ten colleagues, we will reach 1,200 teachers and their students.

The Wet Science Project consists of five levels of teacher enhancement. Level 1 participants learn science and wet-science teaching by visiting local ecosystems, working with scientists, conducting field research, using scientific equipment and curriculum materials, developing curriculum for in-service workshops, practicing peer coaching and presentation skills, and developing teaching management skills. Level 2 participants study upper-division marine ecology, conduct field research, develop curriculum, and learn student research management, science education promotion, multidisciplinary team building, and adult teaching skills. Level 3 participants build teams to transform their wet-science experiences into classroom or field trip experiences for students and colleagues. Level 4 wet-science-trained teachers, with their school administrators, integrate wet science into district goals, curriculum and programs. Level 5 participants disseminate wet science to other school districts, aquariums and zoos.

The Wet Science Project is in the final stages of approval for funding by the National Science Foundation (January 1991).

I. Introduction

Since its opening in October 1984, the Monterey Bay Aquarium has been an important educational resource to all of California. Through public exhibits, educational presentations and materials, the aquarium reaches more than 1.7 million visitors each year. More than 80,000 elementary and secondary students each year participate in tours, classroom and auditorium programs at the aquarium at no charge, or are visited by the Aquaravan and staff who conduct classroom and auditorium programs in the schools.

All of the aquarium's education programs model hands-on, process-based science teaching, which we call "wet science" (as opposed to "dry," hands-off, rote, fact-based learning). All education programs are funded in whole or in part by the income generated from the aquarium's daily operations. Although the aquarium's programs have reached people from all over the United States, the area the aquarium serves best is the local area -- central California. This is a primarily rural area with the following ethnic population percentages: 60% White, 26% Hispanic, 7% Asian/Pacific Islander, 6% Black, 1% Other (U.S. Census, 1980).

In 1987 the aquarium's Education Division established the Teacher Programs Department (referred to as "we" in this proposal). For the past two years we have conducted training institutes, seminars, science symposia and on-going support for 3,500 teachers throughout California.

A teacher enhancement program that teachers and school administrators have received enthusiastically is our Marine Science Teachers Institute. This institute consists of a seven-day, summer resident program and three follow-up weekend sessions during the school year. Participating kindergarten through twelfth grade (K-12) teachers learn about the natural communities of Monterey Bay, discover an ecological approach to studying and teaching science in any natural environment, meet and work with scientists, conduct field studies, acquire presentation skills useful in classroom and in-service teaching, and return to their schools with new knowledge, enthusiasm and activities. This two-year old program has served as a pilot for testing and disseminating our wet-science approach to science education.

Participants in the Marine Science Teachers Institute report an increased interest in science and their ability and confidence to teach it. They have also suggested many ways for improving the program. Suggestions include extending the Institute, including more science and field study practice, more follow-up support and opportunities, additional participant-developed in-services for teachers unable to attend the Institute, more classroom and field study activities, more conservation activities, and funding for participants.

A. Project Description

The purpose of this proposal is to request funding to develop the Monterey Bay Aquarium's Wet Science Project. This project would build on what we've learned from our Marine Science Teachers Institute. NSF funds would be used to 1) develop new institutes that are broader in scope, 2) offer project participants practical experience in developing wet-science activities, using them in the field and classroom, and conducting wet-science in-service workshops,

3) build relationships between scientists and teachers, 4) build a solid, science education support system in local school districts, 5) evaluate the effectiveness of our approach to teacher enhancement, and 6) provide Wet Science Institute participants with stipends and field teaching materials..

The long-term goal of this three-year project is to improve the scientific literacy of 7-12 grade teachers, strengthen the effectiveness of their science teaching skills and develop a permanent, on-going, wet-science support system in school districts. Although the target audience is 7-12 grade teachers, this project will also enhance K-6 grade teachers through in-service trainings and district-wide coordinated activities by participating 7-12 grade teachers. Over the next three years NSF funds would enable us to build a Wet Science teaching model, which, after NSF funding ends, the Monterey Bay Aquarium would maintain and disseminate using our own funds and corporate sponsorship.

B. Project Participants

The Wet Science Project is designed for teachers of grades 7 to 12 from central California school districts, especially those districts that have been identified by state test scores as needing assistance with science education. We will recruit teachers with three to ten years of teaching experience (those nearing the mid-career crisis stage of teaching). During the three years of NSF funding we will recruit and train 120 teachers from thirteen different school districts. With each participating teacher providing in-service training for ten colleagues, this project would reach at least 1,200 teachers (K through 12) and their students.

Selection of individual participants will be based on a completed application and recommendations from the applicant's principal, district superintendent and teaching peers. We are seeking to recruit motivated enthusiastic educators who are excellent classroom teachers, have strong cooperative and peer leadership capabilities, and have time to commit to improving science education. Special preference will be given to qualified applicants who apply as a team and express reasonably clear plans for cooperation as a team within their school district during and after the training.

We plan to recruit 14 teachers of grades 7-8 and 14 teachers of grades 9-12 for Level 1 (Basic Wet Science Institute) and six teachers of each grade level group for Level 2 (Advanced Wet Science Institute).

The number of science teachers who apply to our programs from grades 7-8 is approximately equal to the number applying from grades 9-12. All of the districts served by the Wet Science Project have separate schools for grades 7-8 and grades 9-12. Since the ratio of the number of grades in 7-8 schools (2 grades per school) to the number of grades in 9-12 schools (4 grades per school) is 1:2, we should only have half as many 7-8 science teachers to draw from as 9-12 science teachers. Our experience is inconsistent with these projections.

Based on conversations with grade 7-12 teachers we conclude that this trend is a reflection of the following factors.

- There are a larger number of summer institutes available for grade 9-12 science teachers.
- Many grade 7-8 teachers do not have undergraduate majors in science and actively seek additional training.
- Grade 7-8 teachers teach courses which more easily permit interdisciplinary integration of the sciences and our programs support their kind of teaching.
- Grade 7-8 schools are usually designed to house fewer students than grade 9-12 schools are, so there are more grade 7-8 schools for teachers to apply from than there are 9-12 schools.
- In areas with high student drop-out rates, student population shrinks with each grade, so there are more students (requiring more teachers) per grade in grades 7-8 than in grades 9-12.

Because of the poor representation of women and minorities in the sciences and the need for students to see enthusiastic and competent women and minorities as science role models, we will continue to recruit female participants (70% of Institute participants have been women). We will increase minority and disabled teacher participation (by visiting school sites and personally encouraging appropriate applicants) to at least 10% of the total number of participants.

C. Goals

The goals of the Wet Science Project are to:

1. increase teachers' competence and confidence with wet-science (hands-on, process-based science) teaching
2. augment teachers' knowledge of marine and atmospheric science content and provide them with up-to-date information on ocean and atmosphere research
3. increase teachers' ability to use an ecological approach to integrate technology, physical, earth, life and social science content and instruction

4. engage teachers in information exchanges with working scientists from Monterey Bay oceanographic research institutions such as Stanford University's Hopkins Marine Station, Monterey Bay Aquarium Research Institute, Moss Landing Marine Laboratories, University of California's Long Marine Lab, Elkhorn Slough Reserve, California Department of Fish and Game, NOAA and the Naval Postgraduate School
5. increase teachers' awareness of the importance of natural environments to their daily lives and encourage an attitude of stewardship for natural environments
6. equip teachers with leadership, peer coaching and in-service-workshop presentation skills and encourage them to take leadership roles in their school districts
7. increase the morale of science teachers and encourage them to stay in the teaching profession
8. involve administrators in institutionalizing and sustaining wet-science education in their districts
9. evaluate the effectiveness of this science teacher enhancement partnership
10. disseminate the aquarium's Wet Science Project to other similar institutions, such as aquariums, zoos, museums and nature centers.

II. Needs

The following needs are addressed by this project.

- A. A recent nationwide survey suggests that fewer than 6% of Americans can be called scientifically literate (NSF-funded survey by Miller, 1989). Most adults don't know enough about science to assist with informed problem solving or political and consumer decision making in our technological age (Mallow, 1981). Our nation needs scientifically literate citizens to address the environmental and technological problems facing us.
- B. Current fact-based science teaching methods may be contributing to the science illiteracy problem (Stake and Easley, 1978). Teachers need hands-on, process-based experience with science and effective science teaching resources, methods and materials in order to develop scientifically literate students (Thier, 1986).
- C. Science teachers typically progress through five identifiable stages of professional development. The fourth and most critical is the mid-career crisis stage when a teacher no longer feels good about teaching and may consider leaving the profession. Teachers need a support system that treats them with professional respect, recognizes their skills and offers resources to make their jobs more satisfying. This support will enable them to remain in the teaching profession and progress to the leadership stage (Spector, 1989).

D. Women and minorities are underrepresented in the sciences. Minorities are underrepresented in the teaching profession as well (Nicklos and Brown, 1989). Yet about half our students are female and by the year 2000, approximately 33% of U.S. students will be minorities. Students need to see female and minority teachers as enthusiastic and competent science-literate role models.

The Wet Science Project is an attempt by The Monterey Bay Aquarium to improve the capabilities of local science teachers and schools to deliver effective science education to their students.

In 1983 California Senate Bill 803 initiated a process of change in response to the crisis in science education. Since 1983 legislative changes have raised the graduation requirements in science from one semester to four semesters in grades 7-8, and from one year (physical or life science) to two years (one year of physical or earth science and one year of life science) in grades 9-12. These changes compounded an existing shortage of physical and earth science teachers and heightened awareness of the need for expanded pre-service and in-service science teacher training. The Wet Science Project will help meet these needs.

In 1989 the California State Department of Education adopted its new Science Framework which prescribes how science will be taught in the state beginning in 1992. The new framework differs from previous editions by emphasizing that science instruction will be based on major themes and encourage the use of hands-on instructional methods which involve students in scientific processes of inquiry. Interdisciplinary integration of the sciences is encouraged within each year's courses for grades 7-12. The Wet Science Project approach of training teachers to integrate physical, earth, life and social sciences using natural communities as themes and hands-on science instructional methods conforms to the state's objectives.

Another part of California's educational reform process is leading to various attempts to make the Middle School (including grades 7-8) a more gradual transition from the self-contained multiple subject classroom experience of Elementary School to the departmentalized classrooms experience of High School. One method being adopted by the second largest school district in our area to accomplish this transition involves placing students into "core" groups. Within his or her "core" an individual student would experience fewer peer group changes and fewer teacher changes than is the case in the current High School model used for grades 7-8. Since there is no plan to reduce the number of subjects students study, individual teachers may become responsible for teaching more than one subject in a quasi-self-contained core setting. Current California credential regulations permit any teacher with an Elementary School level teaching credential (Multiple Subject Credential) to teach all subjects when working in a classroom setting described as "self-contained." If districts are allowed to call core settings self-contained settings, it may result in

teachers with little or poor training in science being required to teach science. The Wet Science Project will attempt to identify these teachers and enhance their abilities.

Our experience (based on pre- and post-training assessments of teachers who participate in our programs and on reports from our active network of graduates) is that most local teachers

- are teaching outside their competence and training when called upon to teach introductory physical and earth sciences
- lack training in oceanography and marine biology
- are neither integrating the scientific disciplines nor science with other subjects such as technology, history and social studies in their courses and schools
- have not been exposed to strategies for effective science teaching in their pre-service training
- express interest in and report benefitting from opportunities to learn from peers and scientists and discover local resources for science education
- benefit most from summer institutes which have follow-up sessions and a requirement to deliver a district level in-service workshop.

In the local counties to be served by the Wet Science Project the student population is over 40% minority (largely Hispanic) and the teacher population is under 15% minorities (all groups). By focusing the project on the counties surrounding and inland from the Monterey Bay we will be meeting the needs of grade 7-12 teachers in areas of California not served by the state's eight California Science Project sites for science teacher and science program enhancement.

The Association of Monterey Bay Area Governments (AMBAG) projects that the lower income population groups living in the Salinas Valley of Monterey County will grow faster than the middle to upper income groups. We do not expect the number of paid visitors and income from publications sales at the Monterey Bay Aquarium to grow as fast as the need for school and teacher education programs in areas such as the Salinas Valley. Consequently, we are exploring sources of supplemental funding through additional fees, sales of publications and grants.

III. Rationale

The Wet Science Project will use the enormous appeal of marine science to overcome teachers' anxiety about science. The Wet Science Project approach makes science interesting and enjoyable. This approach will use current issues and everyday examples to make the content relevant: integrated with teachers' existing knowledge and more easily retained for application during teaching.

Our ecosystem, or natural communities emphasis will provide teachers with natural themes for organizing instruction. This will encourage them to view the world as integrated systems instead of isolated facts and subjects. Teachers will also learn how fragile

these communities are and how easily humans can disturb and/or manage their balance.

Teachers will work in teams to conduct scientific research and, through conversations with working scientists, discover science content and process together in a supportive environment. Participants will get to know some of the pleasures and pitfalls of scientific research. This direct experience will show them how to involve their students in basic science research projects. By engaging in the scientific process, teachers will construct their own meaning of concepts through direct experience rather than through abstract words. Because concrete experiences come before the concepts, learning and retention of accurate vocabulary, concepts and science content will be improved.

By discussing issues in science, technology and education, teachers will learn problem-solving, cooperation, critical thinking and communication. They will also gain confidence. Cross-grade groupings and interactions will enrich the experience.

Because participants will learn content and process, their skills will not only be transferable to any natural ecosystem, but will also be transferable to other science content areas. The whole scientific world will begin to open to teachers at all grade levels. They will become scientifically literate citizens, as well as better science teachers.

The Wet Science Project will use multimedia instruction to accommodate a variety of learning styles and to encourage teachers to use a variety of presentation styles. Training methods used during the Wet Science Project will model a variety of teaching methods including practice and feedback, coaching, describing and adapting. Teachers will learn to manage research-based methods with student groups in the classroom, lab and field.

Research on teaching methods indicates that the hands-on teaching methods that will be incorporated into the Wet Science Project work for students of all abilities and language proficiencies, including special-education and English-as-a-second-language students (Bredderman, 1982).

Teachers need follow-up support and district-based teams to succeed in integrating wet-science teaching methods into district science goals, curriculum and programs. The Wet Science Project will support teachers by working with districts to develop commitment; by offering on-going workshops, symposia and expeditions to update information and to boost teachers' skills, confidence and morale; and by acting as a catalyst for contact with established support groups, research institutions and professional organizations.

Blacks, Hispanics and women see few scientists as role models. By recruiting black, Hispanic and female teachers to the Wet Science Project, we hope to enhance their scientific knowledge, science teaching competence and confidence. Back in the classroom these

teachers will provide students with enthusiastic and competent science-literate role models.

IV. Plan

Through the Wet Science Project, teacher enhancement will occur on five levels. Each level allows teachers to follow a natural learning cycle -- from the concrete experiences of Levels 1 and 2 (participating in field studies and hands-on activities) to representational practice of Level 3 (developing curriculum and activities) to the application of learning in Level 4 (leading in-service workshops, serving as science resource teams). Level 5 makes the project available to other regions.

Level 1. Basic Wet Science Institute

Teachers of grades 7-12 will participate in a ten-day summer institute and three two-day follow-up sessions (a total of 16 days over one year). The Basic Wet Science Institute will introduce participants to natural communities as themes for teaching physical, earth and life sciences, literature, writing, art, history, economics, and science/technology/society issues.

Participants will visit major Monterey Bay ecosystems to learn science content; meet and work with scientists; conduct field research; learn to use a variety of scientific equipment and curriculum materials, including the California Science Framework and computers; develop grade-level curriculum with activities and teaching kits for in-service workshops they will conduct in their school districts; practice peer coaching and presentation skills; and develop wet-science teaching management skills.

What follows is a sample of the schedule for the summer Basic Wet Science Institute. This schedule excludes meals, breaks and travel time. Participants live on campus for the Institute. A typical day runs from 8 a.m. to 8 p.m. and involves approximately nine contact hours.

Day 1

Orientation: People, program, resources, the campus	Staff
Group Pre-assessment: An ecological approach	All
Discussion: Introduction to an ecological approach	"
Lecture: The history of the Monterey Bay Aquarium	Staff
Field Trip: Rocky shores	"
Group Pre-assessment: Rocky shores community	All
Lecture: Rocky shores habitat	Guest scientist

Questions/Answers All
 Closing Activities: Journals, problem solving, evaluation All

Day 2

Guided Discovery: Monterey Bay Habitat exhibits Staff
 Hands-on Activities: Physical oceanography "
 Demonstration: Sea otter feeding "
 Discussion: Photography and video skills "
 Group Pre-assessment: Oceanography All
 Lecture: Monterey Bay oceanography and climate Guest scientist
 Questions/Answers All
 Closing Activities: Journals, problem solving, evaluation All

Day 3

Guided Discovery: Physical oceanography exhibits Staff
 Group Pre-assessment: Marine plants All
 Lecture/Discussion: Marine plants Guest scientist
 Questions/Answers All
 Hands-on Activities: Marine plants "
 Group Pre-Assessment: Coastal wetlands All
 Lecture/Discussion: Elkhorn Slough habitats Guest scientist
 Questions/Answers All
 Discussion: Scientific research definitions Staff
 Orientation to field research sites "
 Activity: Sampling methods All
 Field research teams and planning Teams

Day 4

Field research trips: Moss Landing Marine Labs	Teams
Discussion: Student field trips	
"	
Research Teams meet, analyze data, plan reports	"
Closing Activities	All

Day 5

Guided Discovery: Kelp forest exhibits	Staff
Group Pre-Assessment: Kelp forests	All
Lecture/Discussion: Kelp forest community	Guest scientist
Questions/Answers	All
Demonstration: Kelp Forest Exhibit feeding	Staff
Teams work on research presentations	Teams
Hands-on Activities: Marine animals	All
Demonstration: Monterey Bay Exhibit feeding	Staff
Discussion: Collecting specimens	All
Field Research Team Reports and Peer Review	Teams

Day 6

Guided Discovery: Marine Science Education Resource Center	All
Hands-on Activities: Developing and using taxonomic keys	Staff
Hands-on Activity: Vertebrate and invertebrate dissection	"
Lecture/Demonstration: Creative Dramatics	"
Questions/Answers	All
Discussion: Hands-on, process-based science	Staff
Closing Activities	All

Day 7

Guided Discovery: Invertebrate exhibits	Staff	
Group Pre-Assessment: Evolution	All	
Lecture/Discussion: Evolution	Guest scientist	
Questions/Answers	All	
Activities: Evolution	"	
Discussion/Sharing: Marine science education resources		Teams

Day 8

Guided Discovery: Fishes exhibits		Staff
Discussion: Questioning strategies and learning styles	"	
Orientation: California State Science Framework	"	
Brainstorming: Marine science key ideas and activities	All	
Discussion: Applications of the ecological approach to designing curriculum and instruction	Staff	
Activity: Start developing district science curriculum		Teams

Day 9

Activity: Develop district science curriculum	Level 1 and Level 2 Teams
Demonstration: How to conduct an in-service workshop	Staff
Closing Activities and Evaluation	All

Day 10

Activity: Develop district science curriculum	Level 1 and Level 2 Teams
Discussion: Set-up schedules for completing curriculum development tasks	Level 1 and Level 2 Teams
Content Examination	All
Final Evaluations, final closing and check-out	All

During Days 9 and 10 graduates from Level 2 will work with teachers from their districts enrolled in Level 1 to develop a science curriculum model that they can implement and evaluate in their districts.

What follows is a sample of the Basic Wet Science Institute Follow-up Sessions. This schedule excludes meals, breaks and travel time. Participants live on campus for the Follow-up Sessions which begin at noon on Day 1 (usually Friday) and end at noon on Day 3 (usually Sunday).

Level 1 Follow-up I (in the fall)

Day 1

Activities: Geology	All
Lecture/Discussion: Monterey Bay geology	Guest scientist

Day 2

Field Activities: Sandy sea floor, mudflat, deep sea technology	All
Guided Discovery/Field Trip: Monterey Bay Aquarium Research Institute	Staff
Activity: Curriculum development updates	Teams
Activities: Resources and slide sharing; Schooling Fishsticks	All

Day 3

Activities: Deep sea oceanography and ecology	All	
Lecture/Discussion: Deep sea ecology and technology		Guest scientist
Activity: Curriculum unit development	Teams	
Discussion/Practice: In-service workshops	All	
Wrap-up and evaluation	All	

Level 1 Follow-up II (in the winter)

Day 1

Activity: Marine mammals and birds	All	
Discussion: Marine mammal and bird education resources		Staff

Day 2

Lecture/Discussion: Marine mammal communication and cognition	Guest scientist	
Guided Discovery/Field Trip: Long Marine Lab	"	
Field Trip: Fossils	Staff	
Field Trip: Birds	"	
Activity/Sharing: slides, resources	All	

Day 3

Discussion: Curriculum unit updates	Teams	
Wrap-up, evaluation, awards, Follow-up III assignments		All

Level 1 Follow-up III (in the spring)

Day 1

Activities: Energy conservation/Science process All

Day 2

Demonstration: Bat ray feeding Staff

Team Presentations: District curriculum and activities Teams

Field Exercises: Human impacts on Monterey Bay Staff

Guided Discovery: Hopkins Marine Station "

Guided Discovery: Cannery Row "

Guided Discovery: Monterey Bay Aquarium behind-the-scenes "

Team Presentations: District curriculum and activities Teams

Field Trip: Doc Ricketts Lab Staff

Lecture: A Backward Glance from China Point Guest historian

Day 3

Team Presentations: District curriculum and activities Teams

Content Exam All

Closing, evaluations All

Field Trip: Point Lobos State Park All (optional)

Level 2. Advanced Wet Science Institute

Basic Wet Science Institute graduates will be selected by their personal supervisors to apply to participate in a five-week summer institute at Stanford University's Hopkins Marine Station (adjacent to the aquarium) and four, two-day follow-up sessions (a total of 36 days within a year). Advanced Wet Science Institute participants enroll in the Hopkins advanced biology course: Introduction to Oceanic Biology.

Through the Hopkins course participants study the major characteristics of the ocean and the influences of geological processes, water chemistry, light penetration, currents, and tides on marine organisms. Field trips and laboratory work will emphasize the intriguing plants and animals of Monterey Bay's rocky tide pools, sandy beaches, giant kelp beds. A trip to Elkhorn Slough, to Año Nuevo to observe elephant seals, and a cruise to trawl for fishes and benthic invertebrates at the mouth of Monterey's submarine canyon will be included. Lectures will cover diverse topics dealing with the interrelationships of plants and animals in marine habitats and the functioning of the oceanic ecosystem. Bioluminescence, sharks, seabirds, whales, coral reefs, and mangrove forests will be discussed.

During this Institute participants will also learn and practice the application of the science process, curriculum development, management of student research, science education promotion, multidisciplinary team building, adult learning (for working with Level 1 participants and conducting in-service workshops) and analyzing the current status of their districts' science-education program. Level 2 participants will assist with the training of those in Level 1 by participating in Level 1 activity sessions and by coordinating district curriculum development teams.

Here is a sample of the schedule for the Advanced Wet Science Institute. This schedule excludes meals, breaks and travel time. Participants live on campus for three weekends during this Institute: the first weekend of the Institute to get acquainted, weekend two to plan for team meetings in August, and weekend four to learn how to analyze the status of their districts' science-education program. A typical day runs from 8 a.m. to 5 p.m. and involves approximately seven contact hours.

Week 1

Sunday

Orientation

Monday

Introduction to organic biology; Origin and history of the Earth and the oceans

Lecture: Origin and history of life in the sea

Tuesday

Orientation Field Trip, North Point, Hopkins Marine Station Reserve

Lecture: Geomorphology (continued)

Laboratory: Study of marine plants and animals; use of taxonomic keys

Wednesday

Lecture: Light and primary production in various habitats

Lecture: Ecology of hydrothermal vent systems

Field Trip: Collect shells on Agassiz Beach

Activity: Identification exercise

Lecture: Intertidal ecology; Zonation along the shore

Thursday

Lecture: Survey of marine plants

Field Trip: Intertidal algae

Laboratory: Identification of marine algae; Algal reproduction; Pressing marine algae

Friday

Lecture: Crustal dynamics; Sea floor spreading

Lecture: Plate tectonics and continental drift

Field Trip/Picnic Lunch: The geology of Carmel Point and Point Lobos

Week 2

Monday

Lecture: Coastal processes; Erosion and sand drift; Oceanic currents and waves

Lecture: Survey of marine invertebrates

Tuesday

Field Trip: Great Tide Pool

Lecture: Tides and tidal forces

Laboratory: Marine animals and plants of exposed rocky shores

Wednesday

Field Trip: Pescadero Point

Lecture: Chemical and physical nature of sea water

Laboratory: Animals and plants of rocky intertidal zone

Thursday

Field Trip: Monterey Harbor

Lecture: Ecology of harbors

Lecture: Ecology of mudflats

Laboratory: Marine animals and plants of harbors

Friday

Field Trip: Elkhorn Slough and Moss Landing Beach

Lecture: Symbiotic relations in marine organisms

Laboratory: Organisms of mudflats and sandy beaches Seminar

Saturday

Activity: Planning participation in Level 1 curriculum development
(see Level 1 schedule Days 9 and 10)

Week 3

Monday

Lecture: Feeding in marine animals

Lecture: Ecology of kelp beds

Boat Trip: Collecting animals and plants of kelp beds

Laboratory: Kelp bed organisms

Tuesday

Lecture: Water regulation and osmotic problems in marine organisms

Lecture: Color, color change and bioluminescence

Field Trip: Granite Canyon Laboratory Seminar

Wednesday

Lecture: Ecology of coral reefs

Lecture: Mangrove communities

Lecture: West Indian coral reefs

Thursday

Lecture: Marine ecosystems, food chains and food webs

Boat Trip: Monterey Marina and Harbor

Laboratory: Animals and plants of marine floats and wharf pilings

Friday

Lecture: Intertidal organisms; Meiofauna

Field Trip: Hopkins Marine Station Beaches for beach rack

Lecture: Reproduction in marine animals

Laboratory: Beach rack communities

Week 4

Monday

Lecture: Marine plankton

Lecture: Larval ecology

Boat Trip: Collecting plankton

Laboratory: Study of living plankton

Tuesday

Field Trip: Moss Landing; Cruise R/V Ricketts; Whalers into Elkhorn Slough

Laboratory: Examination of benthic organisms collected in otter trawl

Wednesday

Lecture: Marine bacteria and fungi

Seminar: Elephant seals

Laboratory: Culturing marine bacteria and fungi

Thursday

Field Trip: Año Nuevo elephant seal colony Seminar

Friday

Lecture: Biology of wood and stone borers

Lecture: Marine reptiles and birds

Saturday

Activity: District science system analysis training and planning

Week 5

Monday

Demonstration/Activity: Electron microscope techniques

Lecture: Larval jellyfish culture

Tuesday

Field Trip: Elkhorn Slough

Lecture: Marine birds and mammals

Wednesday

Field Trip: Monterey Bay Aquarium

Lecture/Demonstration: Monterey Bay Aquarium research

Lecture: Molecular genetics as a tool for studying life histories
of marine invertebrates

Seminar

Thursday

Lecture: Animal sounds in the sea

Lecture: Dangerous marine animals

Laboratory: Complete notebooks

Friday

Lecture: Exploiting marine resources

Study Period

Final Exam

Clean up and check out

Here is a sample of the Advanced Wet Science Institute Follow-up Sessions. This schedule excludes meals, breaks and travel time. Participants live on campus during these sessions.

Level 2 Follow-up I (in August)

Day 1

Activity: Develop district science curriculum

Level 1
and Level 2 Teams

Closing Activities

All

Day 2

Activity: Develop district science curriculum

Level 1 and
Level 2 Teams

Discussion: Set-up schedules for completing
curriculum development tasks

Teams

Evaluations, closing and check-out

All

Level 2 Follow-up II (in the fall)

Day 1

Discussion/Activity: Evaluate and revise the Advanced Wet Science Institute All

Day 2

Activity: Develop district support models All

Practice: Peer coaching and mentoring skills All

Level 2 Follow-up III (in the winter)

Day 1

Discussion/Practice: In-service leadership All

Activity: Develop district science curriculum Level 1 and
Level 2 Teams

Day 2

Discussion/Practice: Promoting science education All

Level 2 Follow-up IV (in the spring)

Day 1

Presentation: District science curriculum Level 1 and
Level 2 Teams

Day 2

Evaluation of Follow-up Sessions and curriculum development process All

Preparation: for Level 3 All

During the school year each Level 2 teacher on a district's team will be released for four days to work with other members of the team on projects related to the Wet Science Project.

Level 3. Wet Practicum

Selected graduates from Levels 1 and 2 will work in teams with project staff to transform their Institute experiences into classroom or field trip experiences for their students and colleagues. Teachers at Level 3 will develop curriculum, teaching kits and activities for use in the classroom and local field trip destinations including the Monterey Bay Aquarium. They will then field test and evaluate the kits and activities with classroom teachers and students. The final products will be effective lessons and materials Level 3 participants will take to their school districts and train other teachers to use. Level 3 participants over the course of a year will be funded by this project to work approximately 40 hours on their own time on a Wet Practicum project. Participants will be selected by application and represent as many participating schools as possible.

Schedule

Early August: Two members of the project staff will select three graduates of Level 2 from among applicants for Level 3.

Late August: The two project staff members and the three Level 2 graduates chosen will select:

1. six Level 1 graduates from among applicants
2. district curriculum and instructional needs to be met by the products which will be developed by Level 3 participants working in three person teams made up of one Level 2 graduate and two Level 1 graduates
3. in-service workshop dates for Level 3 teams to present the products to teachers in their districts

September: The participants will:

1. prepare audience descriptions
2. list:
 - key ideas
 - suggested themes to unify the ideas and products when used in classroom and in-service units
 - proposed products
 - supporting resources and materials
3. divide into three three-person teams which will each complete a separate Level 3 projects. Each team's project will be expected to:
 - meet Wet Science Project goals
 - produce several of the proposed products from 2 above
 - integrate the proposed products under one of the suggested themes from 2 above
 - fulfill the needs of the greatest number of participating districts
 - be attainable by a fair distribution of effort among

- the team's participants
- be completed by mid-January of the school year

October to February: Each team will:

1. design, critique, develop, pilot, evaluate, and produce a final draft of its project by January 20 of the school year
2. prepare a one hour in-service workshop segment to share their project with teachers from participating districts

March to April: Each team conducts at least one in-service training workshop for other teachers in team members' districts to:

1. demonstrate Level 3 projects
2. inform others about the Wet Science Project
3. encourage teachers to complete applications to be participants in the next summer's Level 1 institute.

Level 4. School District Infusion

The social ecology of a school district needs attention in order for teachers to succeed in incorporating wet science in their classrooms. This level of the Wet Science Project actively involves school administrators in institutionalizing and sustaining wet-science education in their districts. Level 1 and 2 participants will carry out Level 4 tasks with school and district administrators.

The Wet Science Project Director will be responsible for recruiting participating districts, communicating the goals of this project, and negotiating mutual expectations between the project, teacher participants and the districts. Selection of participating districts will be based on the school board's and administration's commitment to the Wet Science Project.

School administrators will show their leadership and on-going involvement in wet-science education in their schools and districts by:

- a. recruiting teachers for the Wet Science Project
- b. conducting, with Level 2 participants and project staff, a district science-education needs assessment and providing clerical staff support for the needs assessment
- c. participating in designing and implementing activities to address the needs defined in the district's science-education assessment
- d. providing release time funding for program participants to attend Level 1 and 2 Follow-up Sessions
- e. providing release time funding for program participants to develop and conduct district in-service workshops, coaching sessions or other science teaching enhancements that address the needs defined in the district's science education assessment
- f. providing release time funding (or stipends), materials, and public endorsement for in-service workshops given by Wet Science Project participants

- g. recognizing their district's Wet Science Team (e.g., press releases, recognition certificates).

Wet Science Institute-trained teachers will work with their school administrators to integrate wet science into district science goals, curricula and programs. Institute participants will serve as leaders and mentors in their districts sharing content, skills, resources, materials, enthusiasm and confidence with other teachers. Level 4 participants will also assist with the evaluation of the effectiveness Wet Science Project in the districts.

Level 5. Institution Diffusion

Wet Science Institute-trained teachers (Levels 1 and 2) and project staff will disseminate the wet-science teaching approach to other school districts and institutions such as zoos, aquariums, museums and nature centers through presentations at national conferences (i.e., American Association of Zoological Parks and Aquariums, Association of Science-Technology Centers, American Association of Museums, National Marine Educators Association), publication in journals and consultations.

Through a fellowship program supported by NSF funding, education staff from other institutions will be invited to participate as guest staff in Wet Science Institutes. This experience will prepare them to develop a Wet Science Project at their institutions.

V. Evaluation Plan

The Evaluation Plan for the Wet Science Project will include methods for formative evaluation at key points within the project (to determine potential problems, identify areas where the programs need improvement, test for participant progress in achievement or attitude) and for summative evaluation (to summarize the project's accomplishments and effectiveness).

A. Formative Evaluation

During the Wet Science Project we will continually strive to improve the program. We have designed into each of the five levels of this project time for pre-, during- and post-training assessments. We will use participants' self-reports, content examinations and project staff observations to determine how materials, procedures, activities and events might be improved. The results of the formative evaluation studies will be used to modify the components of this project from year to year, with all the major improvements implemented by the third and final year of the project.

B. Summative Evaluation

There are three treatment groups for the Wet Science Project: teachers of grades 7 through 12, school districts and other aquarium/zoo institutions. Through time series pre-tests, mid-tests and post-tests, we will determine the impact of the program during its three years of implementation. Time series tests will also allow us to measure changes without using control groups.

Observations, interviews and surveys conducted at school sites will allow us to gather information about the impact of the Wet Science Project on students in grades 7 through 12. We expect to see the following changes in each treatment group.

Participating teachers will:

- a. devote more time each week to science teaching
- b. include scientific processes in science lessons they develop. (Scientific processes include observing, asking questions, predicting answers, designing tests, collecting and analyzing data, and communicating conclusions.)
- c. provide their students with more hands-on, process-based science activities related to course content and the development of science process skills
- d. develop a science in-service teacher training model which includes hands-on experiences that promote science as a process that everyone can enjoy and benefit from
- e. lead at least one wet-science education in-service for a minimum of ten colleagues within a year of participating in a Wet Science Institute
- f. continue to expand their awareness and competence by attending at least one science or science-education in-service, workshop or seminar following their Basic Wet Science training
- g. demonstrate increased mastery of science content through pre- and post-tests
- h. demonstrate a personal commitment to habitat conservation (e.g., participate in a conservation organization or conservation effort in their community)
- i. express their enjoyment and confidence in teaching science.

We will collect data on some of the following indicators which we believe will indicate, although indirectly, a school district's commitment to wet-science education:

- a. the number of districts that complete a district science-education needs assessment
- b. increase in a district's inventory of science education resources (e.g. books, materials, resource centers)
- c. increase in the district's scores on California State science assessment instruments (California Assessment Program)
- d. increase in a district's science education promotion (e.g. press releases, funding proposals)
- e. increase in a district's release time funding for the development and conducting of district in-service workshops, coaching sessions or other science teaching enhancements that address needs defined in the science education assessment
- f. increased district teacher participation science education in-service workshops.

Other institutions (zoos, aquariums, oceanariums, museums, nature centers) will:

- a. attend a presentation on this model at a national conference (i.e., American Association of Zoological Parks and Aquariums, Association of Science-Technology Centers, American Association of Museums, National Marine Educators Association)

- b. send at least one education staff member to a Wet Science Project Institute to participate as guest staff through a fully funded fellowship program
- c. receive consultation from the aquarium's Teacher Programs Department staff on the Wet Science Project.

We have used evaluation instruments like those proposed in this Evaluation Plan successfully in other aquarium teacher programs, however we will have the Advisory Committee review evaluation instruments before implementation with this project.

The final evaluation report will contain the results of the formative and summative evaluations of the Wet Science Project.

VI. Plan for Documenting Project Activities to NSF

Print materials including schedules, handouts, correspondence with participants, contracts and reports produced will provide documentation of the Wet Science Project activities. These will be supplemented by videotapes of representative parts of programs. Copies of self-studies, planning documents and curriculum activities developed during the project for use in participating districts will also be available.

The Final Project Report will summarize descriptions of project activities, outcomes and impacts on teachers, peers, students, administrators and institutions. Project results will be disseminated through the outreach activities described in Level 5 of this project.

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AQUARIUM TEACHER TRAINING

by Deborah L. Gage

Linda Bates's third graders were surprised to find themselves locked out of their classroom, but shocked when Bates opened the door and they saw their room covered with trash.

"We're going on a trip to the beach," Bates told them. With the children squirming in their seats and trying furtively to pick up the mess, Bates talked about how it felt to go to an environment so littered that no one could enjoy it. The class discussed where garbage goes after it's thrown away and what happens when landfills run out of space.

Finally, Bates allowed the children to clean the room and sort the trash. "I took the recyclables home," she said, "and I left the other stuff for the garbage man."

Bates, a former English major who teaches in Butte County, was one of 28 participants in the Monterey Bay Aquarium's 1988 Habitats Institute. Since 1986, the program has taught elementary science teachers how to bring that subject into their classrooms.

"We call it wet science," said Teacher Programs Coordinator Jeffery Bryant. "It's the antithesis of dry science, which is taught from textbooks."

Teachers who participate are ahead of their colleagues, because they learn to teach science the way all California teachers will be expected to in four years. Program designers hope that trained teachers can help students conquer their deficiencies in science and math.

Kathleen Redmund leads a two-hour in-service workshop based on her original teaching activity developed as part of the course requirements.

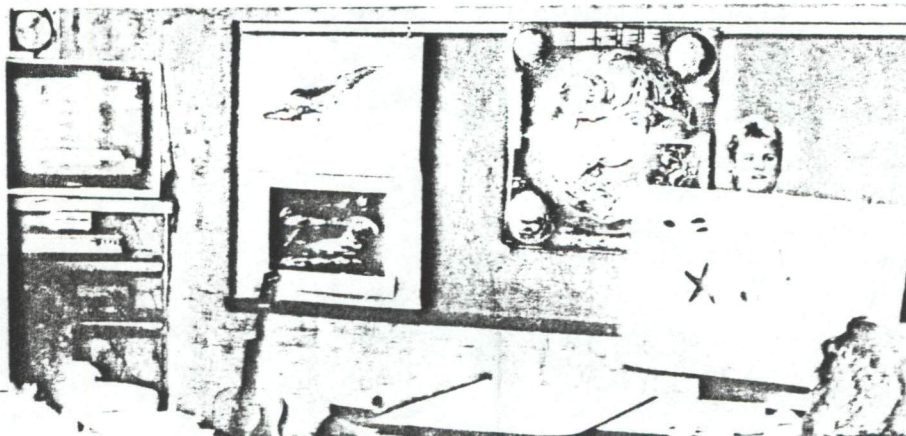
Recent studies by the National Science Foundation and the Educational Testing Service show that American elementary and secondary students know less math and science than both their peers of 20 years ago and students in other developed countries.

Teachers don't know as much as they should, either. Tom Sachse of the California Department of Education said only a third of California's elementary teachers have had coursework in life, earth and physical sciences, a standard set by the National Science Teachers Association.

Up to half of the state's middle and high school science and math teachers are teaching out of their fields, although a recent study shows that 92 percent feel comfortable teaching. (A chemistry teacher may be comfortable teaching physics). About four percent have emergency credentials, meaning they are unqualified to teach their subjects and have six months to acquire the necessary training.

"We need to get a lot better in California," said Sachse, the state's manager for math, science and environmental education. "With the amount of money and attention given to science education, I'm surprised the situation isn't worse. This shows the commitment of our teachers and principals. They've not had much support from the state."

The Monterey Bay Aquarium is one of the few private institutions in California to support science education. Sachse said that commitment makes a big difference to California's students, particularly those in Monterey County who have been underserved by the



Jeffery S. Bryant

state. (Each teacher who goes through the Habitats Institute costs the aquarium \$1,500 in direct expenses.)



Jeffery S. Bryant

Discovering interactions firsthand between physical, biological and human systems in the field increases teachers' comfort, confidence and competence as science teachers. Only a third of California's elementary teachers have had coursework in life, earth and physical sciences, a standard set by the National Science Teachers Association.

Offerings in 1989-90 include two Habitats Institutes, an expedition to Baja California, and a symposium on tropical rainforests. Teachers were introduced to all programs at a free open house on September 30.

Any teacher in the world may apply to the Habitats Institute, although most applicants come from California. Science teachers are asked to consider applying with a non-science teacher from the same school. Two to three times as many teachers apply as can be accepted; over half the participants have had virtually no science instruction since high school.

"We 'demystify' science," says Bryant. "Our highest objective is to increase teachers' comfort. They overcome their anxieties and identify themselves as scientists after listening to, talking to and working with scientists."

The institute encourages teachers to develop lesson plans using simple, readily available materials, so kids can learn scientific principles through their own senses. This is consistent with California's new state science framework, which takes effect in the fall of 1993.

Teachers will avoid having students memorize facts, and will instead teach curriculum organized around six major themes. (State Superintendent of Education Bill Honig has called the new framework "science for the many instead of the few.")

For example, Sachse said, under the theme "patterns of change and stability," students could study cycles from

kindergarten through high school. A young child might study bicycle wheels, learning to predict where a point on the wheel will be at a certain time. An older child could study the lifecycle of a salmon, the metamorphosis of an insect or the earth's air and water cycles.

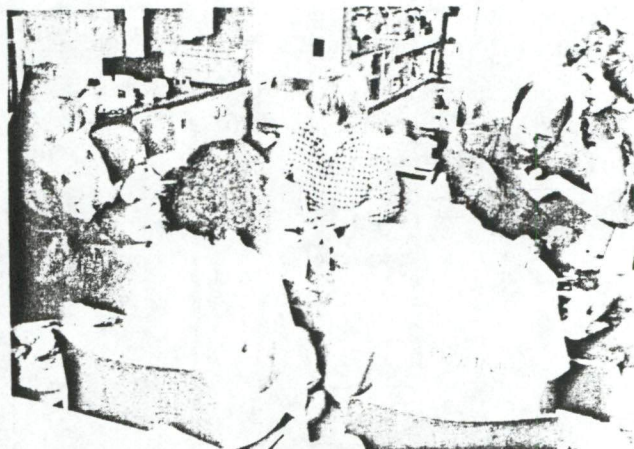
At the aquarium, teachers learn to see the world as a collection of habitats, a concept which elementary teachers can apply to areas other than science.

They also learn classroom activities which help students understand this idea. Field trips, with proper preparation, can teach students how different communities of plants and animals live and interact. Crank case oil poured in a pan with sand and water can teach the difficulties of cleaning up an oil spill.

"We've had a good response by our teachers to the Alaskan oil spill," Bryant said. "More traditional science educator programs package materials and then train teachers how to use them. But there's a difference in training for autonomy and training to use the product. People take responsibility for what they have a voice in shaping."

Teachers live in Monterey for one week in the summer and three weekends during the school year. They pay their travel costs and their districts must cover the costs of releasing them on three Fridays. All other costs, including room and board, are paid for with income from aquarium entrance fees.

Participants must create one original teaching activity and lead a two-hour inservice workshop for at least ten people. To do this they cram themselves with information on the region's history, geography, geology and ecology. The full resources of the aquarium are at their disposal, including the aquarium's sister institution, the Monterey Bay Aquarium Research Institute, which draws scientists from around the world.



Jeffery S. Bryant

The wet science engaging these teachers in the aquarium's institute is the antithesis of dry science, which is taught through lectures and textbooks.

During a typical day last August, teachers met at the tidepools for fieldwork at 6:00 a.m. After breakfast, they heard presentations by aquarium scientists on physical oceanography and the Monterey Bay's rocky shore habitat. After lunch, institute staff members led them through hands-on activities and experiments they could use in their classrooms. After dinner, they met again to review the day and write in their journals.

Even meals are eaten communally. "When teachers are living here and taking all their meals together, it forces them to stay focussed on the topic of the program," Bryant said. "Family life is not intruding."

Third grade teacher and aquarium docent Carolyn Cassell said participating in the institute has changed the way she teaches. "We were students, and they modeled the teaching technique of letting us discover the answers and not just telling us," Cassell said. "For so long there's been an attitude in teaching that 'I have the answers and I will provide them.' It seems obvious that if someone has to discover an answer, they'll remember it better and be more personally involved. They'll own the answer."

Cassell's third graders at Anderson School in San Jose studied marine science for the entire year. They spent a day at the aquarium in February, and did ocean related projects in art, literature, social studies and science. Six students and a parent volunteer used a computer to create an oceanography newspaper.

Linda Bate's littering of her classroom was Cassell's idea. "So many parents work 10 to 12 hours a day just to keep a roof over their heads and food on the table," she said.

"When they come home at night and their children ask them to save newspapers or cans or not to use plastic, they could care less, and rightly so. I wanted to emphasize to the children the importance of the environment. I wanted to make an impact on them."

Schools badly need teachers who can do this. Sachse said California's students are considered average in math and science, possibly below average in the physical sciences.

"For the state to be lingering like this is unacceptable," he said. "We have 12 percent of the nation's population and employ 20 percent of the nation's technological work force. We'll have to draw people from out of state to take the best jobs."

Bryant said a high school freshman enrolled in a science class is statistically more likely to go to jail than to earn a college science degree.

"Most high school teachers teach the way they were taught," he said. "College bound students succeed

very well because they can deal with words on a blackboard. Most kids can't."

Bryant believes the most successful projects to come out of the institute are simulations, where kids are put in real situations, assigned real jobs and told to solve real problems.

"The old fault in teaching science was not enough hands-on experiments," he said. "The new fault is jazzy activities without any development of independent thinking or problem-solving skills. We call our program 'hands on and heads on.'"

Evaluations by institute staff show the program to be successful. Graduates of the institute are more conscious of the environment than control teachers who have not participated. They provide more opportunity for hands-on learning and class discussion, integrate science into other curricular areas, and involve students in experimental methods of approaching problems.

Carolyn Cassell said her students are better able to look at a whole idea and see how all of the parts connect. She has added a category to her report cards: she now grades students' verbal abilities as well as their written work.



Jeffery S. Bryant

Katherine Mook illustrates that the institute puts the fun back in science. "We demystify science; our highest objective is to increase science teacher comfort."

"I have a child who's low in reading and math, but he can tell me the name of every fin on a fish and what it's used for," she said. "He can't get his work done during the day, but I've got to acknowledge his ability. He's capable of working at a high level if he's motivated."

Motivating students is also a problem for high school science teacher and institute graduate Paul Fischbein. He teaches at Prunedale's El Camino High School, a continuation school, and most students take his classes purely to fulfill graduation requirements.

"I have to find a way to make it personal to them," he said. "if I say, 'Today we're going to study oil spills, read these pages,' they'll say, 'No thanks. I've got better things to do.' But when I showed them that picture of the surfer in Santa Barbara who was covered with oil, that really grabbed them."

Fischbein's students studied the 1989 Alaskan oil spill and the 1969 Santa Barbara oil spill. Since the oldest student was born in 1970, Fischbein did research on Santa Barbara and provided articles and pictures.

Students tried to clean crank case oil from a pie pan with straw, cotton balls, nylons and a vacuum. ("Nothing would do it," he said). They had to make a decision for or against offshore oil drilling using facts they'd learned in class and write to the Secretary of the Interior.

Then Fischbein used ideas gathered from the elementary teachers he'd worked with to help students create projects showing their feelings on oil spills.

Several students drew cartoons: Exxon employees cleaning up Valdez with rags or running the "Exxon Oil Dumping Booth," three government officials hearing, seeing and speaking no evil.

One student wrote a poem eulogizing animals killed by the oil. "Not so much will live," the closing lines read, "Look what we've done."

And a student whom Fischbein said "didn't do squat" produced a picture of a man fishing and asking "Where's the fish?"

"I was so proud of him," Fischbein said, his voice catching. "To see the light bulbs go on, that's the greatest part of teaching."

Deborah L. Gage is a freelance education writer in San Jose, California, and volunteers in the public schools. Deborah became aware of the aquarium's program through her daughter's teacher who participated in one of the institutes.



DRY CREEK ELEMENTARY SCHOOL

8098 North Armstrong • Clovis, California 93612
(209) 299-2161

ANN LINDSEY
Principal

FLOYD B. BUCHANAN, Ed.D.
District Superintendent

January 23, 1990

To Whom It May Concern,

I would like to take this opportunity to express my heartfelt gratitude for the Monterey Bay Aquarium Teacher Institute Programs. I have been involved in the teacher institute and a teacher trip to Baja California. I strongly believe in continuation and extension of the aquarium's teacher education programs.

I feel very fortunate to have had the opportunity to participate in this outstanding program. I came into the program with virtually no science knowledge. Now Marine Science is the year-long theme of my instruction and the core of my curricula. In addition, my personal interest and involvement in marine science and our environment have dramatically heightened.

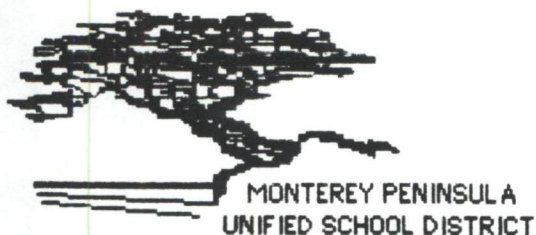
I am a mentor teacher and have enjoyed the opportunity to share my enthusiasm and knowledge of Marine Science Education with K-12 teachers throughout the district. I have also had the opportunity to present at several educational conferences.

I can not begin to express how impressed I have been with the organization of the institutes with which I have participated. The dedication, knowledge and professionalism of the many aquarium staff members that have contributed to these programs is both impressive and laudable.

I look forward to continuing my involvement and education with the aquarium and would love to see more opportunities for teachers in the future.

Sincerely,

Lauri Leone
Mentor teacher
Clovis Unifies School District



ROBERT B. DEWEESE
DIRECTOR OF CURRICULUM
AND STAFF DEVELOPMENT
MPUSD - IMC P.O. BOX 1031
MONTEREY, CALIF. 93942-1031
DAY: (408)899-7151 NIGHT: (408)372-2702

To whom it may concern:

As Director of Curriculum and Staff Development for the Monterey Schools, I have heard only two complaints about the teacher training programs offered by the Monterey Bay Aquarium -

- that our teachers wish there were more of them.
- that they wish the sessions didn't fill up so fast...it's hard to get their registrations in before it's too late.

As a former high school science teacher, I can attest to the high quality of content and process provided by MBA workshops.

As a former kindergarten teacher, I can testify that the MBA staff knows how to adapt their ideas to little learners and non-science teachers.

Training through the M B Aquarium doesn't end with the workshop. After they bring the teachers to the aquarium, they take the aquarium to the classroom. Aquaravans transport tidepools to teachers along with support people and materials.

In short, Monterey Bay Aquarium provides complete and comprehensive curriculum and staff development programs to schools throughout central California. If your organization is able to help in this effort, you couldn't make a better investment in our young people and our schools.

Yours truly,

Robert B. DeWeese

NATIONAL AQUARIUM IN BALTIMORE.



Pier 3
501 East Pratt Street
Baltimore, Maryland 21202
(301) 576-3800
(301) 576-8238 FAX - Aquarium
(301) 576-8641 FAX - Candler Building Offices

January 26, 1990

To Whom It May Concern:

The "Wet Science" program proposal looks very good. I am delighted to be able to comment on it. Because I was associated with Hopkins Marine Station while doing my Ph.D. at Stanford, I am familiar with both the area to be served by the proposal and with many of the staff who will do the work. Also, despite the distance between our institutions, the National Aquarium in Baltimore has a close relationship with the Monterey Bay Aquarium staff. Of particular value to me has been the MBA staff's help in dissemination of the aquatic science curriculum, Living in Water, through their teacher institutes. This demonstrates the spirit of cooperation and sharing typical of many marine educators. I have visited MBA on five occasions since its opening and talk Education staff members frequently at national meetings of organizations such as the National Marine Educators Association, the National Science Teachers Association, and the American Association of Zoological Parks and Aquariums.

There are a number of reasons why I think this program would be valuable. The first is the location. Monterey County and many of the other central California counties which would be served by these institutes are largely rural, agricultural areas with large Hispanic populations. In my experience, rural schools are the least well served school districts in science education. They are distant from academic centers, lack strong parent groups, have low tax bases, and may not have administrators who know how to get and use funds such as Title II effectively. Many of these counties are also custodians of the most unspoiled coastline and ocean in California. Anything that increases the understanding of the value and importance of the nearby marine environment in these counties is great.

I particularly like the concept of a long term relationship that Monterey builds into their courses by having weekend follow up sessions. The advanced course and practicum will further this relationship. Teachers benefit from this continued interaction. I believe that evaluation will prove that this program is successful and that it will be in large measure due to the personal interactions that take place among teachers, scientists and educators which is facilitated by repeated visits over time.

When I was a Stanford graduate student, Hopkins Marine Station had teacher institutes each summer. I got to know many of these teachers and remember how much they enjoyed the high quality academic experience they had. Some of the faculty that helped make those summers exciting are still at Hopkins, ready to work with another generation of teachers. Marine labs tend to be places where the social barriers between groups are non-existent, allowing the students (classroom teachers) and faculty outstanding opportunities for exchanges of ideas and information.

Valerie Chase

Valerie Chase, Ph.D.
Staff Biologist
National Aquarium in Baltimore



BOARD OF STUDIES IN EDUCATION
UNIVERSITY-SCHOOL RELATIONS

SANTA CRUZ, CALIFORNIA 95064

Tuesday, January 30, 1990

To Whom It May Concern:

I am pleased to express my support for the Monterey Bay Aquarium's proposed "Wet Science Project." This project will contribute substantially to the Aquarium's continuing program to strengthen science education in central California's school districts, particularly by supporting the efforts of the participating teachers and school districts to emphasize hands-on science.

This project's activities are very well-conceived relative to the needs and interests of the prospective participants, reflective of the Aquarium's extensive and successful experience with the region's K-12 educators, and responsive to national and state priorities for science education. In addition, by approaching science through an emphasis on this area's natural resources, this project will assist teachers in encouraging their students to understand and appreciate the presence of science in their familiar environment. This strategy has strong potentials for motivating students' interest in continuing studies of science.

The University of California, Santa Cruz has a long-standing and productive relationship with the Monterey Bay Aquarium in implementing science education programs. Several members of this campus' science faculty have worked closely with the Aquarium since it first commenced its programs, and will continue in that work. The Aquarium staff has consistently exemplified a commitment to collaborations between the public and private sectors in the meeting needs in science education. We anticipate broadening these relationships in the future, particularly in programs which address the educational needs of students in groups which typically are underrepresented in postsecondary studies of science and mathematics.

Sincerely,

A handwritten signature in dark ink, appearing to read "Thomas J. Karwin".

Thomas J. Karwin
Coordinator



MONTEREY BAY AQUARIUM®

886 Cannery Row Monterey, CA 93940-1085

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