Ecosystem Observations

Annual Report

for the Monterey Bay National Marine Sanctuary

1998

Monterey Bay
National Marine Sanctuary

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Welcome

to the first edition of what we hope to be an ongoing report of what WE as a community have learned and observed about the ecosystem protected by NOAA's Monterey Bay National Marine Sanctuary. We've titled it, *Ecosystem Observations.*

This Sanctuary has been in need of an annual report for some time, but we decided not simply to highlight our own accomplishments. Rather, this document, while including some classic annual report kinds of things, focuses on the natural resources, organized in a way that tracks the marine biological communities, habitats, and populations of Central California. We accomplished this by meeting another of our goals: to provide an opportunity for the "users" of the Sanctuary to present what they have discovered about its marine resources. By virtue of its many contributors, this annual report, our *Ecosystem Observations,* also stands as a tribute to the strong network of individuals and organizations who cooperate to protect and promote the Sanctuary's resources.

Please view this report as a "snapshot" rather than a thorough overview, and, for space reasons, we have had to omit background on some articles to focus on 1998 observations. Nonetheless, when you read this, you will see why I am proud both of the Sanctuary staff's accomplishments and the contributions of our partners.

Certainly 1998 - the International Year of the Ocean - has been a remarkable year. In March Sanctuary staff pitched in with the JASON Project, broadcast from the Monterey Bay Aquarium, adjacent kelp beds, and NOAA ships to two million school kids. In June we co-hosted, with the Navy, countless leaders in ocean policy, including the President, at the National Ocean Conference. The Monterey Bay National Marine Sanctuary was featured in many national publications - *National Geographic, Sunset, Time, Outside* - culminating in the Sanctuary being identified by *Audubon* magazine (Dec. 1998) as one of the top ten conservation successes, "paradises preserved," in the United States this century. Whoa.

What's up for next year? The Sustainable Seas Expeditions, a partnership between NOAA and the National Geographic Society, kick off the exploration of National Marine Sanctuaries in Monterey this spring. We hope to see the National Marine Sanctuaries Act, our enabling legislation, reauthorized this summer. As a human community, we hope to make further progress on our understanding of, and protection for, the marine ecosystem encompassed by the Monterey Bay National Marine Sanctuary. This annual report - these and future *Ecosystem Observations* - should help us mark that progress.

-WILLIAM J. DOUROS, Superintendent
NOAA's Monterey Bay National Marine Sanctuary

1998 Sanctuary Program Activities And Accomplishments

Established in 1992, the Monterey Bay National Marine Sanctuary is the largest of twelve Sanctuaries nationwide managed by the National Oceanic and Atmospheric Administration (NOAA). Encompassing over 5,300 square miles of water, the Sanctuary stretches along the Central California Coast from Marin County in the north to Cambria in the south. The Sanctuary contains many diverse ecosystems, ranging from rocky shores and kelp forests to the largest underwater canyons on the West Coast. These habitats abound with life. Huge blue whales forage in these waters for tiny plankton, while schools of sardines swim near jellies drifting with the currents.

Our mission is to protect the ecological and cultural integrity of the Sanctuary. To carry out this mission more effectively, we improved the organization of the Monterey Bay National Marine Sanctuary program by clearly defining four divisions in 1998: resource protection, education, research, and program support. Although these divisions work together on projects, each brings a particular focus. Following is a summary of the major accomplishments and activities within each division for 1998.

Resource Protection

The purpose of the Resource Protection Program is to develop and implement strategies to reduce human impacts to the Sanctuary. A significant accomplishment in 1998 was the completion of a recommended, comprehensive plan to address ongoing threats to the Sanctuary from potential spills of oil and other hazardous materials from commercial vessel traffic. With approximately 4,000 large vessels crossing the Sanctuary each year *(see chart, p. 25)*, preventing spills is recognized as a key issue, since a major spill would have a catastrophic effect on the region's seabirds, marine mammals, and fisheries.

Beginning in 1997 NOAA, represented by the Sanctuary, and the U.S. Coast Guard met with representatives from the shipping and petroleum industries, conservation organizations, other government agencies, and the public at large to evaluate ways of reducing the risk of groundings and collisions while sustaining the economic vitality of the shipping industry. In June of 1998 the group recommended a proposal, which includes modifying the port approaches to San Francisco Bay and the Santa Barbara Channel, moving container ships and bulk product carriers approximately ten miles further offshore, better organizing traffic patterns for all types of large vessels, and strengthening vessel monitoring and education.

Portions of the plan will be implemented during 1999, while other strategies requiring international approval will be presented to the International Maritime Organization of the United Nations. Completion of this plan represents a major step towards long-term protection of the Sanctuary.

Sanctuary staff responded to two oil spill events in 1998. In January, a tarball incident occurred off Point Reyes which killed or debilitated at least 600 marine birds, particularly Common Murres. Most of the birds washed ashore on beaches from Point Reyes National Seashore in the Gulf of the Farallones National Marine Sanctuary to beaches in the northern part of the Monterey Bay National Marine Sanctuary. The source of the oil remains unknown, but chemical fingerprinting of oil samples has eliminated the possibility that the tarballs came from natural seeps. The Sanctuary and several other government agencies are evaluating damages that occurred during the spill and the origin of the spill, and assessing the impact of the tarball incidents on Central California bird populations.

In September oil from a slick washed ashore along the San Mateo County coast. Responders recovered about thirty barrels at sea and about 9,000 pounds of oily tarballs from beaches from San Francisco to Santa Cruz County. Marine life was affected in both the Monterey Bay and Gulf of the Farallones Sanctuaries. Several hundred oiled birds (mostly Common Murres) were found, but it is estimated that hundreds more were lost at sea. Bird recovery and evaluation by several agencies, including the Sanctuaries, was paramount to the investigation and restoration of oiled wildlife. In cooperation with other government agencies, the U.S. Coast Guard investigated the cause of the spill, resulting in the U.S. Attorney's Office alleging that it came from the T/V *Command*. In December a federal grand jury delivered three indictments against the ship's owner, ANAX International Agencies, the vessel's captain, and the vessel's chief engineer for criminal violations of the Federal Clean Water Act. The vessel owners have not admitted guilt. The criminal case is being prosecuted by the U.S. Attorney's Office.

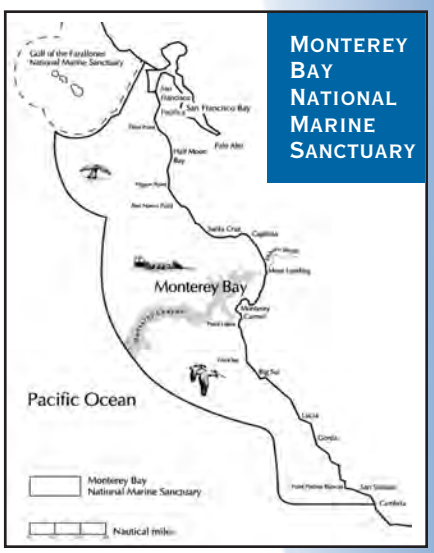
El Niño-driven storms in February tore up Highway 1 through Big Sur in over eighty locations. In past years, such a massive road repair project would have led CalTrans to rebuild the road by dumping rock, soil, and repair debris into the ocean, thereby violating the regulation prohibiting discharging into the Sanctuary. Working directly with CalTrans and other agencies, we crafted a repair program for Highway 1 which allowed CalTrans to clear landslides and repair washouts unabated, while avoiding any dumping in the Sanctuary. These efforts averted discharging a quarter to a half million cubic yards of material into the ocean, thus avoiding the loss of productive intertidal and subtidal habitat and possible impacts to commercial and recreational fishing. CalTrans conducted repairs in an environmentally sensitive manner without delaying the re-opening of a highway crucial to businesses in Big Sur and the Monterey Peninsula.

The agencies, public, and private groups who are members of the Sanctuary's Water Quality Protection Program (WQPP) continued addressing polluted runoff from agricultural sources in 1998. A draft plan for agriculture was completed which includes a commitment by the California Farm Bureau Federation and six regional Farm Bureaus to take a leadership role in addressing polluted runoff. The commitment was formalized in an agreement signed in November establishing the Central Coast Farm Bureau Coalition. The Coalition will focus on educating its members on polluted runoff, establishing landowner committees and pilot projects in several watersheds to strengthen on-farm management practices, developing grower self-monitoring to evaluate the effectiveness of the practices, and serving as a liaison with the WQPP and the Regional Water Quality Control Board (RWQCB).

Stan Wilson, NOAA

President Clinton dons our whale tail hat at the National Ocean Conference in June.

The Sanctuary's WQPP began implementing strategies identified in its urban runoff, marinas and boating, regional monitoring, and agricultural plans as well. A new project included installing and monitoring the effectiveness of stormwater filters in trapping oil, sediment, and trash from the paved areas at Monterey Harbor and Fisherman's Wharf. In cooperation with Save Our Shores, oil absorp-



tive pads were distributed and outreach conducted to boaters at the region's harbors. Two other projects were begun to install bilgewater and crankcase oil pumpout facilities at the harbors and conduct outreach to the fishing community.

The RWQCB has helped implement the WQPP's regional monitoring strategy. These monitoring efforts will be strengthened by a new grant to develop a coordinated citizen's water quality monitoring network for the Sanctuary (under the direction of the Center for Marine Conservation and the Coastal Watershed Council) and by a grant we received jointly with the San Mateo County Resource Conservation District to characterize and monitor sedimentation in the Pescadero watershed. Finally, several grants have been approved to implement agricultural strategies.

A Model Urban Runoff Program (MURP) was completed through the joint efforts of the cities of Monterey and Santa Cruz, the California Coastal Commission, the Sanctuary, and other groups. The MURP is a comprehensive how-to guide for small cities struggling to address the issue of urban runoff. Implementation is underway in Monterey and Santa Cruz, and many other cities have expressed interest in carrying it out.

KENTON PARKER

The Sanctuary's water quality efforts help protect wetlands essential to these Snowy Egrets and other animals.

Education and Outreach

The purpose of the Education and Outreach Program is to promote understanding and stewardship of the Monterey Bay National Marine Sanctuary. In 1998 we took a direct role in carrying out the Model Urban Runoff Program's educational and citizen monitoring elements. Sanctuary staff developed and distributed educational materials on ways the public and businesses can protect water quality, including a brochure and poster for local residents and posters for restaurants and auto repair shops. Additional outreach included use of a watershed runoff model for schools and public events which has provided a hands-on opportunity to "see" polluted runoff for thousands of local residents during 1998.

The first of its kind in California, the Urban Watch Stormdrain Monitoring Program (initiated by the Sanctuary, City of Monterey, and Coastal Watershed Council) serves as a model for other small cities. Data from the volunteers who monitored storm drains in 1997-1998 consistently showed high detergent levels along Cannery Row, resulting in an outreach effort to educate the restaurant community about urban runoff pollution and simple changes in cleaning practices that can reduce detergent outflow. Restaurants have been receptive to the effort and have provided valuable input for future educational efforts.

Sanctuary staff produced *Watersheds to Sea Shores*, a video on water quality issues featuring interviews with growers, ranchers, and watershed educators. The video showcases farmlands, coastal urbanized areas, sensitive rivers, and offshore habitats to illustrate the link between Central Coast watersheds and the Sanctuary. Designed for high schools, colleges, businesses, and the agricultural community, it has already won a first place recognition award at the 1998 Santa Cruz Environmental Film Festival.

In addition to education focused on water quality issues, staff was involved with many other outreach efforts. Volunteer fish enthusiasts helped to make the fifth annual Great American Fish Count a huge success. Over 100 new and returning fish counters attended training seminars in Santa Cruz, Pacific Grove, Cambria, and the San Francisco Bay area. Divers logged nearly 100 hours of bottom time counting eighty-one different species of fish at twenty different locations throughout the Sanctuary. Of the eighty-one species recorded, divers observed señorita wrasses on 78 percent of their dives, followed closely by the colorful bottom-dwelling painted greenling. Of the 127 surveys collected, sixty-eight were submitted by divers who counted fish along Cannery Row.

The Monterey Bay and Channel Islands Sanctuaries participated in the JASON Project during March. World-famous ocean explorer Dr. Robert Ballard (discoverer of the wreck of the RMS *Titanic*) founded the JASON Project, a year-round scientific expedition and distance learning program designed to excite and engage teachers and students in science and technology. For two weeks in March, "you-are-there" telecommunications transported millions of students worldwide live via satellite into the Monterey Bay National Marine Sanctuary. Students watched the expedition, interacted with Dr. Ballard and local scientists, and controlled live-feed video cameras, all from the Sanctuary and the Monterey Bay Aquarium. The two-week research voyage involved two teams of student "Argonauts" based in Monterey, who conducted their own research projects and reported back to students worldwide on the Internet. Much of the Argonauts' research comparing the surface, mid-level, and deep sea ocean environments of Monterey Bay and Bermuda was conducted aboard the R/V *McArthur*, a 175-foot NOAA research ship.

Sanctuary staff also participated in organizing the Oceans Fair, a huge community event celebrating our deep connection to the ocean. Held during the National Ocean Conference in June, the fair attracted more than 10,000 visitors to Monterey's Custom House Plaza. Visitors enjoyed spectacular marine technology exhibits, environmental

Sanctuary Awards

Sanctuary Reflections Awards

Presented at the 1998 *Sanctuary Currents* Symposium:

Special Recognition:
Karin Strasser Kauffmann

Public Official: Roy Torres

Conservation: Ellen Faurot-Daniels

Education: Milos Radakovich

Research: Mary Yoklavich

Organization: UC Sea Grant Program

Business: O'Neill

Ricketts Memorial Award:
George Somero, Hopkins Marine Station, Stanford University

NOAA's National Marine Sanctuaries Stars of the Sea Award and NOAA's Environmental Hero Award

Moss Landing Marine Laboratories

activity booths, continuous music and entertainment, and a flotilla of research ships including NOAA's R/V *David Starr Jordan*. At the Technology Pavilion, visitors could make a 3-D video flyby of the wreckage of the *Titanic*, take the controls of a NOAA robot sub working in Monterey Bay, explore the Bay in 3-D, and visit a virtual kelp forest created by the Naval Postgraduate School. Visitors could also see the *Deep Worker* submersible which Dr. Sylvia Earle will use in 1999 to explore the nation's twelve National Marine Sanctuaries, and view live video broadcasts from the Monterey Bay Aquarium Research Institute's remotely-operated vehicle deep in Monterey Bay.

Some of the ways in which we affect the ocean, and Monterey Bay in particular, were the subject of presentations by an impressive array of speakers at the 1998 *Sanctuary Currents* Symposium, held during March in Santa Cruz. Speakers discussed the impacts of vessel traffic, fisheries, ecotourism, coastal development, exotic species, toxic chemicals, and global warming. Visitors also viewed research posters highlighting scientific work underway around Monterey Bay and exhibits of Sanctuary-related conservation and education groups. In addition, participants honored individuals and organizations for their dedication to the Sanctuary *(see p. 3)*.


© Monterey Bay Aquarium

The Oceans Fair included educational displays.

Research

The purpose of the Research Program is to determine and fill scientific information gaps, develop collaborations to study resource management issues, and interpret research to decision-makers.

With over twenty research institutes, the broader Monterey Bay region is recognized world-wide as a center of excellence for marine science. To facilitate coordinated research throughout the Sanctuary, the Sanctuary's Research Activity Panel, consisting of representatives from all these institutions, met nine times this year. The results of collaborative research funded or organized by the Sanctuary Program and the Research Activity Panel are presented throughout this report: restoring Rhinoceros Auklet populations on Año Nuevo Island *(see p. 19)*, studying human disturbances in kelp forests *(see p. 7)*, monitoring birds and mammals on the water and dead on the beaches *(see pp. 20 - 21)*, and assessing coastal erosion *(see p. 5)*. Moreover, the Sanctuary staff organized cruises on the 175-ft. NOAA R/V *McArthur* to describe ocean currents and map essential fish habitats along the Big Sur Coast *(see pp. 7-8)*, map the continental shelf between Carmel and San Francisco *(see p. 11)*, assess oceanographic conditions of El Niño *(see pp. 11-12)*, and determine why the Sanctuary is a critical area for whales *(see p. 17)*.

The Sanctuary staff has also started using our aircraft to monitor seal and sea lion rookeries and kelp canopies, and more standard techniques to survey for the European green crab. This introduced species has now spread south from San Francisco, but has not become abundant in Elkhorn Slough, perhaps because it is within the sea otter range.

We're proud to have graduated a new class of Beach COMBERS volunteers to expand the beaches we can survey *(see p. 20)*. This group provided information critical to assessing the impacts of significant red tide events, and data that resulted in placing observers on fishing boats to assess mortality of birds and mammals in gill nets.

At long last a regional geographic information system (GIS) for mapping resource management information in a useful format was made available by our office. It includes masses of data on fisheries, water quality, shoreline physical and biological information, and even the pinniped haul-out data collected from our NOAA plane over the last year.

Program Support

As the name might imply, our Program Support team takes care of the tasks that are crucial to support our broad program mandates. We operated our patrol vessel, *SharkCat*, and our plane shared with the Channel Islands National Marine Sanctuary throughout the year. We moved our offices into a more productive and roomy space, still at 299 Foam Street. In January we welcomed our new Superintendent, which was no small task.

The Sanctuary Advisory Council (an appointed group of volunteers and agency representatives who provide diverse perspectives and expertise from an array of Sanctuary constituencies) met regularly in 1998 to assist staff in building short-term and long-term plans, receive information and concerns from stakeholders on current issues, and bring additional technical and other information to the Superintendent as requested. The Council played an active role in 1997-98 strategic planning, and has been asked for future assistance in addressing the National Marine Sanctuaries program's strategic initiatives: human activities assessment and threat reduction, zonal management, cultural resources, program reauthorization, water quality, and habitat characterization.

The Council also worked closely with its four Working Groups (Research, Education, Conservation, and Business and Tourism) to seek information and advice relating to the management of the Sanctuary's resources. Issues of concern in 1998 included a comprehensive Vessel Traffic Study, the impacts of kelp harvesting, the live fish fishery, finalization of the Jade Rule for collection of jade in limited areas of the Sanctuary, invasive species in vessel ballast water, and the Highway 1 Management Plan. Several of these are ongoing areas of concern which will receive additional attention during 1999. The Council will also play an expanded role in educating the public about the Sanctuary program and in fulfilling its liaison responsibilities between its constituencies and the Sanctuary staff.

In January a new Sanctuary website was unveiled with many added and advanced features, such as links to the Sanctuary's listservs and online databases. For instance, the Site Characterization, summarizing what is known about the ecosystems of the Sanctuary, was expanded to include a chapter on the open ocean. Our web page continues to be a source for timely information on Sanctuary activities.

Contributed Ecosystem Observations

Intertidal Systems

Surfgrass Beds Recover, Slowly

For over two decades, researchers from the University of California Santa Cruz (UCSC) have sampled an abandoned intertidal sewage outfall to document the ecological recovery there once the discharge was terminated. The most recent survey, completed in June 1998, indicates that the surfgrass beds have finally recovered. The recovery was slow and erratic over the years.

Twenty-five years ago domestic sewage was discharged onto the rocky intertidal on two sides of Monterey Bay. The Pacific Grove outfall at Point Pinos and the Santa Cruz County "Eastcliff" outfall at Soquel (Pleasure) Point both had been in operation for over twenty years. By the early 1970s they discharged daily 1.5 to 3 million gallons of primary treated sewage, respectively, over the wave-swept rocks. These sewage-impacted areas were characterized by classes taught at Stanford University's Hopkins Marine Station (the Point Pinos site) and UCSC (the Soquel site). The effect was similar at both: fishes, crustaceans, limpets, snails, sponges, ascidians, foliose red algae, and surfgrasses were conspicuously absent. In their place was a near-complete cover of diatoms and low-growing coralline algae, interspersed with clumps of sea lettuce, the red alga *Prionitis lanceolata*, deformed individuals of oar kelp, and large, solitary sea anemones.

Both outfalls were terminated in the mid-1970s when the sewage was redirected to longer outfalls discharging subtidally. Changes following termination were similar. Ephemeral green algae, especially sea lettuce, were conspicuous within months, to be replaced over the succeeding few years by a variety of foliose red algae and kelps, along with numerous invertebrates previously missing. Other species, such as sponges and ascidians, took much longer to become re-established. Particularly slow in becoming re-established were the visual dominants in these low intertidal areas, surfgrasses *(Phyllospadix scouleri and P. torreyi)*; their come-back was accompanied by the slow decimation of the low-growing coralline algae, the visual dominant of the sewage-impacted areas. From a distance, the areas slowly changed from pink (coralline algae) to green (surfgrasses) as they recovered.

Changes following the termination of the discharge at Soquel Point were documented by teams from UCSC, following sampling done the previous three years. Each spring the teams quantitatively sampled the Soquel Point site. A comparative site 1 km to the northeast at Opal Cliffs that showed little sign

Soquel Point

John Pearse

1982

1997

LIDAR Survey Shows Storm Damage Along Sanctuary

In the months of October 1997 and April 1998 scanning airborne laser (LIDAR) surveys were conducted jointly by the USGS, NASA, and NOAA along 1,200 km of the West Coast. The shoreline of the Sanctuary was a focus for one of the survey segments which collects high-resolution topographic information. The primary purpose of the investigation was to document beach and coastal bluff changes as a result of severe El Niño-induced winter storms. Highlights of the LIDAR investigations include documentation of: erosion of the dune/cliff system in southern Monterey Bay of up to 20 m, active bluff retreat along many segments of the Sanctuary shoreline, and dramatic changes in beach width and morphology during the course of the winter. Products from the study will include high-resolution maps depicting coastal topography in October 1997 and April 1998, along with a map showing change between the two survey dates. Further information can be viewed at the web site:

http://aol.wff.nasa.gov/aoltm/projects/beachmap/98results/

-Bruce M. Richmond
USGS Coastal and Marine Geology Program

of impact from the discharge was also sampled. Quarter-meter-square quadrats were placed randomly within permanent plots at each site and the abundance of species recorded. Abundance of surfgrass was estimated by counting the number of 10x10cm squares in the quarter-meter-square quadrats that contained attached plants (total number of squares in a quadrat = 25).

Nudibranchs inhabit the intertidal zone.

The abundance of surfgrass at Opal Cliffs remained high throughout the twenty-five years of sampling, with over half of the squares containing plants on most sampling dates. Considering the number and length of the surfgrass leaves (most over 30 cm long), this abundance means that there was nearly complete and uniform cover of surfgrass. In contrast, there was no surfgrass at all at the Soquel Point site when the sewage was being discharged. *(See figure 1 below.)* The first plants were noted in a few quadrats in 1980, four years after the discharge was stopped, but their abundance increased very slowly, mainly as the seedlings spread by clonal growth. The two sites were finally statistically indistinguishable with respect to surfgrass cover in 1997, twenty-one years after the outfall was abandoned, and a similar high abundance was found again in 1998.

Periodic examination of the abandoned outfall site at Point Pinos also revealed a slow recovery of the surfgrass beds, and they now appear nearly as fully recovered as at the Soquel Point site. The re-establishment of surfgrass was probably inhibited at both sites by the dense cover of low-growing coralline algae. At Soquel Point, where quantitative data are available, the abundance of coralline algae has slowly decreased from being present in all the 10 x 10 cm squares in 1976 and before to being present in slightly more than half in 1998, compared to fewer than 10 percent at the Opal Cliffs site. The two species apparently compete for space, and when well established, the coralline algae probably inhibit seedlings from getting established (the seedling may attach to the algal fronds, which then break off, carrying the seedlings with them). However, once securely attached on the underlying rock, the surfgrass rhizomes slowly grow outward, replacing the coralline algae and trapping sand, which further changes the habitat.

Surfgrass beds are rich, productive, and diverse systems. The twisted rhizomes and long leaves provide shelter and habitat for many animals, as does the thick layer of sand trapped by the rhizomes. Storm-detached leaves become litter that is scattered across the ocean floor and down into deeper water, providing resources for numerous detritivores and their predators far beyond the intertidal. It is reassuring that these surfgrass beds, decimated by sewage discharge, have now - after several decades - essentially recovered to their former health.

-John Pearse, Eric Danner, Lani Watson, and Chela Zabin
Institute of Marine Sciences,
University of California Santa Cruz

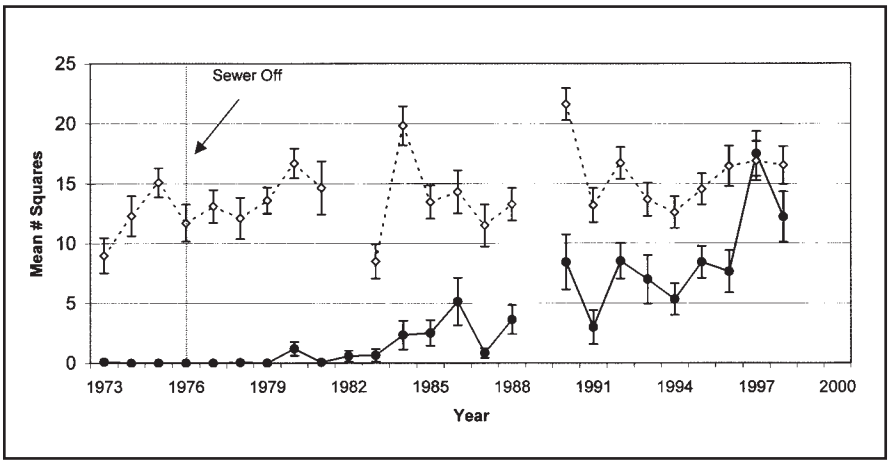


Figure 1: Changes in surfgrass abundance at Soquel Point (solid line), adjacent to the Santa Cruz County sewage outfall, and Opal Cliffs (dotted line), about 1 km northeast of the outfall. Sewage discharge was discontinued in 1976. Samples were taken each summer from 50 x 100' permanent plots; means +/- 95% confidence limits are shown.

Visitor Impacts at Fitzgerald Marine Reserve

Although the number of persons collecting invertebrates from the intertidal zone at Fitzgerald Marine Reserve has declined 94 percent from 1972 to 1996, annual visitor attendance has more than doubled - to 135,000 - during the same period. (Attendance for 1998 was lower - around 110,000 - because the Reserve's sign was destroyed in a traffic accident.)

Most visitation at the Reserve is concentrated in a 500-m length of rocky intertidal reef. Human impact has changed markedly during the 1972-1996 period, from the gathering of intertidal organisms for food and curios to trampling, rock rolling, and displacement.

To determine the extent of recovery from present-day visitor impact along a 350-m length of reef, two sites were selected at random in the mid-tide zones. One section of each site was cordoned off from public use and posted with signs in April 1994; to control for human impact, the second section at each site was given no special treatment. Five quadrats (one square meter each) in each of the four sections have been monitored on a monthly basis since April 1994.

Observations are made on faunal abundances and floral frequencies and dominances. Populations of some attached vertebrates such as the aggregated sea anemone (*Anthopleura elegantissima)* appear to be increasing in areas where visitors are excluded and decreasing in heavily-traveled areas. (Further data are in the process of being analyzed.)

-Bob Breen
Fitzgerald Marine Reserve

Research on Rockfishes, Habitats, and the Fishery at Big Creek Ecological Reserve

Big Creek Ecological Research Reserve (BCER), an area off the Big Sur coast that officially has been closed to fishing since January 1994, affords a good opportunity to evaluate the contribution that a small marine protected area (MPA) might make to the surrounding environment. The California Sea Grant College System, on behalf of the Department of Fish and Game's (DFG) Marine Ecological Reserves Research Program, currently has funded three studies to evaluate fisheries resources in this area. Two research studies are currently using side scan sonar, bathymetry, and underwater video transect methodologies in and out of BCER to characterize and quantify benthic fish and their habitats. A third study is using social science research methods to examine the relationship between nearby fisheries and the reserve and to evaluate a cooperative data collection system involving local fishers and the reserve manager.

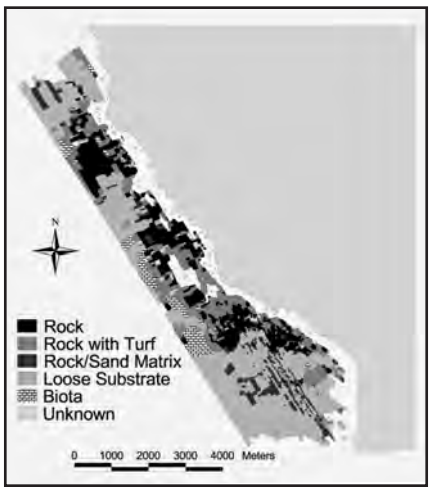


Figure 1: Substratum types of the BCER, as interpreted from acoustic data collected in May and June 1998. Gravel, sand, and rock-with-sand are represented by a single color. Isobaths are 4 m intervals.

During one of these studies, two cruises were conducted by biologists from the DFG's Central California Marine Sport Fish Project aboard the research vessel (R/V) *Mako* in 1998. Fish populations and seafloor habitats were surveyed using SCUBA and laser-scaled video. From preliminary analysis, mean fish densities within BCER, to the north, and to the south have remained generally stable from 1996 to 1998. Greater numbers of large sexually mature individuals occurred within BCER than in adjacent areas. A nearshore habitat map of seafloor within BCER *(Figure 1)* has been completed with cooperation from ABA Consultants. This map was produced from data collected with RoxAnn (an echosounder that indicates substratum roughness and hardness) and a depth sounder on board DFG vessels P/B *Bluefin* and R/V *Melanops.* Nine distinct substrate types (and percent coverage) have been identified: sand (23%); rock (20.3%); rock w/turf (20%); gravel (19.6%); rock w/sand (7.1%); biota (5.5%); sediment (4.2%); unknown (1.2%); compacted (<1%).

The second study involved the coordinated effort of biologists and geologists from NMFS Pacific Fisheries Environmental Lab, Moss

Figure 2: Rock outcrop with an assemblage of adult vermilion (Sebastes miniatus) and widow (Sebastes entomelas) rockfishes, as viewed from the occupied submersible in the vicinity of Big Creek Ecological Reserve. Note the extremely warm water temperature (9.9° C) at 169-m water depth. Two glowing laser dots, 20 cm apart, are visible in center of photograph.

Diver Disturbance in Kelp Forests

Recreational SCUBA diving activity has greatly increased in the past twenty years, with the potential for causing disturbance to subtidal reefs. While diver disturbance on coral reefs has been assessed in a number of studies, effects on kelp forests have not been previously examined.

Researchers from Moss Landing Marine Laboratories estimated diver disturbance in southern Monterey Bay giant kelp forests by following forty-two divers in summer 1997 and recording disturbances they caused. During a one-half hour dive, the average diver contacted the bottom forty-three times, touched four animals, and detached two algal blades. It is estimated that over 60,000 divers use these kelp forests every year.

The study's initial results, released in early 1998, suggest that the concentration of large numbers of divers in local, usually wave-protected kelp forests could lead to alterations in community structure. Such effects might be mitigated through more environmentally aware diving promotion, better training, and designation of ecologically resilient shore entry and exit points and underwater training areas. Of these recommendations, the Sanctuary is pursuing, with local and national dive organizations, the development of educational programs and products to ensure that diver effects within kelp forests are reasonably minimized.

-Tim M. Schaeffer and Michael S. Foster
Moss Landing Marine Laboratories

Kelp forests provide habitat for many marine species.

Landing Marine Labs, and DFG. Twenty-eight research dives were made in water depths from 30-270 m inside and outside BCER using the *Delta* occupied submersible and R/V *McGaw*. Habitat type and associated fishes were surveyed at about twelve sites in the BCER study area. Several distinct assemblages of fishes have been described in general. Large schools of young-of-the-year (YOY) rockfishes were documented in rock areas of 40-120 m depth; low relief fields of coarse sand and sea pens in about 70 m of water appeared to be a nursery ground for YOY stripetail rockfishes. Adult fishes of small species were associated with sand, fine sediments, and shell-hash substrata of low relief, while large species, especially rockfishes, were closely associated with rock crevices, small caves, and boulders/pinnacles *(Figure 2)*.

Bottom types included: rock outcrops primarily in 40-70 m of water; isolated rock pinnacles and single boulders up to 20 m in height and surrounded by sediment; steep rock walls in the head of submarine canyons outside BCER; fields of coarse sand and sea pens; boulder fields; and soft sediment in deep water. With funding from the MBNMS, maps from the deep water study have been developed and eventually will be merged with similar information from the shallow study into one comprehensive map of fishes and habitats of BCER.

In a third study, UC Santa Cruz researchers have conducted interviews with local fishers, collected observational and archival data on the relationship between the reserve and nearby fisheries, and begun to analyze fishery-dependent data collected by local fishers in cooperation with the reserve manager (through their "hook-and-line survey"). Preliminary analysis of shore-based observation of fishing activity north and south of the reserve and of Pacific Fisheries Information Network data suggests that fishing activity does not increase with proximity to the reserve, even though such an MPA "edge effect" might be expected. Data collected through interviews and from archival sources are being used to develop explanations for the observed patterns of activity. The hook-and-line survey data - which have been collected since three years prior to the reserve's legal establishment - together with interview data, are being used to evaluate the local fishery, its interaction with the reserve, and the potential value of the cooperative arrangement to resource management.

Results of these studies are important in the resource assessment and management of BCER, and will contribute to our understanding of the role that habitats within an MPA play in maintaining populations of marine fishes that are being harvested in unprotected areas. From a social scientific perspective, monitoring the fisheries adjacent to BCER will help us understand the dynamic relationship between MPAs and local fisheries. In particular, assessing the spatial and temporal patterns of both the fishes and fisheries associated with MPAs will contribute to effective design, management, and evaluation of MPAs. The results of all three studies will be especially valuable to the long-term characterization and monitoring of the natural and human resources of the Sanctuary.

-Mary Yoklavich
NMFS Pacific Fisheries Environmental Laboratory
-David VenTresca
California Department of Fish and Game
-Caroline Pomeroy
University of California Santa Cruz

Kelp Habitat

The rocky nearshore environment of the Monterey Bay National Marine Sanctuary is characterized by forests of giant kelp *(Macrocystis pyrifera)* and bull kelp *(Nereocystis leutkeana)* that occur on rocky substrates at depths of two to over thirty meters. These forests are host to a rich mosaic of benthic algae and provide habitat for numerous fish and invertebrate species.

Although giant kelp is perennial, in Central California its populations exhibit seasonal patterns of abundance, attaining maximum surface canopies in summer and minimum canopies in winter. Increased water motion from winter storms, coupled with entanglement with drifting plants, appears to be the primary source of annual giant kelp mortality along much of its distribution. During 1997 and 1998, several local research programs examined the effects of both natural and anthropogenic disturbances on Central California's kelp forest communities.

The 1997-98 El Niño event, one of the most severe in recent history, resulted in abnormally warm water and strong swell activity along much of California's coast. Whereas the majority (up to 100 percent in many areas) of the adult giant kelp occurring south of Point Conception was removed during this period, populations along Central California (including the Sanctuary) were relatively unaffected. The most dramatic reductions in kelp density in this region were observed along the Big Sur coast, where populations are less protected from the large ocean swells. In this region, although giant kelp densities remained fairly high, there appeared to be a shift in relative species abundance after the storms; giant kelp tended to decrease in abundance while bull kelp increased. A similar shift was observed after the 1982-1983 El Niño. The large disparity observed between southern and Central California was most likely due to large-scale oceanographic differences between the two regions. In southern California, unusually warm ocean temperatures and associated low nutrients probably resulted in the giant kelp being in generally poor condition when the large swells arrived, leading to extremely high kelp mortality. In contrast, the cooler ocean temperatures and higher nutrients along Central California may have allowed the kelp to remain in comparatively better condition when the swells arrived, resulting in much higher survival.

Other research programs around the Sanctuary have examined additional factors that may potentially impact its kelp forest communities. For example, Moss Landing Marine Laboratories researchers are examining the effects of commercial kelp harvesting on the giant kelp surface canopy along the Monterey Peninsula. Their study should elucidate the comparative effects of kelp removal by anthropogenic and natural processes.

-Matthew S. Edwards
University of California Santa Cruz

(Note: kelp as a harvested resource is discussed on page 22.)

Oceanographic Observations on the Sanctuary

The Year of the Ocean inaugurated an era of expanding research cooperation in the Monterey Bay National Marine Sanctuary. From partnerships forged between regional institutions to international collaborations, interdisciplinary investigations revealed details of the complex physical, chemical, and biological forces at work in the Sanctuary.

Researchers from the Naval Postgraduate School and Stennis Space Center used computer models to simulate water circulation in the Monterey Bay region and Monterey Canyon, which features some of the steepest undersea topography anywhere. Other scientists at the University of California Santa Cruz (UCSC) and the U.S. Geological Survey investigated the role of topography on the distribution and transport of sediments in the central region of the Sanctuary.

The 1997-98 El Niño event, now recognized as the strongest of the century, probably affected our Sanctuary ecosystems more than any other single natural phenomenon. Studies of that event contributed to our understanding of the biogeochemical effects of El Niño in coastal ecosystems. The California Current System, which dominates the circulation in the Sanctuary, normally conveys upwelled nutrients such as nitrate, phosphate, and silicate to the sunlit sea surface from late winter to early spring. At the surface, the nutrients support phytoplankton growth, also called primary production because it is the primary basis of most ocean food webs. UCSC scientists demonstrated that iron is key to this primary productivity, by adding iron to water samples from the California Current and measuring the resulting increase in phytoplankton production.

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Moorings gathered at sea are equipped with sensors that gather data on water chemistry, meteorological conditions, currents, and temperature.

Researchers from Moss Landing Marine Laboratories (MLML) and the Monterey Bay Aquarium Research Institute (MBARI) measured iron concentrations in Sanctuary waters during March of 1997 and 1998. Conditions in 1997 favored coastal upwelling: strong winds from the northwest pushed surface waters offshore and allowed deeper nutrient-rich water to upwell. The scientists measured high coastal concentrations of nutrients, iron, and chlorophyll from plankton blooms. However, early 1998 - the peak of the El Niño event - revealed very different conditions. Winds favorable to upwelling were rare; ocean surface waters were nearly 3° C warmer than in 1997; and very low levels of iron, nutrients, and chlorophyll were measured near the coast. The source of iron appears not to be coastal runoff, but rather, dissolved iron resuspended from sediments on the continental shelf and then upwelled into surface waters. This raises the possibility that primary production in water that upwells over narrow shelf regions (or further offshore at the shelf break and along jets and filaments) may be iron limited. Researchers at UCSC reported that primary production in water from the Point Sur region, where the shelf is particularly narrow, is iron limited.

During late 1997 and in 1998 when upwelling was greatly reduced, the extremely high ocean temperatures and extremely low levels of nutrients, chlorophyll, and primary production were the greatest anomalies ever recorded in MBARI's ten-year records on coastal water properties. Far from Monterey Bay, along the equator, water temperatures during mid-1998 changed from abnormally warm to abnormally cold. Researchers expect these conditions to spread to the Central California coast beginning in 1999, resulting in the resumption of periodic high levels of primary production in the Sanctuary's coastal waters. Associated with this high productivity we may see the recovery of typical fisheries of the region and the replenishment of marine food webs on which the fishes and many marine mammals depend. Also, there are some indications that the climate oscillation is shifting the Pacific from the warm phase that has prevailed since 1976 to a cold phase, which would enhance the return to more normal oceanographic conditions in Central California's coastal waters.

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The ROV Ventana, which can be outfitted with a variety of equipment depending on its mission, is launched from the R/V Point Lobos.

HARMFUL ALGAL BLOOM

The year marked the first recorded episode of marine mammal illness and mortality strongly linked to a documented bloom of *Pseudo-nitzschia australis* and associated toxic poisoning by domoic acid. During May 1998 a bloom of *P. australis*, a pennate diatom that produces domoic acid, occurred in the waters of the Sanctuary. Researchers detected the organism - using DNA-targeted molecular "probes" developed at MBARI - and tracked the bloom in near real-time as it spread. The toxic diatoms were found in plankton and in the stomachs of anchovies collected and dissected at the time of the bloom.

Coincident with the toxic algal bloom, sea lions suffered from a neurological disorder, now attributed to domoic-acid poisoning.

Marine mammal rescue agencies reported treating seventy stranded sea lions, forty-seven of which died. This may represent only a fraction of affected animals, as the victims were collected only from accessible beaches; large stretches of coastline were unmonitored and not all sick animals land on the beaches. Following the spread of the bloom in Monterey Bay, the National Marine Fisheries Service conducted surveys from Half Moon Bay south to Point Conception and detected more harmful organisms related to *P. australis*. In October a similar algal bloom occurred further offshore, and again a number of sea lions died from domoic-acid poisoning.

Midwater Explorations and Discoveries

Researchers continued extensive midwater video surveys using MBARI's remotely-operated vehicles (ROVs) during 1998. These systematic studies, conducted over the past five years, have deepened scientific understanding of both individual species and the mesopelagic community of Monterey Bay. MBARI's regular research missions in Sanctuary waters have provided opportunities to observe species and animal behaviors new to science. During the last year researchers discovered a half dozen undescribed varieties of larvaceans. These tadpole-like animals secrete filters of mucous that function to strain larger particles from their watery surroundings. A scientific description was published of *Mesochordaeus erythrocephalus*, the "red-headed" larvacean, which produces filtering structures up to the size of a basketball and typically populates waters 200-750 m deep. Midwater scientists also found an unusual new doliolid (a tunicate) and a pair of medusae, likewise suspected to be new to science.

Using ROVs to observe residents of the dimly-lit midwaters over hundreds of hours has allowed ecologists unprecedented glimpses into their characteristic behaviors. One such behavior, witnessed in a variety of mesopelagic animals - including certain marine worms, eelpout fishes, and "houseless" larvaceans - is a curling of their elongate bodies into a circular shape when threatened. MBARI ecologists hypothesize that this action represents protective mimicry, the imitation of an unpalatable animal for the sake of escaping predation. By assuming a curled profile, elongate animals resemble round gelatinous animals such as medusae, comb jellies, and salps, which make poor meals for active predators.

MBARI's investigations have also revealed new information about the abundance of the siphonophore *Nanomia bijuga*, the most commonly observed of all the gelatinous animals in the midwaters of Monterey Bay. This fragile animal, ranging up to about one-third of a meter in length, turns out to be one of the Bay's most important predators, feeding on krill and other zooplankton. Researchers determined that abundance of *N. bijuga* is cyclical, regularly occurring about three months after the onset of upwelling and the consequent surge in primary production.

Deep-Sea Experiments on Clathrate "Ice" Formation

The Sanctuary was also the setting for novel field experiments on the behavior of carbon dioxide (CO_2) in the deep ocean. During 1998 ROV-based experiments were conducted in part to evaluate the potential for

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An eelpout displays the curling behavior found to be common of midwater animals trying to avoid predators.

eventual disposing of fossil-fuel CO_2 in the ocean as a way of curtailing its increase in the atmosphere. MBARI chemists injected several liters of liquid CO_2 into a glass laboratory beaker on the Bay seafloor at a depth of 3,650 meters. At this depth liquid CO_2 becomes denser than seawater, so the researchers expected to see it form a stable pond with a thin "skin" separating it from the seawater, like a layer of ice on a winter lake. Instead, to the surprise of the scientists, who observed the experiment via the ROV's video camera, the CO_2 appeared to expand in volume, then overflowed the container in huge droplets that bounced to the seafloor and were carried away by the current. In fact the reaction between liquid CO_2 and water had produced large volumes of clathrate "ice," which sank to the bottom of the beaker and pushed the remaining liquid over the top. The chemists are working with biologists to conduct further experiments to determine whether the presence of CO_2 in this form has any measurable effects on deep-sea animals.

New Perspectives on Monterey Bay Seismicity

Researchers from MBARI, UCSC, the University of California Berkeley, Institut de Physique du Globe in Paris, and other institutions continued the first-ever ROV deployments of seismic instruments at five sites in various parts of the Monterey Bay seafloor. During 1998, the second year of this multi-year study, the sensitive, state-of-the-art sensors measured seismic waves for hundreds of earthquakes, both large and small, including many events not recorded by the permanent onshore seismic network. To complement the seafloor array, other instruments loaned to UCSC by the Incorporated Research Institutes for Seismology were installed at coastal sites around the Bay. The researchers used data from all these stations to locate seismic events more accurately than was previously possible from land measurements alone. These results have helped to derive a new model for the travel times of seismic waves beneath the Central California seafloor, which has led to a better understanding of the structure of the offshore faults and their associated earthquake mechanisms. Using this information and historic seismic data, the collaborators reanalyzed earthquakes from the past seventy-two years, uncovering strong evidence that all major earthquake activity in the Bay occurs along the San Gregorio and Monterey Bay faults.

Discoveries on the Deep Seafloor

In spring 1998 surveys along part of the continental margin in Central California's offshore waters were completed using a state-of-the-art multibeam sonar system.

In sonar images from the surveys, MBARI scientists saw what looked like areas of mineral deposits formed on the seafloor, possibly due to the seepage of sulfide- and methane-rich fluids. Using an ROV to investigate, researchers discovered at 2,310 m an underwater spring, or cold seep, they named "Tubeworm Slump." Like the other cold seeps in Monterey Bay, it supports an oasis of life in total darkness; in this location the prominent residents are vestimentiferan worms, cousins to the tubeworms of hydrothermal vents. Like hydrothermal-vent residents, most cold seep animals depend on chemosynthesis - the conversion of fluid chemicals into nutrients - rather than photosynthesis, which requires sunlight. Tubeworms had previously been found at only one other site in the canyon, and with lengths of up to one-half meter, Tubeworm Slump's worms are significantly larger than those previously observed. This was also the first discovery in the Bay of barite deposits. The researchers suspect that fluids rich in barium from the underlying, organic-rich Monterey Formation are flushed through the sediments, where they mix with seawater containing sulfate and then precipitate out as barite at the seafloor.

-Noreen Parks and Judith Connor
Monterey Bay Aquarium Research Institute

Seafloor Geologic Mapping

To help characterize the various benthic habitats of the Sanctuary continental shelf, a seafloor geologic map of the shelf is being produced from the interpretation of acoustic swath-map imagery collected since 1995 by the U.S. Geological Survey (USGS). In the northern Monterey Bay, 100 kHz and 59 kHz side-scan mapping systems that produce 0.4 m per pixel resolution have been used for this work, in addition to the collection of vertical acoustic profiles of the sediment section to depths of about 50 m. These data were collected using USGS's R/V *David Johnston* for the inner shelf and NOAA's R/V *McArthur* for the outer shelf. On the southern Monterey Bay shelf, two multibeam bathymetric surveys were carried out in 1996 and 1998 respectively, resulting in coverage of both acoustic backscatter (side-scan) and bathymetric data at the 2.5 and 5-m per pixel resolution, respectively. The multibeam bathymetric surveys employed the Simrad EM-1000 and EM-300 systems. Most of these images are now available on a web browser at http://TerraWeb.wr.usgs.gov/TRS/projects/MontereySonar/.

Interpretation of this seafloor imagery in terms of seafloor geology is now complete and comprises a layer in our GIS (geographic information system) for our Sanctuary project. The resulting maps (e.g., Figure 1) show that rock outcrops occur predominantly on the inner and outer shelves, whereas the mid-shelf is covered with recent sediment. Coastal areas that are uplifting, such as the coast around Santa Cruz, have rock outcrops at the seafloor that have been eroded by wave action in the surf zone. In contrast, coastal areas that are stable or subsiding, such as the central Monterey Bay around Moss Landing, have only recent sands and other sediment at the seafloor. Around the Monterey Peninsula the granites that constitute the structural backbone of the Peninsula crop out on the seafloor. Sedimentary rocks with distinctive acoustic signatures can be recognized and equated to the common rock formations around the Bay, principally the Monterey, the Santa Cruz Mudstone, and the Purisima Formations, from youngest to oldest respectively.

The Purisima Formation is the most common rock outcrop on the outer shelf and it forms ledges and hardgrounds for many benthic species that require a hard substrate. Outcrops on the outer shelf are most commonly the result of relatively more resistant cuestas of dipping rock strata that were probably eroded down to their present relief at times of lowered sea level, the last of which occurred prior to 15,000 years ago. The outcrops of the Purisima formation on the outer shelf south of Año Nuevo are populated with vast fields of Brachiopods (mollusk-like animals), based on video transects, and these presumably provide a major food source for fish and mammals of the area.

In addition to rock outcrops, coarse sand bodies are prominently outlined by the acoustic imagery and occur mostly in the 20- to 30-m depth range around the Bay. These sand bodies are in the form of shallow, 1-m deep troughs floored by coarse sands molded into one-meter length waves. Such sand troughs are most common in the offshore former Fort Ord area, and the deepest one occurs offshore of Seaside at a depth of 56 m.

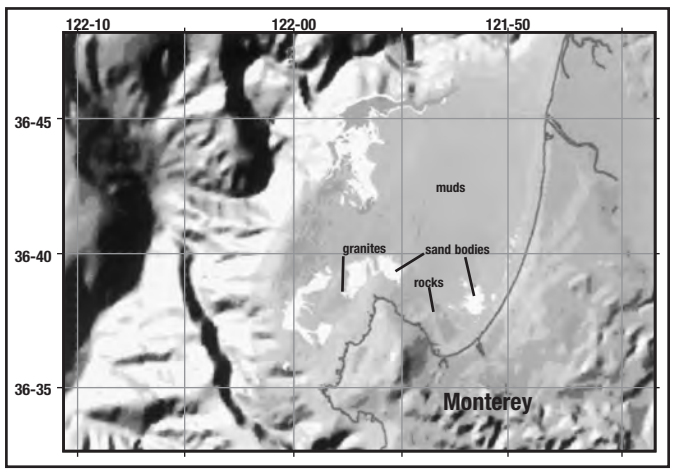

Figure 1: Portion of seafloor geologic map, here in gray-scale image, showing the southeastern Monterey Bay shelf.

The sand waves are successfully modeled as being produced by the oscillation of winter-storm-wave driven bottom water during times of the largest waves over the shelf.

The seafloor imagery and interpreted geology will be published along with other studies of the seafloor and water-column in a special volume of the journal *Marine Geology* in summer or fall 1999.

-STEPHEN L. EITTREIM
U.S. GEOLOGICAL SURVEY

Physical Oceanography in the Sanctuary

Through the efforts of the many marine science institutions around Monterey Bay, moored and remotely-sensed current observations, ship-based hydrographic sampling, and coastal modeling efforts have far exceeded those in most other parts of the country. Measurements, plans, and results related to physical oceanography in the Sanctuary during 1998 have been many. Some examples, drawn primarily from programs at the Naval Postgraduate School (NPS), Monterey Bay Aquarium Research Institute (MBARI), and the U.S. Geological Survey (USGS) are outlined in this section.

The USGS has deployed a moored current and temperature array on a line offshore of Davenport in water depths of 32 m, 70 m, and 120 m. Measurements span the last two years and include near-bottom currents and sediment data. During the first year, an additional mooring was deployed at a depth of about 60 m off Santa Cruz. Across the Davenport shelf, poleward currents dominate the mid-depth and near-bottom flows, even during spring/summer when surface winds and surface currents are predominantly equatorward. Results also suggest that suspended sediment transport on the shelf is mainly storm-driven and that Monterey Bay is the origin of the suspended sediments. In addition to the riverine sources entering Monterey Bay (north of the Monterey Canyon), coastal cliff erosion is likely to play a role. These

results, based on data from 1997, should be considered in the context of the El Niño conditions during that period. Observed temperatures show that the entire shelf down to a depth of 100 m was unusually warm, with temperatures of greater than 15° C at depths of 60 m in November and December 1997. During this time, unusually strong poleward currents throughout the water column of up to 40 cm per second were observed, particularly at mid-water depths. The currents shifted abruptly equatorward in early 1998 at the outer-shelf mooring. Near the end of February 1998, temperatures at depth on the shelf and sea level off Davenport dropped over a relatively short period of several days, during a time of both strong equatorward winds and currents at mid-water depths. The USGS efforts are summarized online at: http://walrus.wr.usgs.gov/docs/projects/mbms/.

A cooperative program between MBARI and NPS has been underway during 1997 and 1998 to monitor this critical El Niño period and the return to "normal" conditions. Fourteen hydrographic cruises crossing the Sanctuary along CalCOFI (California Cooperative Oceanic Fisheries Investigations) line 67 - a survey line that intersects the coast at Monterey Bay - have been carried out between January 1997 and November 1998 with five additional sections planned over the following year. A strong El Niño signal was clearly present in the subsurface temperatures from mid- to late 1997. Physical oceanographic conditions at the thermocline depths offshore returned to near normal by the time of the 1998 spring upwelling season.

-Jeffrey D. Paduan
Naval Postgraduate School

Wetlands and Watersheds

Elkhorn Slough

Elkhorn Slough is an arm of the sea extending seven miles inland at the apex of the Monterey Bay. Meandering through over 2,500 acres of salt marsh and mud flats, it is the second largest habitat of its kind remaining in California. Subject to the rise and fall of the tides each day and recipient of the surface water draining from 45,000 acres of watershed, this precious coastal resource is under increasing pressure from human activities. Numerous efforts are under way to understand the ecology of this region better and to modify our activities to minimize detrimental impacts.

The Elkhorn Slough Watershed Project, a collaborative effort of the Elkhorn Slough Foundation, the Resource Conservation District of Monterey County, the USDA - Natural Resources Conservation Service, and the Sanctuary, has been working closely with local farmers to prevent loss of topsoil. In addition to over 20,000 tons of soil that have been trapped in sediment basins installed on farms throughout the watershed, recent tests of sediment samples indicate that agricultural chemicals are also being successfully contained in these basins and prevented from working their way downstream into the Slough. A poignant event which illustrates the importance of this work occurred in 1995 when old pesticides buried in the sediments of the Pajaro and Salinas rivers were stirred up by the torrential rains and flooding, entered the food chain, and led to the collapse of a colony of Caspian Terns that was being closely monitored. The terns had been thriving on an island in a restored salt marsh on NOAA's Elkhorn Slough National Estuarine Research Reserve (ESNERR). Volunteers and researchers watched closely this year and terns were seen but did not attempt to nest.

On a more encouraging note, the Reserve is home to a growing rookery of Great Blue Herons and Great Egrets. Volunteers are also adding their powers of observation to assist scientists in monitoring this colony, which has grown from a single nesting pair of herons in 1985 to fifteen heron nests and thirty-eight egret nests in 1998. Several pairs of Double-crested Cormorants have added their nests to the Monterey Pine canopies of this rookery for the second year in a row. The Reserve has only recently been surveyed for the presence and reproductive activity of the California red-legged frog. Observations indicate several sites on the Reserve that are supporting a viable population of this threatened species. It is thought that small coastal drainages, like the Elkhorn Slough watershed, are the only remaining regions in California where the red-legged frog can still be found in significant numbers. This year's surveys indicate that this is one of only four localities in the state supporting populations of more than 350 individuals. The water quality of the fresh water ponds that are being used by the California red-legged frogs is now being monitored by volunteers to provide the data necessary for proper management of these habitats.

This is the tenth year of the Reserve's volunteer water quality monitoring program, a collaboration of ESNERR, the Elkhorn Slough Foundation, the Monterey County Water Resources Agency, and highly dedicated volunteers. Twenty-four sites throughout the

Mark Silberstein

Elkhorn Slough Reserve

Jim Harvey

Old pesticides stirred up by flooding in 1995 led to the collapse of a colony of Caspian Terns in Elkhorn Slough. (Adults and chicks shown here.)

watershed have been sampled monthly for temperature, salinity, dissolved oxygen, pH, turbidity, nitrate, ammonium, and dissolved inorganic phosphate. This is the only long-term data set on water quality in this region, and has been essential in documenting some of the highest inputs of nitrates into the Slough from the lower Salinas River and the old Salinas River Channel.

While work is being done to contain top soils in the uplands of the watershed, another type of erosion caused by the daily tidal currents is deepening the main channel of the Slough and contributing to the loss of salt marsh. Researchers continue to gather the information necessary to make decisions about which of several proposed hydrodynamic modifications will be the most effective in slowing this trend.

From oak woodlands to salt marsh, from sediment movement to nesting birds, collaborations of federal, state, and local agencies/organizations, scientists, and community volunteers are helping us to appreciate and manage this rich and sensitive coastal region better.

-Kenton Parker
Education Coordinator,
Elkhorn Slough National Estuarine Research Reserve

Water Quality Monitoring Programs

The Central Coast Regional Water Quality Control Board initiated several elements of its Central Coast Ambient Monitoring Program (CCAMP) in 1998. Development of a regional monitoring program was one of the key early recommendations of the Sanctuary's Water Quality Protection Program, and much of the effort in the past year was focused within the watersheds draining to the Sanctuary. Data were collected and/or analyzed from a Pajaro watershed monitoring project, a coastal estuaries sediment screening project, and the Bay Protection and Toxic Hot Spot Cleanup Program (BPTCP).

Watershed Characterization Monitoring

The Pajaro River was the target of a pilot effort for watershed monitoring. This was accomplished in collaboration with the Association of Monterey Bay Area Governments (AMBAG), with much laboratory analysis conducted by the California Department of Fish and Game and Granite Canyon Marine Laboratories. Data were collected for conventional water quality parameters (dissolved oxygen, pH, temperature, turbidity, coliform, nutrients) on a monthly basis at seventeen sites in the watershed. State Mussel Watch funds were used to place freshwater clams at a number of locations in the watershed to assess bioaccumulation. Samples were collected for sediment and water column chemistry (metals and organics), and sediment toxicity. Benthic invertebrate sampling was conducted at eight sites to assess instream ecological conditions. Data from the project are being analyzed and will be summarized in AMBAG's Pajaro Watershed Management Plan and CCAMP's Watershed Characterization Report.

Initial results show some very high concentrations of nutrients, coliform, and sediment at a number of sites in the watershed. At some sites high nutrient levels were accompanied by excessive algal growth and reductions in dissolved oxygen, indicating impairment of stream habitat. Llagas Creek consistently had the highest levels of nitrates in the watershed, with the lower Pajaro also quite elevated. Tres Pinos Creek and the San Benito River had very elevated levels of sediment, turbidity, and at times total phosphorus. Tequisquita Slough was particularly high in ammonia and orthophosphate, and low in dissolved oxygen. High levels of zinc, copper, and lead were found in water at two sites (on the San Benito and the Pajaro rivers). Benthic invertebrate assemblages showed a wide range of variability in species composition. Assemblages on lower Llagas and Salsipuedes creeks were particularly impaired.

A portion of the Pajaro River watershed, where the river meets the ocean.

Coastal Estuaries Monitoring

Unexpected laboratory funds allowed for a one-time sampling of sediment for metals and organic chemicals in each of the major coastal estuaries in Region 3 (extending from southern San Mateo County to northern Ventura County). The highest concentrations in the Region of some organochlorine pesticides were found in Watsonville and Tembladero sloughs. These included endosulphan, DDT, dieldrin, and gamma-BHC. High concentrations of mercury were found at the Santa Rosa Creek lagoon near the southern boundary of the Sanctuary.

Bay Protection and Toxic Cleanup Program

Sediment chemistry and toxicity data collected by this program, combined with bioaccumulation data collected by the State Mussel Watch Program, supported the listing of Moss Landing and its tributary watersheds as a high priority toxic hot spot through the BPTCP. The toxic hot spot cleanup plan for the area is being finalized and includes budgetary and remediation recommendations. Though the Bay Protection Program is scheduled to end in 1999, one of the final tasks of the program is to prepare a Statewide Consolidated Clean Up Plan which will include funding and implementation strategies.

Final reports for each of the three studies will be available in 1999. Also in 1999, the CCAMP will focus on characterization monitoring of the Salinas watershed. Major ocean dischargers from within the Sanctuary and elsewhere in the Region will be meeting with Regional Board staff early in 1999 to reexamine receiving water monitoring efforts. The goal of this process will be to make better use of resources, to detect impacts resulting from discharges more effectively, and to incorporate an ambient ocean monitoring component into the overall study design.

-Karen Worcester
Regional Water Quality Control Board

Sea Otters in the Sanctuary

An apparent decline in the California sea otter population which began in 1994 persists in 1998.

A large proportion (72 percent) of the California population of sea otters *(Enhydra lutris nereis)* is found within the boundaries of the Monterey Bay National Marine Sanctuary. Small populations of otters also exist at San Nicolas and San Miguel Islands off Southern California. For the past ten years, the mainland range has been well-established between Año Nuevo Island at the north end and Purisima Point at the south. Through the years, individual otters have occasionally been seen as far north as Bodega Bay. Within just the last year, otters also for several months occupied Cojo Bay to the south of the established range, in a group often numbering over 100 animals.

In 1911, otters were protected under the International Fur Seal Treaty from fur hunting. Additional protection was afforded via the federal Endangered Species Act (ESA), under which the species has been listed as "threatened" since 1977, and by the Marine Mammal Protection Act, where otters are listed as "depleted." With these protections, the population has slowly grown in size and range. However, the population remains small relative to historic levels, and is vulnerable to impacts from oil spills, point- and non-point water pollution, accidental capture in some types of fishing gear, and other human-related activities. Despite the ease with which sea otters can be observed and studied, the individual and collective role each real or potential impact can play remains difficult to isolate and quantify.

Reversing what had been a generally slow but positive growth trend, the California otter population began an apparent decline in 1994 that persists in 1998. *(See Figure 1.)*

Survey counts can fluctuate from year to year without providing proof that the population is actually declining. However, there has been an overall decline of 11 percent between the Spring 1995 and Spring 1998 counts, a downward trend that has persisted for three years and appears real. If this rate of decline continues, the California sea otter population may qualify for an "endangered" listing under the ESA as early as the year 2000.

Hand in hand with the decreased numbers from the surveys, and supporting the sense that the decline is indeed real, has been an increase in the number of dead otters recovered each year since around 1991 (shown in

Sea Otter Survey Data

Year	Spring Total	Spring Pups	Fall Total	Fall Pups	Pup Production Index	% Change Total Otters, Spring	%Change Total Otters, Fall	# Dead as Percent of Spring Count
1982	1346	222	1338	144	292			7.4
1983	1275	122	1226	164	214	-5.3	-8.4	9.2
1984	1304	123				2.3		10.1
1985	1360	236	1221	155	306	4.3		5.1
1986	1570	225	1204	113	285	15.4	-1.4	5.1
1987	1650	220	1369	108	267	5.1	13.7	5.6
1988	1724	219				4.5		5
1989	1856	285	1599	115	337	7.7		5.1
1990	1678	214	1636	120	281	-9.6	2.3	5.7
1991	1941	241	1661	138	309	15.7	1.5	3.9
1992	2101	291	1715	134	344	8.2	3.3	4.9
1993	2239	217	1805	143	288	6.6	5.2	5.5
1994	2359	283	1845	115	343	5.4	2.2	5.3
1995	2377	282	2190	137	331	0.8	18.7	6.6
1996	2278	315	2019	161	385	-4.2	-7.8	7.9
1997	2229	310	2205	197	378	-2.2	-0.7	6.8
1998	2114	159	1937	211	250	-5.2	-12.2	9.3

Figure 1: Survey data of sea otter population off California.

Sea Otter Research and Conservation Program

In a cooperative project headed by the Marine Wildlife Veterinary Care and Research Center in Santa Cruz and the Wildlife Health Center at the University of California at Davis, with assistance from the U.S. Geological Survey Biological Resources Division and the Monterey Bay Aquarium, thirty otters were captured from Monterey, Moss Landing, and Santa Cruz as part of an ongoing effort to assess the health status of the southern sea otter population. During a short holding period, project participants tagged the animals for identification purposes, and collected blood to monitor baseline hematological parameters and to test for the prevalence of *Brucella, Leptospira*, canine distemper, calicivirus, and *Coccidioides immitis* in free-ranging and rehabilitated southern sea otters.

Plans are underway by this same group to study behavior and causes of mortality in juvenile southern sea otters, to examine contaminant levels in sea otters and coastal invertebrate species, to monitor accidental drownings of sea otters that become entrapped in gear used for coastal fin-fish fisheries and gillnet fisheries in Monterey Bay, and to reinitiate field studies on basic behavioral and demographic parameters, all in an effort to understand and mitigate the causes of the current southern sea otter population decline better.

On another note: at least three boat-strike deaths occurred in Elkhorn Slough in 1998, including an otter successfully raised and reintroduced through the Aquarium's rehabilitation program. Another boat-strike victim, rescued from Monterey harbor, required orthopedic surgery to repair a broken ankle, but was eventually returned to the wild.

-Andrew B. Johnson
Monterey Bay Aquarium,
Sea Otter Research and Conservation Program

Endangered Species Snapshot:
Sanctuary Salmon and Steelhead Populations

- Warm ocean temperatures associated with El Niño harmed southern Coho salmon populations. Adults arriving in the fall and early winter, when the temperatures were highest, were most affected; because of the warm temperatures early females produced eggs with no nucleus. Even in March-April (with cooler water), where 80-90 percent fertility is common, fertility was in the 60-70 percent range.
- Very high winter and spring river flows destroyed both Coho food (aquatic insects) and their nests. The good news: in the summer the tremendous flows continued, so populations were in better shape, in that regard, than they've been in past drought years.
- Angling regulations changed significantly in 1998. The San Lorenzo River is now the only river where one can catch and keep steelhead; all others are "catch and release." In that river one can keep hatchery fish only. The Carmel River was opened for "catch and release" of steelhead in winter 1998 for the first time in ten years.
- Sea lions' fondness for salmon continued to create conflicts between sea lions and fishers. However, this year saw an increased cooperative effort between conservation groups, fishers, and scientists to address this issue.
- The California Department of Fish and Game allotted significant funds in 1998 to watershed restoration. (These include, by county: Marin - $40,881; San Francisco - $0; San Mateo - $136,684; Santa Cruz - $241,188; Monterey - $117,271; San Luis Obispo - $65,000.*) It also completed a draft restoration plan for Coho salmon in Santa Cruz and San Mateo Counties.

** These figures represent funds allocated by the end of the calendar year; additional 1998 funds will be distributed in 1999.*

-Jenny Carless
Editor

The California Brown Pelican is an example of an endangered species making a comeback.

Southern sea otter

Figure 1 as a proportion of total otters counted the previous spring).

Sources of mortality among otters range from the natural to the unexpected. The unexpected finding of the past few years, from studies by the National Wildlife Health Center, has been that infectious disease accounts for 40 percent of the sea otter deaths, a level five times higher than that typically seen in wild, free-ranging populations of other animals known to or studied by the Center. These diseases are encountered by otters in food or water; there is no known incidence of these diseases being communicable to other otters, other marine animals, or humans.

Some of these diseases may have been present in the otter population for decades but gone undetected until recently, when more exacting post-mortem examinations were made. In others cases, the presence of some diseases are apparent on even a gross examination of the dead otter, and changes in infection rates indicate a change within the otter environment or with an otter's physiological and immunological ability to ward off the infection.

Increased susceptibility to disease can be caused by the presence of environmental contaminants. Sea otters are exposed to various environmental contaminants through point- and non-point sources and through the nearshore food web, which includes many species of filter-feeding shellfish that concentrate contaminants before they are eaten by otters, seabirds, or humans. Our understanding of the role played by these contaminants is still astoundingly incomplete.

Our knowledge of the role played by nearshore fisheries is also still incomplete. Resource users - particularly those in commercial sea urchin and abalone shellfisheries - are watching closely to see how recent sea otter survey and mortality information affects sea otter population recovery and management decisions, and potentially, the livelihood and survival of key fisheries. Likewise, concerns over possible sea otter entrapment in fish and shellfish traps have grown over the past year, as has renewed awareness of possible continued entanglement in coastal gill nets. A clearer understanding of the impact of fisheries on sea otters, and of otters on fisheries, is critical to guiding future conservation management decisions. Other California coastal resource uses, such as oil extraction and transport, local kelp harvest activities, and human recreational activities, also contribute to possible impacts on otters and their habitat.

Sea otters serve as an "indicator" species of ecosystem change, and perhaps more telling, an indication of how well we can use our collective creative intelligence to resolve

issues of sea otter and nearshore ecosystem recovery, protection, and future management. The Sanctuary provides not only critical habitat to 70 percent of the population of this species, it will serve a catalytic role in addressing issues related to its health, recovery, and management.

-Ellen Faurot-Daniels
Energy, Ocean Resources, and Technical Services Div.,
California Coastal Commission

Right Whale Sighting

One of the world's most endangered baleen whales, the right whale, was sighted off the Big Sur coast in early 1998. For marine scientists and whale biologists, this particular event was extraordinary not only because of the rarity of such sightings, but because it was a unique observation of two different types of baleen whales interacting.

Sanctuary Superintendent Bill Douros and NOAA pilot Matt Pickett looked down from their plane during aerial surveys and saw a large black whale being chased by several gray whales. Douros estimates that there were twelve gray whales in an area of about a quarter square mile near the right whale, although only two were obviously interacting with the right whale.

The fifty-foot right whales were hunted to the brink of extinction near the turn of the century. They are very rare along the California coast.

Nineteenth century whaling records show that right whales were once abundant along all major continents in the temperate waters of the northern and southern hemispheres, although their numbers may have been much lower along the Central Coast. In the eastern North Pacific, they could once be seen from central Baja California to the Bering Sea in Alaska. Today, such sightings are few and very scattered. During the past fifteen years, only four verified sightings have been recorded in the eastern North Pacific, yet now three of these were within the boundaries of the Sanctuary.

Some experts estimate that as few as fifty to 100 right whales are left in the eastern North Pacific. *(Please see Spring 1998 newsletter for further details on this sighting and on right whales.)*

-Kip Evans
Monterey Bay National marine Sanctuary

Examples of Endangered and Threatened Species of the Monterey Bay National Marine Sanctuary

The Sanctuary is home to many endangered and threatened species. The Sanctuary's legislation works in concert with the Endangered Species Act (ESA) and other laws to protect the marine environment.

A species is listed as "endangered" if it is in danger of extinction throughout all or a significant portion of its range, or "threatened" if it is likely to become endangered in the foreseeable future. The chart below highlights some of the listed species found in the Sanctuary.

Organism	Federal Status	State Status
Cetaceans		
Blue whale *(Balaenoptera musculus)*	Endangered	None
Humpback whale *(Megaptera novaeangliae)*	Endangered	None
Fin whale *(Balaenoptera physalus)*	Endangered	None
Sperm whale *(Physeter macrocephalus)*	Endangered	None
Right whale *(Eubalaena glacialis)*	Endangered	None
Sei whale *(Balaenoptera borealis)*	Endangered	None
Pinnipeds		
Guadalupe fur seal *(Arctocephalus townsendi)*	Threatened	Threatened
Steller sea lion *(Eumetopias jubatus)*	Threatened	None
Birds		
California Brown Pelican *(Pelecanus occidentalis)*	Endangered	Endangered
California Least Tern *(Sterna antillarum browni)*	Endangered	Endangered
California Snowy Plover *(Charadrius alexandrinus nivosus)*	Species of Special Concern	Threatened
Marbled Murrelet *(Brachyramphus marmoratus)*	Threatened	Endangered
Fissiped		
Southern sea otter *(Enhydra lutris)*	Endangered	None
Turtles		
Green sea turtle *(Chelonia mydas)*	Threatened	None
Leatherback sea turtle *(Dermochelys coriacea)*	Endangered	None
Pacific ridley sea turtle *(Lepidochelys olivacea)*	Threatened	None
Loggerhead sea turtle *(Caretta caretta)*	Threatened	None
Anadromous Fishes		
Chinook salmon *(Oncorhynchus tshawytscha)* - spring	Candidate for Endangered Listing	Threatened
Chinook salmon *(Oncorhynchus tshawytscha)* - winter	Endangered	Endangered
Coho salmon *(Oncorhynchus kisutch)* - Central CA	Threatened	Endangered
Steelhead trout *(Oncorhynchus mykiss)*	Threatened	None

Compiled by Kip Evans, Monterey Bay National Marine Sanctuary

Endangered humpback whales are regular visitors to the Sanctuary.

El Niño, Krill, and Endangered Whales in the Sanctuary

There is widespread agreement among scientists that marine ecosystems are profoundly affected by global climatic events. In the Pacific Ocean, climatic events are natural phenomena, and they are known to cause changes in both the short-term (5-7 year El Niño events) and long-term (50-60 year cold-to-warm water regime shifts). For example, the 1982-83 El Niño event caused declines in nutrient upwelling, phytoplankton growth, zooplankton, and larval fish productivity; decreases in seabird and marine mammal abundance and reproduction; and abrupt declines in commercial fish landings in Monterey Bay. It is important to point out that these "natural" global climate events are probably our best opportunity to understand the impacts of human-caused global climate change such as global warming on the Monterey Bay National Marine Sanctuary's marine ecosystem.

The world's most productive fisheries and marine mammal foraging areas are located in coastal upwelling centers, and are responsible for approximately 95 percent of the annual global marine productivity. Monterey Bay is one such center where during the spring in normal years, northwest winds blow along the coast between Año Nuevo and Davenport. These winds bring cold, nutrient-rich water to the surface, which feeds an explosive growth of phytoplankton, providing the base of a food chain that ultimately leads to dependably high concentrations of feeding blue and humpback whales in the summer.

For the past three years we have been studying the impacts of the 1997-98 El Niño on the links between coastal upwelling, primary production, krill production, and the distribution and abundance of marine mammals and seabirds in the Sanctuary upwelling system. Our data prior to the 1997-98 El Niño event established that in normal years krill are the most abundant phytoplankton grazers in the Monterey Bay upwelling system. Most marine predators in the Bay (including humans) are only one or two links in the food chain away from krill, and krill is the primary prey of seven of the ten most important commercial fishes on the Central California coast. Because whales cannot eat phytoplankton directly, krill form a key food link for whales. Our research has shown that over 95 percent of the diet of endangered blue and fin whales consists of krill.

The recent 1997-98 El Niño event provided us with the opportunity to understand how short-term climate change affects the upwelling ecosystem of the Monterey Bay.

Preliminary analyses have shown us:

- The recent El Niño event led to remarkable declines in coastal upwelling, phytoplankton growth, and krill abundance in Monterey Bay. This is consistent with what has been seen in past El Niño events.
- Paradoxically, whale populations in Monterey Bay during the summer of 1998 were the highest we have ever recorded.

What could account for this? During "normal" years a large proportion of the whale population feeds on scattered schools of krill many miles offshore on the edge of the California Current. Dr. Francisco Chavez at the Monterey Bay Aquarium Research Institute has indicated that during this recent El Niño event, offshore productivity was very low, and these offshore krill swarms likely didn't develop. We believe that the bulk of the whale population moved into the coastal upwelling zone in search of what little krill was available - these centers became the only food source available. An additional observation supports this hypothesis: more fin whales were spotted in the Bay in the summer of 1998 than had ever been seen before. Normally, fin whales do most of their foraging offshore. This species, too, likely came in search of krill.

A blue whale diving for krill.

Our studies of the 1997-98 El Niño event have served to underline the importance of coastal upwelling centers such as Monterey Bay to marine productivity. Hopefully in the not too distant future we can use our studies to help predict the effects of global warming on productivity in the Monterey Bay.

-DONALD A. CROLL[1], BALDO MARINOVIC[1], SCOTT BENSON[2]
[1]UNIVERSITY OF CALIFORNIA SANTA CRUZ
[2]MOSS LANDING MARINE LABORATORIES

ELEPHANT SEAL POPULATIONS

PIEDRAS BLANCAS:

Year	Births*	High Count**
1998:	1,650	5,000
1997:	1,200	5,000

** approximate number of births*
*** high count occurs during the spring molt, and consists primarily of juveniles and adult females (approximate number)*

-Unpublished data, provided by Brian Hatfield, USGS, Piedras Blancas Field Station

AÑO NUEVO:

Year	Births*	High Count**
1998:	2,797	4,588
1997:	2,684	5,358

** estimated production (95% of all females)*
*** high counts occurred in April of 1998 and February of 1997*
-Data provided by Pat Morris and Guy Oliver, University of California Santa Cruz

GRAY WHALE CALF CENSUS DATA*

Year	Calves	Est. % of total pop.
1998**	1,316	
1997	1,439	6.5
1996	1,141	5.1
1995	601	2.6
1994	1,000	4.5

**Preliminary results; data gathered from shore-based sighting surveys of northbound migrating gray whale calves passing Piedras Blancas.*

***Estimate*

Please note: these results are preliminary and still unpublished; they are not to be cited without the permission of the author.

-PROVIDED BY WAYNE PERRYMAN
SOUTHWEST FISHERIES SCIENCE CENTER

Pinniped Research

The Sanctuary has one of the most diverse pinniped communities in the world. Researchers continue to study their population dynamics, foraging behavior, and physiology. Most relevant this year is the response of Sanctuary pinnipeds to the profound El Niño event that occurred earlier in the year.

All California breeding colonies of elephant seals are protected by National Marine Sanctuaries. A young male is shown here.

California sea lion, *Zalophus californianus.* California sea lions are the most common pinnipeds in the Sanctuary, and their numbers continue to increase. Possibly in response to El Niño, we observed more sea lions (3,000-8,000) at Año Nuevo Island than ever before. We also observed a dramatic increase in the number of pups born there. Typically, a small number are born every year (about twelve), but this year there were at least 160 pups, eighty of which were alive several weeks after birth.

Northern sea lion, *Eumatopias jubatus.* Año Nuevo Island is the southern limit of this species' breeding range. The population has been in decline over most of its range. During July the National Marine Fisheries Service conducted an aerial survey of the Island and counted forty-two adult males, 137 adult females and/or juveniles, and 186 pups. These data indicate a continuing decline in pup production of about 6 percent a year (209 pups in 1997). At least six adult female sea lions were observed with salmon flashers (attractants attached to fishing hooks) hanging from their mouths.

Harbor seal, *Phoca vitulina.* Work by Moss Landing Marine Laboratories (MLML) researchers on the foraging behavior and population dynamics indicates that the local population is healthy and growing steadily, with a large increase in the number of seals and pups using Elkhorn Slough. Seals from throughout the Sanctuary appear to forage offshore at the edges of the Monterey canyon breaks, and have an extremely diverse diet, consisting mainly of non-commercial prey species. Investigators from UCSC, the Monterey Bay Aquarium Research Institute, and MLML, using acoustic tracking, underwater video, and molecular DNA techniques, have demonstrated behavioral and acoustic differences between seals in Monterey and Elkhorn Slough, and have also revealed that animals move between these areas. Research has revealed that although young pups can dive at birth they are not physiologically mature until at least one year of age. This past year many of the pups born were underweight and still had their neonatal pelage, which suggests that younger age classes were negatively impacted by the El Niño event. Aerial survey and tracking work has indicated that once weaned, pups are highly mobile and can move out of the Sanctuary.

Northern elephant seal, *Mirounga angustirostris.* UCSC researchers have shown that females forage across a wide area of the northeastern Pacific, from Central California to Alaska and west five degrees across the International Date Line, diving nearly continuously to mean depths in the range of 400-700 m. Given their deep diving and spatial distribution, we would expect El Niño events to have less impact on northern elephant seals than other more coastal pinnipeds. We tested the response of elephant seals to the 1998 El Niño by deploying a combination of ARGOS-linked satellite tags and time-depth recorders. During 1998 rates of mass gain were the lowest ever measured (0.29 ± 0.36 kg/day), with one female losing mass at a rate of 0.44 kg/day. In both the 1982-83 and 1997-98 El Niño events, female seals appeared to compensate for low foraging success by increasing trip duration. In 1998, females spent more time at sea, but they went to the same general locations. However, the diving depths and the patterning of the dives were different (Figure 1). This demonstrates the strong effect of the 1998 El Niño event on the foraging behavior of elephant seals. We also studied the impact of the 1998 El Niño event on elephant seals during the breeding season. Births in 1998 (2,893) were similar to those of other years; however, pup mortality on the Island was the third highest ever measured, due to the high storm surf that accompanied El Niño.

-Daniel P. Costa, Dan Crocker, Pat Morris, Jen Burns, and Burney LeBoeuf
University of California Santa Cruz

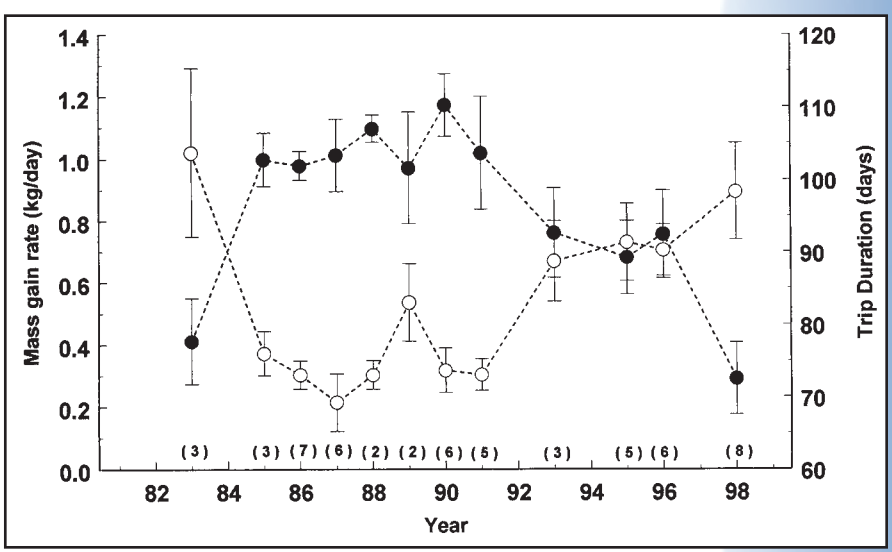

Figure 1: This shows the annual rate of mass gained by females over a foraging trip and the length of the post-lactation foraging trip. Notice the two El Niño years had the longest trip durations and the lowest mass gain. ●: mass gain rate; ○: trip durations.

Seabirds and El Niño

Because this most recent El Niño event was forecast well in advance of its spread to temperate northern Pacific realms, biologists had a chance to prepare specific studies for assessment of ecosystem response to changing marine conditions. Researchers studying marine birds in the central and southern portions of the California Current marine ecosystem knew from previous El Niños and other basin-scale events that birds can serve as stand-ins for more difficult-to-study marine organisms, and that certain reproductive and population parameters can be used as timely bio-indicators of both physical and biological oceanographic change. Partners for these investigations in the Central California region included: NOAA/Environmental Research Laboratory, U.S. Fish and Wildlife Service/San Francisco Bay National Wildlife Refuge, National Park Service/Channel Islands National Park, National Fish and Wildlife Foundation, and Friends of Point Reyes Bird Observatory.

In Central California, we studied the response of seabirds to El Niño at Southeast Farallon (SEFI) and Año Nuevo islands (ANI). ANI is home to the Rhinoceros Auklet, a relative of puffins, and a species which nests in underground burrows and approaches the colony only under the protective cloak of darkness. SEFI is located about 90 km north of ANI, beyond the boundaries of the Monterey Bay National Marine Sanctuary. This colony supports core populations of Brandt's and Pelagic Cormorants, Western Gulls, Common Murres, Cassin's Auklets, and Pigeon Guillemots in Central California. During the non-breeding season, individuals disperse to the north and south, thus bringing SEFI birds into the Monterey Bay region.

While seabird breeding at these sites in 1997 was relatively unaffected by El Niño, it was apparent early on that things would be different in 1998. (*See Figure 1 for examples.*) From March to June, mean sea surface temperatures at SEFI were 1 - 2.5° C higher than long-term (27-year) averages. By July and August, however, temperatures had dropped to average values. Warmer than normal winter and spring ocean temperatures, and the corresponding drop in ocean productivity (i.e., prey for birds) resulted in moderate to substantial delays in egg-laying. For example, the mean Common Murre and Cassin's Auklet egg-laying dates were delayed by two and eight weeks, respectively. Breeding populations were also much reduced. Again, considering the murre and auklet: the SEFI murre population was about 20 percent lower than in 1997, while the auklet population was almost 65 percent smaller. Similarly, numbers of breeding Pigeon Guillemot declined by over 75 percent, Brandt's Cormorant by about 35 percent, and Pelagic Cormorant by roughly 50 percent. For those that attempted reproduction, success was very poor. Pelagic Cormorant and Pigeon Guillemot experienced near total reproductive failure. The reproductive performance of Brandt's Cormorant was 30 percent of the 27- year mean, whereas for the murre, this value was 52 percent, and for Rhinoceros Auklet it was 22 percent.

The only species which demonstrated near normal productivity was Cassin's Auklet, in which the value for 1998 exceeded the long-term mean by 16 percent. However, given that very few Cassin's Auklets attempted to breed, island-wide offspring production was extremely low. In short, these observations were quite similar, with slight variations, to observations made on the Farallon seabird community in other severe El Niño years.

Our time series for Rhinoceros Auklets on ANI is considerably more limited, and efforts to enhance this population by providing habitat (nest boxes) may complicate interpretations. Nevertheless, El Niño's influence was apparent there as well. While the auklet population increased 98 percent from 1993 to 1997 (due to management efforts), it declined by 18 percent in 1998. Mean productivity for pairs in nest boxes also increased from 0.33 to 0.64 young/pair between 1993 and 1997, yet dropped to 0.47 young/pair in 1998. In natural burrows, productivity dropped from an average of 0.83 young/pair to 0.55 young/pair. Lastly, we noted a major change in the chick diet for Rhinoceros Auklets on ANI. In past years, northern anchovies composed the vast majority of the prey items brought to developing offspring, whereas in 1998 Pacific saury made up most of the diet. Saury generally occur further offshore than anchovies, requiring greater foraging effort by adults. This mechanism may help explain reduced productivity in this species on ANI in 1998.

El Niño, and its counterpart, La Niña, generally persist on time scales of one to two years; however, the biological effects of El Niño may be further complicated by oceanographic change which operates on longer time scales. In particular, the 1998 El Niño has come at the end of a period of general ocean warming. Thus, while El Niño serves to illustrate one endpoint in the natural range of variation, it is only applicable to the climate regime under which observations are obtained. Few El Niños studied by marine ornithologists occurred during a cool-water climate regime. This highlights the need for continuing long-term observations to evaluate El Niño/La Niña effects under both warm and cold water climate regimes. As highly-visible upper trophic level predators, birds can be used as accurate and immediate gauges to the timing and intensity of both relatively short and longer-term oceanographic anomalies.

-WILLIAM J. SYDEMAN
DIRECTOR OF FARALLON/MARINE STUDIES,
POINT REYES BIRD OBSERVATORY

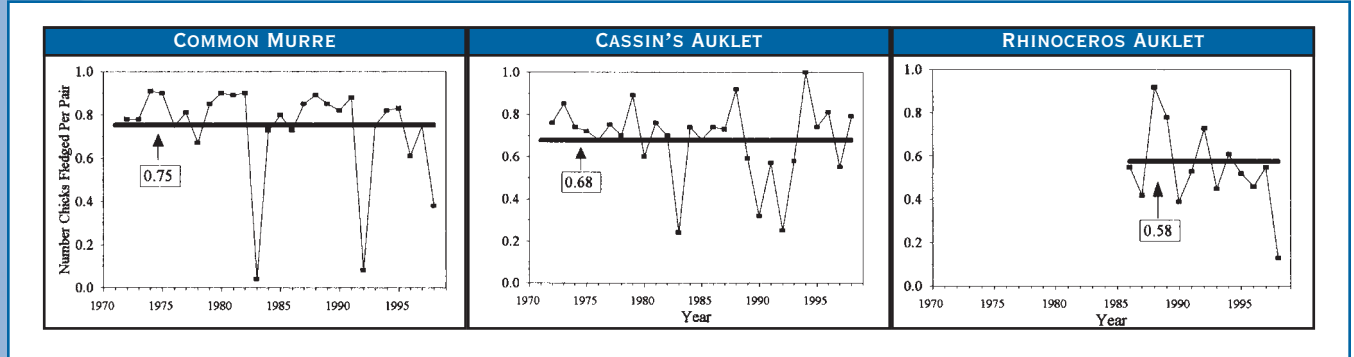

Figure 1: Inter-annual variability in productivity for three species: Common Murre, Cassin's Auklet, and Rhinoceros Auklet in the Sanctuary.

Deposition of Marine Birds and Mammals on Monterey Bay Beaches

In May 1997 the Sanctuary established a monitoring study of beachcast birds and mammals in the Monterey Bay region. During monthly surveys, trained volunteers systematically search 49 km of sandy beaches along Monterey and Carmel Bays. The primary goal of the program, designated Beach COMBERS (Coastal Ocean Mammal / Bird Education and Research Surveys), is to obtain information on rates of stranding for all species of marine birds and mammals in Monterey Bay.

PRELIMINARY RESULTS: JANUARY-AUGUST 1998

SEABIRDS:

The results outlined below refer only to newly-deposited birds. Beachcast deposition of marine birds from January to August 1998 was extremely variable. A low beachcast deposition was recorded in February and high deposition was recorded during April. Beachcast deposition remained high from early April through early July. The amount of deposition was greater at all beaches throughout the study area from May through July, compared to the same period in 1997. The causes of this elevated deposition during 1998 are not clear. Many foraging guilds seem to have been affected and overall species diversity was greater in 1998, although Common Murres dominated the composition of seabird carcasses encountered. In particular, overwintering and resident seabirds were more frequently found beachcast during the May - July 1998 surveys compared to the same period in 1997. Although no comparable data exist for April 1997, deposition rates of overwintering and resident birds for April 1998 were also high. The extended period of high beachcast indicates that resource limitations (perhaps caused by El Niño) may have been a factor contributing to elevated seabird mortality from March through early July. Seabird deposition recorded during August was much lower than the four previous months and remained low through the fall.

Pelagic Cormorants can be found in the Sanctuary year-round.

Among individual seabird species, Surf Scoters and Cassin's Auklets exhibited the greatest difference between years and Common Murre carcasses were found three months earlier than the previous year. The causes for these differences are not known; however, several necropsied Surf Scoters exhibited a high parasite load of banjo worm, and the Cassin's Auklet, a small planktivore, may have been more susceptible to El Niño-enhanced storms than larger fish-eating species.

MARINE MAMMALS:

In contrast with seabirds, marine mammal carcasses could not be reliably marked at each survey, and therefore the results outlined below include all carcasses found, regardless of residence time. Marine mammal deposition was relatively constant from January through early May of 1998, and the May 1998 count was nearly identical to the number encountered during May 1997. A large (four-fold) increase in the deposition of marine mammals occurred between the May 1998 and June 1998 samples, with the June 1998 sample being nearly three times as high as the June 1997 sample. The most frequently encountered species was the California sea lion.

The increase in marine mammal deposition during May and early June 1998 may have been caused by the unusual presence of female California sea lions in Monterey Bay during late spring/early summer. Normally, these animals would be expected to be at breeding rookeries off Southern California; however, El Niño conditions may have forced them to move north in search of resources. Although the causes of the increase in marine mammal mortality are not known with certainty, it is suspected that a toxic diatom bloom during May *(Pseudo-nitzschia australis)* was partly responsible. The number of marine mammal carcasses encountered remained high during July and August, but these were likely the same carcasses as those counted during the June survey.

-SCOTT R. BENSON[1], ANDREW DEVOGELAERE[2], AND JAMES T. HARVEY[1]
[1]MOSS LANDING MARINE LABORATORIES
[2]MONTEREY BAY NATIONAL MARINE SANCTUARY

Monterey Bay Marine Mammal and Seabird Surveys

In 1998 Moss Landing Marine Laboratories and the University of California Santa Cruz continued a third year of ship-board surveys (partially funded by the Sanctuary), which were designed to examine marine mammal and seabird habitats in Monterey Bay. A set of transect lines, spaced at three-mile intervals, spanned the Bay from Santa Cruz to Cypress Point and extended approximately fifteen miles offshore. Surveys were conducted monthly between May and November 1998, typically spanning two consecutive days.

A total of 402 marine mammal sightings encompassing seventeen species were made during the seven surveys. The California sea lion was the most frequently encountered marine mammal. Pacific white-sided dolphins and humpback whales were the most frequently-encountered toothed cetacean and baleen whale, respectively. Common dolphins were numerically the most abundant cetacean, because this species was seen in large groups.

A total of 2,359 sightings of 9,994 seabirds were made while the ship was on transect. Species composition varied from month to month. The most abundant families of seabirds were the shearwaters and alcids (80 percent and 11 percent of all birds seen, respectively). Species composition was similar from May through September, but changed notably in October and November, with fewer Sooty Shearwaters and Common Murres, and an increased number of Buller's Shearwaters, Black-vented Shearwaters, and Rhinoceros Auklets.

Preliminary results indicate that El Niño conditions likely affected the number and types of marine mammals encountered during the surveys. Dall's porpoises were seen less frequently than in previous years, whereas common dolphins were more numerous. In 1998 California sea lions were unusually abundant in early summer, when they normally would be expected to be at breeding rookeries off Southern California. The number of baleen whale sightings was greater in 1998 than 1997, and peak abundance was observed later in the season (August vs. May-June). The observed pattern of abundance was similar for zooplankton, the whales' primary prey. Seabird assemblages were roughly similar to those seen in 1997, but abundances of several species were notably lower (e.g., Common Murres, Cassin's Auklets, and Brandt's Cormorants). Furthermore, a large number of Storm Petrels was seen in September 1998, whereas this group of species was rare on all previous 1996-97 surveys.

-Scott R. Benson[1], Donald A. Croll[2], and Baldo Marinovic[2]
[1]Moss Landing Marine Laboratories
[2]University of California Santa Cruz

Harvested Species

Fish and Invertebrate Resources

The ocean environment in the Monterey Bay region is very dynamic and greatly influences resident fish populations. This variability makes estimating the "health" of marine fish and invertebrate populations difficult using one year as a basis for discussion. Additionally, most of the information used to estimate the size of fish populations is derived from commercial and recreational fisheries. Catch rates are used as an index of abundance, and long term data sets are usually needed to model or estimate trends in the abundance of fish stocks effectively. Even with these long term data sets, it is often difficult to determine if changes in fish populations are the result of societal activities, such as fishing or coastal development, or due to environmental changes.

Events occurring in 1998, however, can be placed in a longer term framework to provide an indication of the current status of marine fish and invertebrate resources. This report provides a brief summary of the status of fish stocks in the Monterey Bay National Marine Sanctuary from 1980-95 as described in *Fishery Resources of the Monterey Bay National Marine Sanctuary*, and discusses the main events affecting fishery resources in 1998.

About 200 species are typically caught in commercial and recreational fisheries in the Sanctuary. From 1980-95, reported commercial catches increased or were stable for about 17 percent of the species frequently harvested in this region. Reported catches declined for about 10 percent of the frequently harvested species. Catches and thus population status of other species are either unknown or highly variable. Invertebrate species most frequently harvested commercially include spot prawn, pink shrimp, Dungeness crab, rock crab, and market squid. Harvests of spot prawn, Dungeness crab, and rock crab all increased from 1980-95. Pink shrimp populations declined throughout much of the late 1980s, then increased from 1994-95. The market squid population was low during the El Niño years of 1983-84, reached record levels in 1994-97, then declined dramatically with the onset of the 1997-98 El Niño.

Rockfishes are the most diverse group of fishes living in Sanctuary waters.

Shark and ray species are no longer harvested in large numbers in the Sanctuary. There is, however, evidence to suggest that the population sizes of some shark and ray species are lower now than they were before 1980. Chinook, or "king," salmon is the most common anadromous species caught in the Sanctuary. Reported catches of Chinook salmon have been high in the last few years. Scientific stock assessments indicate that the fall run Chinook salmon of the Sacramento River is in good shape, but that populations of Coho salmon and winter and spring run Chinook salmon are severely depressed. Steelhead populations are extremely depressed in this area, due primarily to degraded stream habitats.

Abundances of most pelagic species are greatly determined by large scale environmental phenomena. Northern anchovy and Pacific sardine are the predominant nearshore pelagic fishes caught in the Sanctuary. Anchovy spawning biomass in Central California declined after 1985, but experienced a substantial increase from 1994-95. Pacific sardine populations are also increasing rapidly throughout their range after nearly disappearing from the region in the 1950s. In 1998 the commercial fishers reported seeing large numbers of small (young) sardines. The population of Pacific albacore, another common pelagic species, is currently thought to be stable or increasing.

Biological and fishery data indicate that lingcod may be overfished in much of their range. In 1998 the Pacific Fishery Management Council's stock assessments indicate that lingcod abundance is at approximately 9 percent of the estimated unfished biomass off Washington and Oregon. This caused the Council to reduce recreational harvest quotas and begin to develop a rebuilding plan. Similarly, sablefish have been heavily fished

in California waters. Sablefish catches in the Sanctuary have been decreasing since 1980, but data from recent surveys suggest the population may be increasing. Pacific hake are very abundant seasonally in the Sanctuary as they migrate from Mexican to Canadian waters. Pacific hake catches were high off Central California throughout most of the 1980s.

"Of course, El Niño was the big story in 1998. For example, it affected the migration patterns of salmon and squid, which looked for colder water so were less plentiful here. Conversely, albacore came in more because of the warm waters."

-Dave Danbom, Moss Landing Fishing Industry Representative, Sanctuary Advisory Council

Rockfishes are the most diverse group of fishes living in Sanctuary waters. Sufficient data are available to show stable or increasing trends in abundance for some rockfishes such as bank, chilipepper, shortbelly, widow, and splitnose. Other rockfish species such as bocaccio, yellowtail, canary, and Pacific ocean perch have exhibited decreasing trends in abundance along the U.S. West Coast. Many of these depleted rockfishes are deep water species that are slow growing, long lived, or have experienced high exploitation rates. Fishery managers are concerned about the capability of some of these species to recover from high harvest rates and in 1998 continued to reduce harvest guidelines for many rockfish species.

"This was a good year for albacore, which attracts a lot of fishermen. However, fishing for rockfish, the 'bread and butter species,' was dismal. Our Cambria sports fishing club catch was down this year, except for blue bass."

-Dr. Mal Stock, Fisher, Cambria

Several species of fishes that occur in kelp forests and other nearshore habitats are under high fishing pressure from both commercial and sport anglers. In the late 1980s, fishers started transporting fish alive to restaurants. This type of fishery became very lucrative and fishing pressure increased rapidly. Landings of live fish in Central California increased from 15,000 pounds in 1989 to 536,000 pounds in 1997. The result of this interest in live fish for the restaurant market was an increase in the harvest of immature fish, a major resource conservation problem. There are already signs that some nearshore species such as cabezon are rapidly becoming depleted from the high fishing pressure. New legislation was enacted in 1998 that placed size limits on many nearshore fishes and directed the California Department of Fish and Game to develop specific fishery management plans for nearshore species. California AB 1241 also provided a fundamental change in the way that fisheries management will take place in California in the future. It requires the state to manage fisheries proactively for sustainability, instead of for short-term profits. It also transfers much of the responsibility for management from the legislature to the Fish and Game Commission.

Surfperches represent a diverse group of nearshore fishes in the Sanctuary waters. Historical catch data show that surfperch populations have declined, due to a number of factors including environmental variation, lower production caused by smaller fish, habitat degradation, and increased fishing pressure. In contrast, landing data and stock assessments suggest that populations of most species of flatfishes are robust and could withstand increased levels of harvest.

"This year was a disaster for squid fishermen - literally. The disaster people came and made loans, but the fishermen are still feeling the effects. A few were able to switch and fish sardines, but even that hasn't been very good - the sardines have been very small. Only about fifteen tons of squid were caught on the whole Central Coast this year, whereas the typical catch is around 7-8,000 tons, and as high as 15,000 tons, for a season."

-Dave Crabbe Fisher, Monterey

In addition to population changes brought about by fishing activities, broad scale environmental changes affected marine resources in 1998. Most notably, marine habitats and species were affected by strong El Niño conditions. The marine environment experienced high inflows of fresh water, sediments, and nutrients from winter floods. Northwest winds were lighter than normal, causing poor upwelling conditions. These poor upwelling conditions have been shown to be detrimental to survival of juveniles of many local species, such as rockfishes. Water temperatures were also 2 - 4° C above normal, probably causing poor survival of many species, but notably juvenile market squid. The strong

Kelp Harvesting

Many activities, consumptive and non-consumptive, could have an effect on a kelp forest and its ecology. In the interest of resource protection, the Sanctuary collaborates with researchers, kelp harvesters, and other interests to determine if the effects of kelp harvesting are ecologically important.

South of Monterey Bay, kelp is harvested primarily by large vessels and is used as a processed food additive. Kelco, a subsidiary of Monsanto, is the major kelp harvester south of Monterey Bay. While Kelco's operations are mostly in southern California, it occasionally cuts kelp in the Sanctuary in late summer and early fall. In fall 1998, for one day, a Kelco boat cut kelp as far north as Carmel Bay.

Kelp on and north of the Monterey Peninsula is primarily hand-harvested, and fed to abalone in mariculture farms and used as substrate for herring roe spawnings (exported for sushi). From Cypress Point to the Monterey Coast Guard Wharf, kelp harvesters removed 571 and 683 tons in 1996 and 1997, respectively, according to the California Department of Fish and Game (DFG). The long-term average of kelp harvested around the peninsula is higher than this, due to occasional visits from Kelco's ship. While many biologists believe this level is not environmentally detrimental to the kelp plants, increased harvesting has led to "use-conflicts" with non-consumptive users (divers, kayakers, hoteliers, conservationists).

Since 1996 the Sanctuary has been working with DFG, local kelp harvesters, and non-consumptive use interests to develop a non-regulatory solution to kelp "use-conflicts" along the Monterey and Pacific Grove coasts. These efforts have partially paid off: in September 1998 all the kelp harvesters who use that area signed an agreement to work among themselves and with other non-consumptive users for the benefit of all interests, and to ensure sustainable kelp harvesting in that area. Additionally, in 1998 the cities of Monterey and Pacific Grove issued resolutions designating this area as being of special environmental significance.

The Sanctuary retains authority under its Management Plan to regulate kelp harvesting, and is interested in furthering the scientific understanding of kelp harvesting impacts. To this end, in 1998 we funded some research on the effects of kelp harvesting on kelp canopy cover, and will expand that work in the next year.

-Aaron King
Monterey Bay National Marine Sanctuary

water mass flow from the south and corresponding warm water brought many species to this area that are not typically seen here. Species that occurred in the Sanctuary in 1998 that are typically not seen in large numbers included albacore, sheephead, marlin, swordfish, pelagic red crabs, and jumbo squid.

The Sanctuary's enabling legislation excludes fishery management from the purview of its regulations. The Sanctuary charge is to protect resources, however, and there is much the Sanctuary program can do to improve fishery management. More scientific information is needed to optimize catches from fisheries without depleting fish populations. Information is needed not only on population abundance and critical life history stages, but on the interactions between species, the effect of harvest activities on marine habitats, and the effect of environmental change on marine fishes. Increased research is also needed to evaluate the design and effectiveness of current methodologies, as well as to develop new, more efficient management strategies.

-Richard M. Starr
University of California Sea Grant Extension Program

"This summer on the ocean we saw a northern shift in the salmon population, with smaller fish being caught here and the larger fish in Oregon. This happened in the 1992 El Niño as well. Some remnants of this El Niño were still evident at the end of summer, with barracuda and giant squid being caught, both of which are usually found farther south."

-Duncan McLean, Fisher, El Granada

Human Interactions

The people of California's Central Coast can't help but interact with the Monterey Bay National Marine Sanctuary. We surf and swim in its waters and walk along its shores - even dispose of our sewage within its boundaries. People from around the country and the world also come into contact with the Sanctuary as tidepool visitors, recreational fishers, and travelers aboard vessels transiting the California coast.

This section illustrates some of the many human/Sanctuary interactions that occur every year. It is by no means a complete accounting; we have simply compiled some examples and - where possible - given relevant statistics for 1998. (For example, Fitzgerald Marine Reserve is only one example of many tidepool locations within the Sanctuary, and Monterey Bay Kayaks represents only one of many kayak rental companies.) Footnotes describe the limitations of, and sources for, these statistics.

Some of these interactions are generally considered harmful (such as oil spills or effluent discharge) and some are beneficial (beach cleanups, docents). However, often the line is not clear-cut; many of these interactions could have a positive or negative effect, depending on the behavior of those involved.

Suniel Thomas

Save Our Shores' Sanctuary Stewards organize beach clean-ups like this one.

ACTIVITY	DETAILS
Tidepoolers	Visitors to Fitzgerald Marine Reserve - approximately 110,000[1]
Whale Watchers	Monterey Bay Whale Watch - 8,145 people[2] *(see article p. 25)*
Kayak Trips	Monterey Bay Kayaks - 15,400 kayak trips (via rentals) (from Monterey and Elkhorn Slough)
Divers	Southern Monterey Bay giant kelp forests - over 60,000 + divers/year.[3] Of the above total, Pt. Lobos - 3,720 divers[4]
Fishers	Commercial Fishing Licenses, by county[5]: Marin - 196 San Francisco - 204 San Mateo - 308 Santa Clara - 44 Santa Cruz - 209 Monterey - 648 San Luis Obispo - 574
Charter Boats (Recreational fishing)	Charter Boats Licenses, by county[6]: Marin - 11 San Francisco - 25 San Mateo - 9 Santa Clara - 6 Santa Cruz - 16 Monterey - 9 San Luis Obispo - 17
Great American Fish Count (5th Annual)	Total Locations - 20 Total Bottom Time - 95:57 hrs Total Species Counted - 81 Total Surveys Completed - 127 *(For more details, see p. 3.)*
1998 Coastal Cleanup	Coastal Cleanup Beach Debris Collected, by county[7]: Marin - 17,263 lbs trash; 3,597 lbs recyclables; 1,181 volunteers San Francisco - 5,492 lbs trash; 792 lbs recyclables; 2,718 volunteers San Mateo - 32,902 lbs trash; 3,190 lbs recyclables; 1,546 volunteers Santa Cruz - 5,020 lbs trash; 1,750 lbs recyclables; 1,850 volunteers Monterey - 12,902 lbs trash; 2,521 recyclables; 2,665 volunteers San Luis Obispo - 4,741 lbs trash; 730 lbs recyclables; 760 volunteers
Volunteer Docents	Contacts with the public: Save Our Shores Sanctuary Stewards - 45,000 (Santa Cruz and San Mateo Chapters) BAY NET - 23,000 (Santa Cruz and Monterey Peninsula) Friends of the Elephant Seal/BAY NET* - 60,000 + (San Luis Obispo County) **Friends of the Elephant Seal was created from over 60 volunteers trained initially by BAY NET. The two programs worked closely in San Luis Obispo County during much of 1998.*
Wastewater Treatment	Both the Santa Cruz and Watsonville wastewater treatment plants were upgraded to secondary treatment level in 1998.

ACTIVITY	DETAILS
Volume of Permitted Effluent	National Pollution Discharge Elimination System (NPDES) Permits - 65 Average dry weather flow from these discharges: approx. 1.77 billion gallons/day State Waste Discharge Requirement (WDR) Permits - 220 Maximum design flow for these discharges: 91.4 million gallons/day
Sanitary Exceedances and Unauthorized Discharges	Sanitary Exceedances and Unauthorized Discharges, by county[8]: **San Mateo** (Mid Coastside WWTP): 54 reported violations, either effluent exceedances or overflows/bypasses, directly to the Sanctuary **Santa Cruz:** Effluent exceedances in watershed - 14 Effluent exceedances w/direct discharges to Sanctuary - 6 Unauthorized discharges in watershed - 2 Unauthorized discharges w/direct discharges to Sanctuary - 5 **Monterey:** Effluent exceedances in watershed - 31 Effluent exceedances w/direct discharges to Sanctuary - 4 Unauthorized discharges in watershed - 3 Unauthorized discharges w/direct discharges to Sanctuary - 1 **San Luis Obispo:** Effluent exceedances in watershed - 10 Effluent exceedances w/direct discharges to Sanctuary - 2 Unauthorized discharges in watershed - 0 Unauthorized discharges w/direct discharges to Sanctuary - 0
Beach Closures	Beach Closures, by county[9]: **Marin:** Not available. **San Mateo:** 19 beaches closed for a total of 278 days **Santa Cruz:** 6 beach closures for approx. 3 days each and 1 closure for 1 day, for an approximate total of 19 days **Monterey:** 2 beach closures for a total of 14 days **San Luis Obispo:** 1 beach closed for 3 days (outside Sanctuary boundaries); advisories posted at all beaches during big storm events
Shipwrecks	1) *The Vaya Con Dios* was wrecked north of San Pedro Point (technically out of the Monterey Bay Sanctuary boundary, in the exclusion zone off San Francisco) in June. The wreck was eventually removed. Four crew died in the accident. 2) *The Lovely Day* sank and washed ashore north of Point Joe (Pebble Beach) on the Monterey Peninsula in mid-December. Both crew members aboard died. No oil or petroleum products were observed on the ocean's surface.
Oil Spill Responses	1) Pt. Reyes Tarball incident, Nov. 97 to Feb. 98. Most activities occurred outside of the Monterey Bay Sanctuary, in the Gulf of the Farallones Sanctuary. *(See p. 2 for details.)* 2) San Mateo Coast Oil Spill, Sept.-Oct. 98. Fifty to 100 barrels of an unknown oil product were spilled west of Half Moon Bay. The Coast Guard tracked down a possible responsible party. *(See p. 2 for details.)*
Enforcement Actions under the Marine Sanctuaries Act	-Three fines were issued: two for harassment of marine mammals; one for operation of a jet ski out of prescribed zones. (Fines ranged from $200 to $750 dollars.) -A homeowner and builder were issued official warnings for constructing a seawall without authorization from the Sanctuary. -Several verbal warnings were issued to jet ski operators operating in unauthorized areas.

Notes:

1 - This number is low (1996 was 135,000, for example) because the Reserve's sign was destroyed in a traffic accident.

2 - This is thought to be a low number for the average operator, because this company includes interpretation in its trips, and so takes fewer than average trips.

3 - Saunders, R., Okey, T.A. and Sobel, J. 1997. Recommendation for the establishment of the Edward F. Ricketts Marine Park. Center for Marine Conservation, San Francisco, 17 pp.

4 - Estimates, provided by Judy Pollack, Point Lobos State Reserve

5 - Source: California Department of Fish and Game

6 - Source: California Department of Fish and Game. These are not necessarily exclusively doing sport fishing; they may also do whale watching tours, marine mammal tours, etc.

7 - Source: California Coastal Commission

8 - Sources: San Luis Obispo Regional Water Quality Control Board (for Santa Cruz, Monterey, and San Luis Obispo counties). Data were not available from the Oakland RWQCB, which includes Marin, San Francisco, and San Mateo counties; Pat Cotter (Monterey Bay National Marine Sanctuary) provided details from Mid Coastside Waste Water Treatment Plant in San Mateo County.

9 - Sources: County Environmental Health Departments. Note that all counties except Santa Cruz test weekly, so that in those counties a beach, once closed, usually remains closed for seven days. In Santa Cruz County, a closed beach will normally be tested every day until it is safe and opened again.

Human Interactions Statistics compiled by Lisa de Marignac, Monterey Bay National Marine Sanctuary, and Jenny Carless.

Windsurfing is popular in parts of the Sanctuary.

Friends of the Elephant Seal

Friends of the Elephant Seal (FES) was formed and incorporated in March 1998 by concerned members of the Cambria community. These activists formed FES under the guidance of the Center for Marine Conservation's BAY NET program to establish and operate an elephant seal docent program on the Central Coast. There is a large and growing colony of northern elephant seals located in the Piedras Blancas area just north of Cambria. Over the years, the colony - which is easily viewed from Highway 1 - has become an attraction for tourists and nature lovers. Unfortunately, many of the people who came to view the elephant seals unwittingly harassed or interfered with the seals' natural activities.

By posting trained docents at the elephant seal viewing areas, FES has been able to educate thousands of people on the natural history of the elephant seal and how to view and enjoy them without disturbing their environment. Over sixty volunteer docents also provide the public with information on the seals' habitat and the other marine mammals, such as gray whales, harbors seals, sea lions, and sea otters, which frequent the area. The program has been instrumental in preventing incidents of harassment to the seals through its educational programs and presence on the beaches.

Since the program first began posting docents in November 1997, docents have contacted over 60,000 people who stopped at the viewing areas along Highway 1. The visitors are local residents, tourists from around the world, tour groups, and school children. FES is now expanding its efforts by developing a portable educational program to be taken to public schools and other interested groups.

-William Raver
Friends of the Elephant Seal

Sanctuary Vessel Traffic at a Glance

Number and type
- Approximately 4,000 large vessels (> 300 gross tons) traverse the Sanctuary each year
- 500 - 750 are tankers
- the majority of the remainder are large container ships and bulk product carriers

Distance from shore
- Most U.S. crude oil tankers voluntarily travel 50 + nm* from shore
- Large container ships and bulk product carriers usually travel 2.5 to 15 nm from shore

**nm: nautical miles*
(Note: for further information on Sanctuary vessel traffic, see page 2.)

Boaters/Harbors:

	Monterey	Moss Landing	Santa Cruz	Pillar Point
Number of berths	413	625	1,140	371
Number of moorings (permanent)	200	0	0	30
% Commercial	*34	50	5	60
% Recreational	*66	50	95	40
Ratio of recreational sail/power	*50/50	Not avail.	65/35	50/50
Visitors/night/year (transients)	10,000	Not avail.	12,000	7,952
Launches/year	8,000	9,000	15,000	10,976

**except for those boats moored in the lee of Wharf #2 (approximately 40), where 100 percent are recreational, with a breakdown of sail/power at 75/25.*
Sources: Harbormasters

Whale Watching

Whale watching is becoming a common means for the average person to experience the Monterey Bay National Marine Sanctuary. Monterey Bay Whale Watch conducted year-round trips during 1998 to observe the diversity of marine life within the Sanctuary. Our biologists documented all marine mammal species including location, group size, and behavior. We also photo-identified individual humpback whales, blue whales, and killer whales, and contributed that documentation to scientists working on these species.

The year started off with the southern migration of the gray whale, which was a bit delayed due to El Niño conditions. The migration peaked off Monterey between the second and third week of January with over fifty whales sighted per 3-hour trip, with whale group sizes ranging from ten to fifteen. The highlight of the season was our observation of a gray whale giving birth to her calf inside the Bay off Pacific Grove.

For unexplained reasons the northern migration of the gray whale was early, with the first northbounders observed during the second week of February. As the main migration of adult and juvenile whales passed us by early April, the migration of mothers with calves was just beginning in our area. This is a time of danger for the young calves, as killer whales prefer to hunt them in Monterey Bay as they cross the deep canyon and are away from the protection of shore. Although this is an unpredictable event, we observed three full attacks and the end of a fourth. The killer whales generally work as a group to tire the gray whales, separate the mother from calf, and eventually kill the calf.

Spring marked the beginning of the upwelling season, coinciding with the arrival of humpback and blue whales to feed on the abundance of fish and krill in the Monterey Bay region and along the Central Coast. May and June offered incredible opportunities to watch multi-species feeding aggregations in the Bay involving humpback whales, thousands of long beaked common dolphins, hundreds of California sea lions, and up to 10,000 seabirds - mostly Sooty Shearwaters.

Both humpback and blue whales were consistently sighted through the summer and fall. An abundance of sardines and krill was the mainstay for these whales. As during the winter and spring, common dolphins - both long beaked and short beaked species - were the most abundant dolphin in the Bay through the end of fall, often encountered in groups of over 2,000. They displaced the normally abundant and frequently-sighted Pacific white-sided dolphin, which was still occasionally present but in smaller group sizes. Baird's beaked whales were sighted several times during October, as in past years. Killer whales were sighted two to five times per month, with peaks in spring and fall. October marked above-average sightings and numbers (1,000 per group) of Risso's dolphins, often in the company of northern right whale dolphins.

Another late burst of upwelling in October created huge krill concentrations off the coast between Point Pinos and south of Point Lobos, near the canyon edge, lasting through most of November. This late season krill brought, on some days, up to 100 whales to the area, including humpback, blue, and fin whales. Fin whales are not commonly seen in most years, but were a consistent presence during October and November.

-Nancy Black
Monterey Bay Whale Watch

Further Reading

The following sources have been suggested by the authors of each section, for readers who are interested in learning more about the specific topics discussed in this report. (Note: this is NOT a comprehensive bibliography about Sanctuary resources.) A general reference for all Sanctuary resources is the Site Characterization and its bibliography, on the Sanctuary's web page, at http://www.mbnms.nos.noaa.gov/sitechar/

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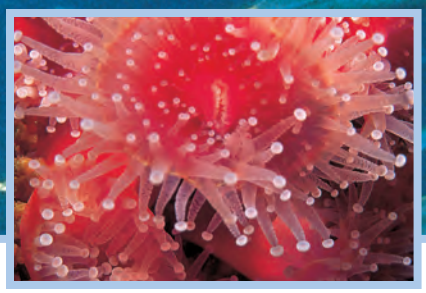

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