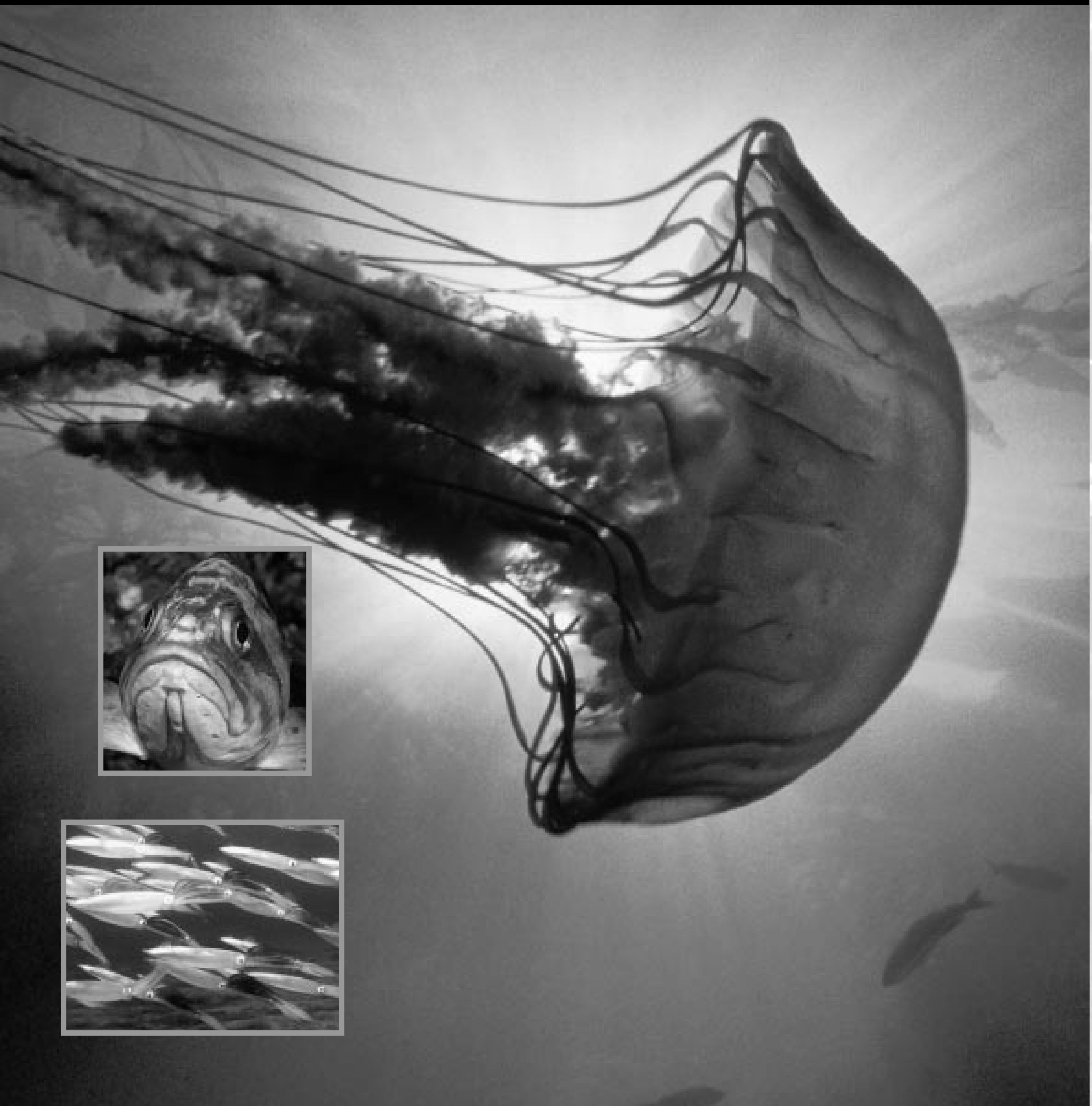
Ecosystem Observations

for the Monterey Bay National Marine Sanctuary

2000



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Welcome

The year 2000 has been a remarkable one for that tried and true hallmark of the national marine sanctuary system – the "stakeholder" process. Perhaps no other site in the national system has a better track record of involving stakeholders in solving resource management problems than the Monterey Bay National Marine Sanctuary.

While "unique" can be an overused word these days, we believe our Agricultural and Rural Lands water quality plan is darned rare and may be unique in our country. It involves growers and ranchers around central California who will be taking steps to reduce pollutant runoff and sedimentation from agricultural fields into coastal streams and ultimately into the Sanctuary. I'm sure that this program leads the nation in its creativity and the sheer fact that our $5 billion regional agricultural industry has accepted its role to help protect marine water quality.

In June in San Francisco we rolled out the results of another stakeholder initiative – a plan to protect marine water quality by moving shipping further offshore and providing greater vessel traffic organization along the central California coast. Our vessel traffic strategies received final approval by an international shipping organization in London in May and went into effect in December.

In October we completed the design for our ecosystem monitoring program, SIMoN, developed to integrate and expand monitoring of the Sanctuary's ecosystem. And, after years of public dispute as to the effects of kelp harvesting, we prepared and released a plan that evaluated kelp harvesting's effects and recommended several means to reduce the limited adverse effects it can have on kelp forests in the Sanctuary.

All of these efforts have one thing in common. We took the time to listen to that broadly-defined group called stakeholders – members of the public, and in particular, those who may be most affected by a resource protection program. Such a process means that rarely will everyone get everything they want, but most often everyone gets something they can live with and support. We are proud of what these and many other lesser-known programs bring to understanding and protecting the Sanctuary, and we thank our partners and the stakeholders for their commitment to them.

And, we are proud that *Ecosystem Observations 2000* offers another compelling example of the value of partners. Thanks to all of the contributors.

– William J. Douros, Superintendent
NOAA's Monterey Bay National Marine Sanctuary

2000 Program Activities for the Monterey Bay National Marine Sanctuary

Dedicated in 1992, the Monterey Bay National Marine Sanctuary is the largest of thirteen sanctuaries nationwide managed by the National Oceanic and Atmospheric Administration (NOAA). Encompassing more than 5,300 square miles of water, its boundaries stretch along the central California coast from the Marin County headlands south to Cambria. The Sanctuary features many diverse biological communities, including wave-swept beaches, lush kelp forests, and one of the deepest underwater canyons in North America. An abundance of life, from tiny plankton to huge blue whales, thrives in these waters.

Our mission – to understand and protect the coastal ecosystem and cultural resources of central California – is carried out through the work of four program divisions: resource protection, education and outreach, research, and program support. Following is a summary of each division's major accomplishments and activities for 2000.

Resource Protection

The goal of the Resource Protection Program is to initiate and implement strategies to reduce or prevent detrimental human impacts to the Sanctuary. To aid these efforts over our expansive range, Monterey Bay was one of two national marine sanctuaries selected to pilot an enforcement program in 2000. We were assigned a special agent from NOAA's Office of Law Enforcement to concentrate on Sanctuary enforcement issues. As a result, we have improved our response and investigative capabilities and are developing a strategic enforcement plan to improve monitoring and surveillance within the Sanctuary.

We reviewed more than fifty-nine permit requests during the year. Permits were issued for seabed alteration activities, discharges to the Sanctuary, and overflights below 1,000 feet in restricted zones. Distinct conditions were added to the permits to reduce or eliminate potential threats to Sanctuary resources.

Staff reviewed proposed fiberoptic cable projects and requested the preparation of an Environmental Impact Statement for one project. Two proposed cable installations within the Sanctuary were instrumental in prompting NOAA to develop a policy for fiberoptic cables throughout U.S. waters and all national marine sanctuaries. This policy development is currently underway with a final document due shortly.

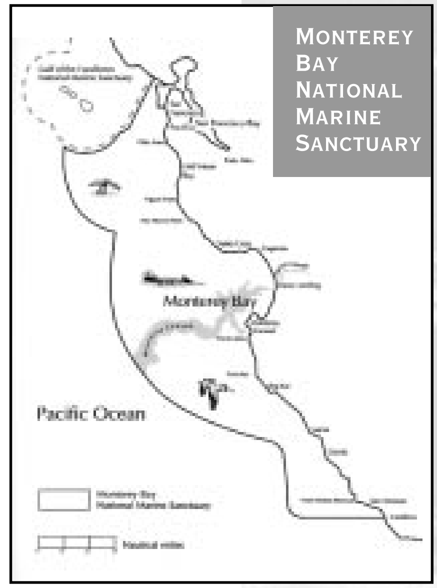
We are participating in the development of a Coast Highway Management Plan with the California Department of Transportation (CalTrans). The plan is an interagency, multi-stakeholder effort to manage landslides and construction of Highway 1 along the Big Sur coastline. In addition, we are working with CalTrans and the U.S. Geological Survey (USGS) to develop a sediment budget for the region in an effort to assess the volume of sediment that is lost from natural and anthropogenic coastal erosion along Highway 1.

We had a busy year responding to environmental emergencies related to sewage spills, boat groundings or sinkings, and airplane crashes, coordinating the salvage and defueling of vessels and the removal of debris. We also sent a team to help the Channel Islands National Marine Sanctuary respond to the Alaska Airlines crash. (*See page 26 for list of vessel incidents in the Sanctuary*.) After responding to a 70,000 gallon raw sewage spill at Lovers Point and subsequent smaller spills, we worked with the City of Pacific Grove to initiate a Model Urban Runoff Program.

Early this year we announced the completion of the Agricultural and Rural Lands Plan, a collaborative effort of the Sanctuary's Water Quality Protection Program (WQPP) with government agencies and six County Farm Bureaus to protect and enhance water quality in the Sanctuary and its surrounding watersheds. Congressman Sam Farr acquired $500,000 for the Department of Agriculture's Natural Resources Conservation Service to help implement the plan. The County Farm Bureau Coalition hired a regional coordinator who began efforts on the industry's commitments under the plan.

The WQPP continued to implement strategies outlined in the urban runoff, marinas and boating, and regional monitoring plans. Bilge water pumpout and oil/water separator equipment was installed at Monterey and Moss Landing harbors. Staff worked with the California Coastal Commission and local cities to present a series of three Model Urban Runoff Program Technical Training workshops throughout the year.

Along with many partners, the Sanctuary's Citizen Watershed Monitoring Network organized more than one hundred volunteers for a one-day, Sanctuary-wide monitoring event. The event, "Snapshot Day 2000," held on Earth Day, was the largest simultaneous water quality



monitoring event in California (*see page 13*). In October, the Network mobilized twenty-five volunteers to sample storm water pollutants in three cities during "First Flush," the first heavy rain of the season, which flushes out pollutants that have accumulated during the dry season.

The International Maritime Organization gave final approval in May for a Sanctuary vessel traffic scheme that moves recommended tracks for ships of 300 gross tons and above, as well as ships carrying hazardous materials and barges, further offshore. We began educating mariners about the new vessel tracks by distributing flyers to shipping agents and captains, placing the new tracks on nautical charts, and including the strategy in NOAA's *U.S. Coast Pilot*. These accomplishments are the result of a three-year planning effort initiated by the Sanctuary and the U.S. Coast Guard in collaboration with a variety of government agencies, the shipping industry, and environmental groups.

Education and Outreach

The goal of the Education and Outreach Program is to promote understanding and stewardship of the Sanctuary. One focus in 2000 was to expand outreach to the southern part of the Sanctuary. We sponsored three Cambria teachers to participate in our annual teacher workshop, worked with San Luis Obispo County to install a new "Sanctuary southern monument" exhibit, began planning a new outdoor exhibit at the Hearst Castle visitor center, and partnered with California State Parks and National Geographic Theatre in San Simeon to host a special event launching the 2000 Sustainable Seas Expeditions (SSE). We also hired a new education specialist to work in a satellite office provided by California State Parks, San Simeon District at Hearst Castle.

Our Santa Cruz-based education specialist continued to enhance public awareness of the Sanctuary by attending many public events and providing numerous presentations in the Santa Cruz area. She worked closely with the Santa Cruz Interagency Task Force to produce a new brochure, *Fifty Ways to Get Your Feet Wet in the Monterey Bay National Marine Sanctuary, Santa Cruz County*, highlighting the many marine education and recreation facilities in the region. Visitors can also learn more about the Sanctuary by viewing a new traveling exhibit at Seacliff

State Park Visitor Center and a new outdoor display kiosk on the Santa Cruz Wharf.

Causes of Ecosystem Change: Natural or Human? was the theme of the 2000 *Sanctuary Currents* Symposium. Presentations touched on fisheries, marine mammal populations, climate variability, and coastal land use as well as ecological change in kelp forest, rocky intertidal, and pelagic environments. Individuals and organizations were honored for their dedication to the Sanctuary (*see box on page 4*).

Our annual SSE Student Summit events featured the theme ecosystem monitoring. To inspire high school student teams to undertake field projects, we organized a workshop on rocky intertidal monitoring techniques with regional scientific experts. At the summit, forty students from six high schools presented their results to an audience of peers and local scientists.

Other education activities related to SSE included two on-the-water excursions for students and a live satellite uplink that allowed the public to interact with divers in the Sanctuary. Our "teacher in the sea," Mike Guardino, continued his research project using the *Deep Worker* submersible. The Sanctuary was featured in an SSE virtual teacher workshop that reached more than 200 participants around the country and in new school curriculum activities developed by the National Geographic Society.

We are continuing to expand "The Land-Sea Connection," a curriculum produced earlier in the year as a companion to our new Sanctuary map. We also supported the development of S.E.A. Lab Monterey Bay, a residential marine education program for students that piloted a successful week-long program in July.

Educational activities associated with the Model Urban Runoff Program continued in the cities of Monterey, Pacific Grove, and Santa Cruz and expanded to Watsonville and Capitola. Working with the city of Watsonville and the California Coastal Commission, we developed new bilingual products and programs with messages about preventing urban runoff pollution. With the city of Monterey we completed a bilingual training video, "Make The Connection," which provides storm drain pollution prevention tips for restaurant employees. In addition we produced a bilingual PSA for television on urban runoff pollution and our Urban Watch monitoring program, already underway in Monterey and Pacific Grove, was expanded to Capitola.

Last year NOAA's National Marine Fisheries Service contracted us to provide outreach on protecting threatened salmon and steelhead populations. Working with various partners, we used the funding to enhance the Sanctuary's Citizen Watershed Monitoring Network, conduct technical training workshops on sediment control, and develop educational materials for targeted audiences including a poster on "Salmonids of the Sanctuary."

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Sanctuary education specialist Jen Jolly helps a student from the Boys and Girls Club of the Monterey Peninsula sample water quality on a Sanctuary cruise last summer.

Working with members of the Pacific Grove Tide Pool Taskforce, we led the effort to produce new interpretive panels for the Pacific Grove shoreline. Six new signs were placed along access ways to the tidepools to inform visitors how to avoid harming or disturbing intertidal creatures.

Through our Diver Partnership Program, we held an underwater photo contest with winning images used in a new brochure on ways divers can enjoy and protect the Sanctuary. The seventh annual Great American Fish Count attracted many divers who counted fish during the first two weeks of July. (*See page 25 for more information.*)

This fall, with our enforcement team, we piloted a new outreach program for the growing community of sea kayakers in Monterey and Elkhorn Slough, informing them about the Sanctuary and appropriate wildlife-watching etiquette. Our new Team OCEAN program involves a team of Sanctuary staff on-the-water who educate fellow kayakers about wildlife and how to protect sensitive animals, especially marine mammals, from disturbance.

An exciting new effort was launched this year to develop a Multicultural Education Plan that will guide us in expanding outreach to the Hispanic communities in Salinas, Watsonville, and San Jose. We surveyed more than forty local groups to find out what types of programs and services they offer to Hispanic students, teachers, parents, and families and then evaluated what types of services were still needed and how we could help provide those within the framework of our mission. The support and enthusiasm from the community has been phenomenal.

RESEARCH

The Research Program focuses on science for resource management, identifying information gaps, developing collaborative studies to improve understanding of issues, and interpreting research for decision-makers. In 2000 several important personnel changes aided the research team. We gained a research assistant position, developed a shared contract position with the CDFG geographic information system laboratory, and added Research Activity Panel members to represent the Coastal Commission and Point Reyes Bird Observatory.

It is critical to know what the natural resources are and how they change through time in order to be effective in managing natural resources. We made great strides in this direction by developing a Sanctuary Integrated Monitoring Program (SIMoN). SIMoN was developed with extensive input from resource managers and scientists and will include coordinated historical data compilations, state of the Sanctuary publications, Web access for education and resource management purposes, and new funds for monitoring. NOAA has committed to providing more staff to coordinate this effort, $1.5 million in permit monitoring funds has been promised to start the program, and we have submitted proposals to develop this model monitoring program for the nation.

In the meantime, the Sanctuary continued to support monitoring data on: beachcast organisms (*page 19*); pelagic surveys for birds, krill, whales, and other mammals; gray whales (*page 18*); kelp forest canopies; and rocky shore habitats.

The Site Characterization document continues to be an important tool in summarizing what we know about the Sanctuary's physical setting and biological communities and continues to be heavily used by the public. This year we added hundreds of references to the online bibliography. We also initiated new studies

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The Sanctuary and Moss Landing Marine Laboratories provided logistical support for attaching satellite transmitters to two leatherback sea turtles. (See article, pages 16-17.)

characterizing the Sanctuary's cultural resources as well as invertebrates that dwell on the continental shelf. Mapping projects by the USGS and CDFG are also providing new insights into Sanctuary seafloor geology and critical habitats.

The research team participated in research cruises aboard MBARI's *Western Flyer*, Moss Landing Marine Labs' *John Martin*, and NOAA's *McArthur*. We also took advantage of NOAA's airplane, the *Shrike AeroCommander*. These collaborative efforts included exploring the Davidson Seamount (*page 8*); assessing krill, bird and mammal populations; and tagging leatherback turtles (*page 16*). Using the *Deep Worker* submersible for SSE, we were able to photograph the seafloor associated with no-fishing reserves and potential communication cable routes.

Politicians, educators, scientists, resource managers, the news media, and the general public are increasingly turning to the Research Program for technical information. In addition to answering numerous minor questions, the research team produced a kelp management report, which summarizes existing information on kelp systems, harvest, and policy recommendations. This report facilitated extensive public input on the topic, and the CDFG is using it in developing its updated five-year kelp management plan. We are also working with citizen groups on a scientific assessment of human impacts to the Point Pinos rocky shores in Pacific Grove. The research team has a vision of providing near real-time summary data for the public and resource managers over the Web. We are currently developing a Web site with maps and graphs of natural resource information that should be available to view next year. In the mean time, see our Web site for numerous research technical reports. One of our publications, with many fine regional collaborators, was in the prestigious journal *Nature* and focused on impacts of harmful algal blooms.

Sanctuary Awards

SANCTUARY REFLECTIONS AWARDS

Presented at the 2000 *Sanctuary Currents* Symposium:

Public Officials: *Congressman Sam Farr, 17th District and Ms. Sally Yozell, former deputy assistant secretary, Oceans and Atmosphere, National Oceanic and Atmospheric Administration*

Citizen: *Mr. Scott Benson, graduate student, Moss Landing Marine Laboratories*

Conservation: *Mr. Steve Shimek, founder/ executive director, The Otter Project*

Education: *Mr. Mike Guardino, science teacher, Carmel High School*

Science/Research: *Dr. Francisco Chavez, biological oceanographer, Monterey Bay Aquarium Research Institute*

Business: *Duke Energy*

Organization/Institution: *The City of Santa Cruz*

Special Recognition: *Dr. Marcia McNutt, president and chief executive officer, Monterey Bay Aquarium Research Institute*

NOAA'S ENVIRONMENTAL HERO AWARD

Mr. Mark Silberstein, executive director, Elkhorn Slough Reserve

Program Support

The Sanctuary staff experienced substantial change in 2000. We welcomed two contractors onboard as government service employees, hired four new staff members, and said farewell to four talented people. We also opened a new satellite office in Cambria, co-located with the California Department of Parks and Recreation at Hearst Castle and managed by a new education specialist.

Sanctuary staff hosted delegations interested in marine protected areas from Korea and Australia as well as government staff members from the Secretary of Commerce policy department. Our national headquarters detailed an employee to our office to help with Sanctuary Advisory Council coordination and public relations. As a result, we have increased our participation with the media as well as our local, national, and international visibility by hosting media from around the United States, England, Japan, and Germany.

The Sanctuary Advisory Council continued to work with staff to establish priorities for the Sanctuary, offer a forum for presenting public issues and concerns, and provide information and advice to the superintendent. At this year's annual strategic planning session, the Council elected to focus its efforts next year on the upcoming Management Plan Review, the Sanctuary Integrated Monitoring Network, and policies addressing fiberoptic cables and desalination plants.

Council issues of interest and concern in 2000 included the kelp forest management plan, fiberoptic cable policy, SAC charter amendment, Sanctuary Integrated Monitoring Network, Duke Energy power plant expansion, and the Diver Partnership Program. As in the past, the Council worked closely with the Conservation Working Group, Research Activities Panel, Sanctuary Education Panel, and Business and Tourism Panel.

The Monterey Bay Sanctuary Foundation was busy marketing and distributing numerous educational products and managing grants in support of the Sanctuary's mission. Projects included Point Pinos tidepool facilitation, salmon/steelhead education, and Citizen Watershed Monitoring Network coordination. In cooperation with the Sanctuary, the foundation sponsored fundraising efforts that involved Robert Lyn Nelson Studios and the Ansel Adams Gallery.

Contributed Ecosystem Observations

Beach Systems

Observations of Physical Ocean Processes by the Monterey Inner Shelf Observatory (MISO)

Wave and current forcing over the continental shelf and surf zone have profound effects on all life forms within the coastal ocean, as they interact strongly with the shallowing ocean bed towards the shore. This is most obviously seen during extreme storm events when waves reshape the inner shore bed, removing massive volumes of sand to offshore bars, lowering beach levels, and increasing undercutting of sand dunes and cliffs. However even during times of low wind and wave forcing, waves and currents shape and modify the ocean bed, which provides habitats for a wide range of species. The complex interactions between the moveable sandy bed and fluid motions resulting from surface waves, wind-forced currents, internal waves, and tidal currents are still poorly understood. These are important research topics for physical oceanographers interested in understanding and modeling these processes.

In August 1999 the Monterey Inner Shelf Observatory (MISO) was established as a component of the Naval Postgraduate School (NPS) Oceanography Department's Rapid Environmental Assessment Laboratory (REAL). The facility consists of a long-term cabled instrument frame deployed near the southern end of Monterey Bay, offshore from the NPS property. The cable end node, which can power and provide data links for up to eight instrument systems, is deployed in twelve meters of water in a sandy area, about 600 meters from the shoreline. A multi-conductor/fiberoptic cable connected to the shorefront Marine Operations Laboratory at NPS provides power and high-bandwidth data links, including multiple video channels, to data acquisition and processing computers onshore. Two additions were made to the REAL observation program early in 2000. A complete meteorological station was established on the sand dunes inshore from the MISO array, and a directional wave rider buoy was deployed ten kilometers offshore from NPS. Further information on these systems and real time graphical data from all the sensor systems can be found at: http://www.oc.nps.navy.mil/~stanton/miso/

During the first year of operation, nearly continuous observations have been made of the ocean current velocity. These include measurements of cross- and along-shore currents every 0.5 meters to the surface, high resolution water pressure time series, continuous digital video and structured light observations of the sandy bed, and acoustic altimeter mappings of the bed. The scientific emphasis has been to measure the changes in bed ripples in response to wave and current changes, since the bed ripples greatly affect the rate of wave energy loss as large swell waves travel across the continental shelf. The long-term observations at the MISO site are being used to improve wave propagation models in coastal areas so that the effects of large storm systems on the coast can be predicted more accurately.

Figure 1 illustrates the application of wave and current observations to the understanding of the inner shelf ecosystem. A two-day period of current velocity profiles has been integrated in time to infer the lateral displacement of particles in the water column at different heights above the bed. Each particle trajectory starts from the (0,0) coordinate in the figure, and the different displacement traces in the water column result from the differing, depth-dependent, time-evolving currents. For example, at 2.9 meters' height the currents are dominated by four small tidal displacement loops with a small net offshore displacement of one kilometer, whereas 12.5 meters above the bed the tidal component is much smaller than the wind-driven on-shore and long-shore currents resulting from the summer-time afternoon sea breeze typically seen across Monterey Bay. The strong vertical gradients in currents that result in these depth-dependent particle tracks are largely the result of density gradients in the water column (caused by small temperature and salinity changes with depth), which act to isolate surface wind stress from the deeper water column.

Understanding the physical oceanography of the water column and bottom boundary at inner shelf sites will allow more complete models of biological processes like cross-shelf larval transport to be developed.

– Timothy Stanton
Oceanography Department,
Naval Postgraduate School

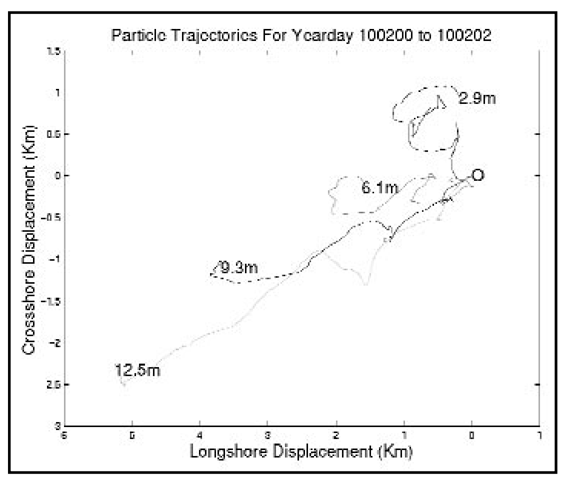

Figure 1: The displacement of neutral particles released at different depths in the water column at the MISO instrument frame from July 18 to 19, 2000. These particle trajectories are inferred from time integrations of the 1 Hz acoustic Doppler profiler measurements of current velocities.

The PISCO Project

Nearshore marine ecosystems are an important regional resource. They support societal and economic activities ranging from fisheries and kelp harvesting to tourism and recreational activities. These ecosystems are subject to many human pressures that can impact their natural state. However, marine ecosystems are ecologically complex and the ecological processes that influence them range from large-scale oceanographic and climatic events (El Niño and La Niña events, for example) to small-scale processes such as competition and predation. The differences in scale at which these processes operate have a profound importance in our understanding of how these ecosystems work. This complexity has been a major stumbling block in developing the scientific basis for management and conservation of coastal marine resources.

In January 1999 the David and Lucile Packard Foundation awarded a grant to support the activities of a consortium of scientists at four universities: Oregon State University, the Universities of California at Santa Cruz and Santa Barbara, and Stanford University's Hopkins Marine Station. The general goals of the consortium are to overcome two major impediments to conserving marine ecosystems: (1) a lack of understanding of the ecological processes that influence coastal ecosystems and (2) the slow transfer of new scientific knowledge to the public and policy makers. The consortium, *Partnership for Interdisciplinary Studies of Coastal Oceans* (PISCO), offers a new model for addressing these issues. Our emphasis is on regional-scale, multidisciplinary research on the ecology of biological communities that inhabit coastal rocky reefs and developing policy links needed to foster new programs in marine conservation. We at UCSC are responsible for the PISCO research program being carried out within the Monterey Bay National Marine Sanctuary.

Our research program has four main elements. First, we use a variety of oceanographic instruments to measure coastal currents and biological productivity. These instruments measure how oceanographic features such as upwelling result in different patterns of water flow and productivity. Second, we measure the delivery of larvae to adult populations that inhabit both intertidal and subtidal rocky reefs. We do this with larval collectors on moorings *(Figure 1)* and at intertidal sites. Together, this information gives unique insight into the coupling of large-scale and small-scale oceanographic events and the resultant delivery of larvae that replenish populations on reefs ("larval recruitment"). Third, we ascertain the consequences of this larval recruitment by monitoring changes in both intertidal and subtidal communities. These monitoring surveys include a wide range of intertidal and subtidal sites ranging from north of Monterey Bay to the southern end of the Big Sur coast. Finally, the community patterns gleaned from these surveys direct experiments we conduct to identify the importance of particular ecological processes – competition and predation, for example – that are responsible for modifying or maintaining the patterns generated by larval recruitment.

The cross-disciplinary emphasis of PISCO provides some unique opportunities to address questions central to coastal marine ecology and to incorporate this information into conservation applications. For example, we are exploring the interconnectedness of populations of organisms at different sites using the genetic and natural chemical markers of individual organisms. These markers include chemical elements that are incorporated into the ear bones (otoliths) of young fishes, which can then be analyzed to identify the sites of origin and movement patterns of these larvae. This information is supplemented with genetic fingerprinting to provide another means of inferring movement patterns.

Understanding the movement and interconnectedness of populations has important consequences for management and conservation. In particular, the effects of marine reserves are dependent on the degree and distance to which populations within reserves contribute to the replenishment of fished populations outside reserves. This is one reason why PISCO-UCSC is including three marine reserves (Hopkins, Point Lobos, and Big Creek) in our subtidal and intertidal sampling programs.

In the short period since PISCO's inception, we have been involved in a wide range of activities. Our first year was spent developing both monitoring and experimental protocols, and results from 2000 have already provided us with our first insights into the temporal variability of intertidal and subtidal community patterns and processes. In addition, we have supported many graduate students and undergraduate interns to help develop sampling procedures that will be used throughout the consortium-wide study. By the end of 2001, we expect to begin synthesizing these regional scale studies and communicating results to the public and policy makers.

For more information on PISCO, visit our Web site: www.piscoweb.org.

– Craig Syms
Department of Ecology and Evolutionary Biology,
University of California Santa Cruz

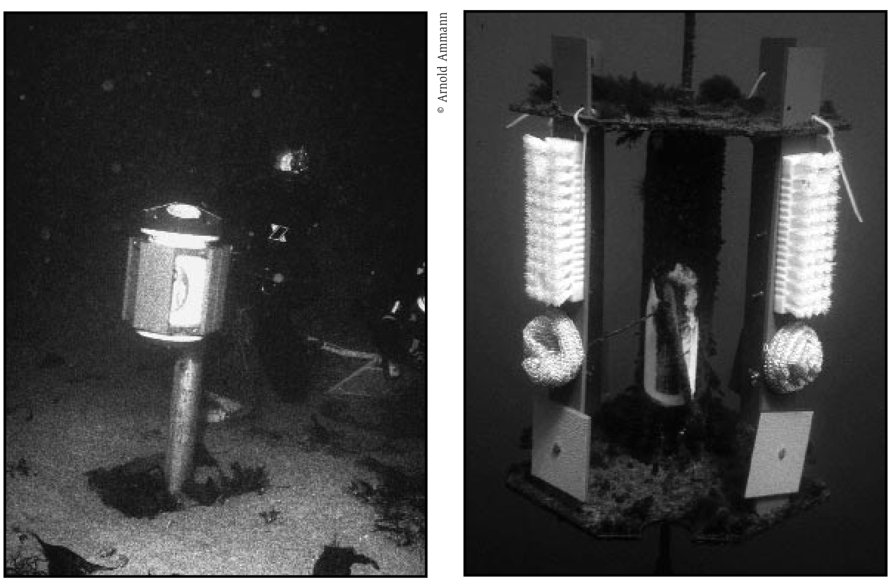

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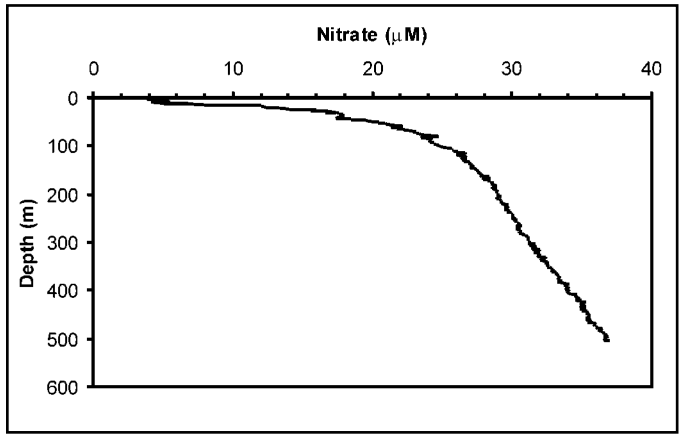
Figure 1: Current profilers (left) measure direction of water flow, while settlement collectors (right) measure larval delivery to the reef.

MUSING on Monterey Bay

Toxic algal blooms and dramatic fluctuations in fisheries demonstrate that living resources in our national marine sanctuaries are vulnerable to chemical and biological changes. In Monterey Bay and the waters of the California Current, wind-driven upwelling supplies the upper ocean with major nutrients such as nitrate and silicate. This nutrient supply, coupled with light, fuels the production of plankton – the basis of our Sanctuary's biological riches. However iron, which is also required for plankton growth, is not abundant in upwelled water. Instead iron comes from seafloor sediments that are resuspended in the ocean during natural iron fertilization events caused by strong winds.

Monterey Bay Aquarium Research Institute (MBARI) plans for monitoring the chemistry and biology of the Monterey Bay National Marine Sanctuary include instruments at the sea surface and on the seafloor, as well as mobile units – all contributing to long-term observations. The **M**BARI **U**pper-Water-Column **S**cience **E**xperiment (MUSE) was a step toward implementing these plans, with a study of the interrelationships between the physics, chemistry, and biology of coastal upwelling systems. MUSE embraced a range of science investigations, from natural iron enrichment to the biological and geochemical responses to upwelling, and culminated in a Monterey Bay field experiment in August 2000.



Profile of increase in nitrate with depth to 500 meters, as determined with the in situ ultraviolet spectrometer.

The two-week MUSE experiment was designed to study natural iron fertilization. It involved the use of moorings, autonomous underwater vehicles (AUVs), drifters, and underwater gliders, with the support of eight research ships. The weather cooperated nicely, with a series of small upwelling events followed by relaxation of the upwelling as the wind died. We traced the process with a number of novel tools: a towed, undulating vehicle with chemical sensors (the "Smart FISH"), two AUVs, and Navy and NASA aircraft. Scripps Institution of Oceanography and the University of Washington operated gliders and vehicles in the region, as well.

Francisco Chavez © 2000 MBARI

MBARI scientists deploy an OASIS drifter from the R/V New Horizon, a Scripps Institution of Oceanography vessel.

After an initial survey of the region, MBARI instrumented drifters were deployed to track the ocean fronts that separate cold, upwelled water from warmer water masses. One drifter, released north of Davenport, moved south with upwelling-favorable winds, turned east into Monterey Bay, and then went north. After a week the drifter came nearly full circle, as we recovered it near Davenport. Another drifter was deployed further north, near Año Nuevo. Instrumentation on the drifters showed that they stayed with the cold pools of water in which they were deployed. Daily experiments were conducted in the cold water mass marked by the drifter and at control areas outside the cold mass. During the evenings we conducted surveys from Año Nuevo to Cypress Point to map iron, nitrate, and inorganic carbon concentrations and the subsurface physical structure.

In a tremendous advance for real-time measurements of plankton distributions, MBARI DNA probes revealed a major bloom of *Pseudonitzschia australis*, a toxic diatom. The distribution of this diatom was inversely related to iron concentrations, but it wasn't clear if the relationship was driven by iron abundance or simply a result of bloom formation. A series of ship-board experiments showed strong iron limitation in our coastal waters, which paralleled our field observations that the iron injected by upwelling is very rapidly lost, while other nutrients remain in the sunlit layers of the ocean.

High concentrations of iron have been observed in the region between Año Nuevo and Davenport after upwelling-favorable winds. Data gathered with the Smart FISH show that the high iron concentrations occur in regions where upwelling is bringing deep waters up to the surface. These high iron concentrations disappear within a few days after winds relax.

– Ken Johnson
Monterey Bay Aquarium Research Institute

Exploring the Davidson Seamount

Seamounts are volcanoes that rise up from the ocean floor. Their cascading slopes with outcropping cliffs, rocky fragmented bases, and sedimented valleys impinge on the mid-to-upper water column, modifying local current patterns. These factors result in highly-variable environmental conditions for life over the seamount, ranging from sediment-laden areas with few currents to exposed undersea ridgelines swept by strong currents with high densities of suspended material. Consequently, seamounts appear to support a high diversity of life both on their surfaces and in surrounding waters.

Located 120 kilometers to the southwest of Monterey, the Davidson Seamount is forty kilometers long and rises 2,300 meters from the ocean floor, yet is still roughly 1,300 meters below the sea surface. This large geographic feature was the first to be characterized as a "seamount" and was named after George Davidson, a scientist at the Coast and Geodetic Survey – the forerunner to the National Oceanic and Atmospheric Administration's (NOAA) National Ocean Service. In 1978-1979 the U.S. Geological Survey collected the first geological samples, and recent work on these same samples shows the seamount is about 12 million years old.

In May 2000 MBARI began describing biological communities on the crest and flanks of Davidson Seamount using a remotely-operated vehicle. The Monterey Bay National

Corals, such as this enormous gorgonian, are found on the Davidson Seamount.

Marine Sanctuary collaborated in this exploration by performing bird and mammal surveys over the seamount during the cruise and compiling oceanographic data taken from MBARI's research vessel, *Western Flyer*. The Sanctuary has since conducted aerial surveys from the NOAA plane *Shrike AeroCommander* to enhance the mammal observation data sets.

In addition to being geologically young and having a unique shape (most seamounts are circular) the Davidson Seamount has remarkable biological communities. Davidson has large, dense patches of sponges and apparently extremely old coral forests with individuals commonly reaching more than three meters in height *(see photo above)*. Moreover, many invertebrate species collected during the cruise were previously unknown to scientists. Perhaps related to the rich life on the seamount, the waters above Davidson Seamount appear to be a productive feeding ground and – as observed at nearby seamounts – are frequented by sperm whales and albatross.

Although samples from the recent exploration of Davidson Seamount have not been analyzed fully and new discoveries concerning Davidson Seamount and similar ocean habitats are expected upon further research, information from this year's sampling efforts have been recognized at the highest levels. On June 12, 2000 President Clinton directed NOAA to work in partnership with marine research institutions and universities to explore four unique sites in the United States, and Davidson Seamount is one of these sites of high research priority.

New technologies are enabling detailed investigations of deep-sea habitats, promising discovery of presently-unknown marine resources. We are planning future expeditions to Davidson Seamount. Greater knowledge of the biodiversity, community patterns, and function of this area will improve our options for management of these unique marine environments for the education, enjoyment, and use of generations to come.

– Andrew De Vogelaere[1], Mario Tamburri[1, 2], David Clague[2], James Barry[2], and Scott Benson[3]

[1]Monterey Bay National Marine Sanctuary
[2]Monterey Bay Aquarium Research Institute
[3]Moss Landing Marine Laboratories

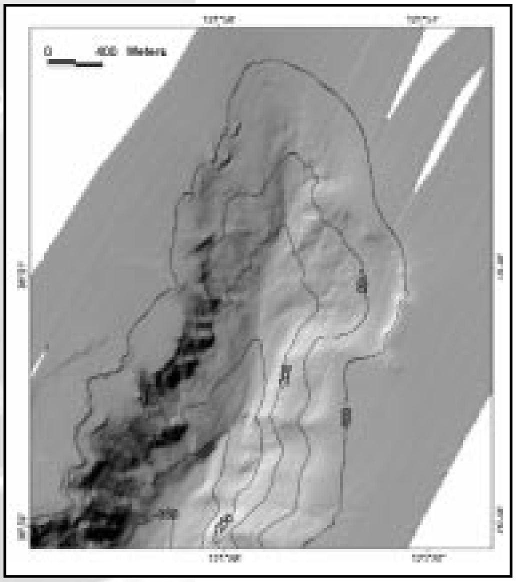
The Physical Environment

Mapping Rockfish Habitats of the Sanctuary

Rockfishes (*Sebastes* sp.; often referred to as red snapper or rock cod in fish markets) have been declining at alarming rates along much of the U.S. West Coast. Concern by sport and commercial fishers, government scientists and managers, and the general public has led to an increased effort to seek solutions for sustaining and conserving these economically important fisheries. Because many rockfish species are commonly associated with high, rugged seafloor relief, it is essential to identify and quantify areas with these characteristics.

Marine benthic habitats are identified and mapped using a suite of geophysical remote sensing tools. Unlike terrestrial habitats, which are defined by flora and fauna in relationship to altitude and climate, deep water (> 30 meters) marine benthic habitats initially are defined by substrate type, relief, and depth or by their seafloor morphology as imaged by the various geophysical mapping tools. All of these tools rely on sound to produce the images. Side scan sonographs that exhibit backscatter signals and shadows form an image that looks much like a photograph. Another recently-developed tool is the multibeam echo sounder, which also produces a photographic-like image of the seafloor that can resolve features on the order of one to three meters. Geophysical surveys are followed by on-site examination of the habitats using remotely-operated vehicles (ROVs) and manned submersibles. This approach allows confirmation of interpretations of the geophysical data and observations of rockfish assemblages associated with the habitats.

These modern habitat characterization methodologies have evolved from studies undertaken in the Monterey Bay National Marine Sanctuary. In the early 1990s a multidisciplinary approach to characterizing marine benthic habitats began with biologists and geologists from government, academic, and private scientific agencies and institutes – the National Oceanic and Atmospheric Administration (NOAA)/National Marine Fisheries Service, U.S. Geological Survey, Moss Landing Marine Laboratories (MLML), and Monterey Bay Aquarium Research Institute (MBARI) – applying their respective disciplines to the definition and understanding of these habitats. With the application of new geophysical technologies the Monterey Bay team made considerable contributions in refining habitat



Norman M. Maher © 2000 MBARI

Figure 1: Multibeam bathymetry data, artificially illuminated from the northwest, help scientists differentiate between steep rocky ledges and gentler sedimented slopes in the headward part of Soquel Canyon.

characterizations. Rockfish habitats were mapped first in Monterey Bay, at the head of Soquel Canyon *(Figure 1)*.

As progress in habitat characterization and mapping advanced, the team expanded to keep pace with the demand for delineating benthic fish habitats. In the mid-1990s the Center for Habitat Studies at MLML was formed. Seafloor mapping continued, with funds from Monterey Bay National Marine Sanctuary, UC California Sea Grant, and California Department of Fish and Game (CDFG), in the vicinity of the Big Creek Ecological Reserve. Techniques developed in the Sanctuary were used to map marine benthic habitats in Southeastern Alaska. In the late 1990s, the Monterey Bay team organized and participated in several national and international workshops to classify and characterize marine habitats, reporting on the success of their mapping activities. The Seafloor Mapping Laboratory of CSU Monterey Bay (CSUMB) was formed and convened a regional workshop on marine benthic habitat characterization and mapping in 1999, which was supported by CDFG and NOAA Special Projects.

Most recently the team, supported by CDFG and the National Sea Grant Program, has been actively involved in digitally compiling offshore geological information and recently-released industry geophysical data for the construction of marine benthic habitat maps, not only within the Sanctuary but throughout offshore California. CSUMB's Seafloor Mapping Lab used grants from the U.S. Department of Defense and CDFG to purchase a 27-foot boat with technologically-advanced multibeam and ROV systems that are being used to map benthic habitats in the Sanctuary. In addition, the excellent deep-water multibeam data collected by MBARI are being used to define deeper water habitats.

In the past year we have identified many areas within the Sanctuary that are probable deep-water rockfish habitats. Potential rockfish habitats exist at the heads of submarine canyons and on the continental shelf where eroded granitic and sedimentary rocks are exposed. During the past year extensive marine benthic habitat maps have been produced through the conversion of the California Continental Margins Geological Map series, published by the California Division of Mines and Geology, into geographical information systems (GIS).

– H. Gary Greene[1], Mary Yoklavich[2], Rikk Kvitek[3], and Norman Maher[4]

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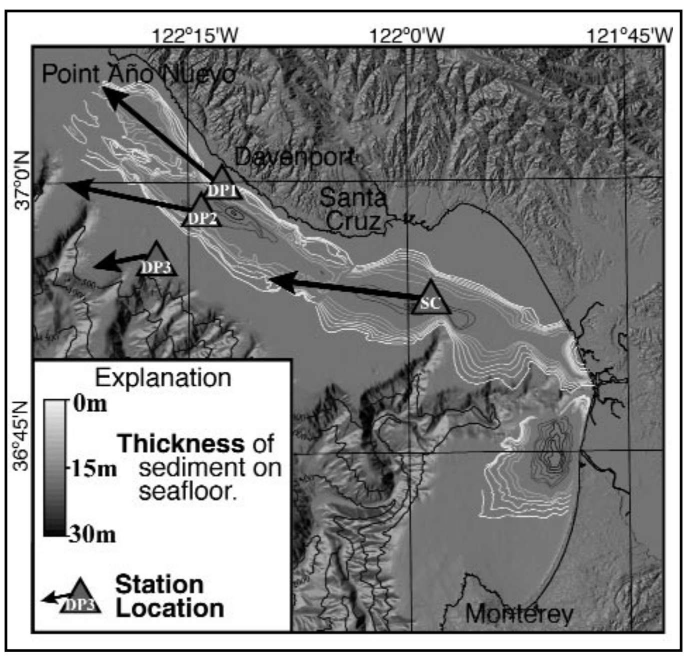
Where Does the Mud Go?

Mud and sand covering the continental shelf underlying the Monterey Bay National Marine Sanctuary are relatively young, geologically speaking. During the glacial age, ending about 18,000 years ago, the level of the oceans was much lower due to the amount of water locked up in continental ice sheets, and a large portion of today's Sanctuary was dry land. As the glaciers melted, the level of the oceans began to rise and sand and mud carried offshore from rivers began to accumulate on the continental shelf, filling in depressions and covering the once-dry surface. The process of land erosion and transport to the Sanctuary environment continues today, and recent studies are shedding light on where the mud is coming from and where it is accumulating.

The Sanctuary floor north of the Monterey Peninsula today is covered at water depths between about forty and ninety meters by a nearly continuous blanket of mud as much as thirty meters thick. The shape of this mud deposit is like a long stretched-out pancake from central Monterey Bay toward the northwest; although it may reach a maximum thickness of thirty meters, it thins both toward the land and farther offshore to thicknesses of a few meters or less. Past calculations of sediment erosion rates and river discharges by researchers at UC Santa Cruz have shown that the offshore muds may be explained by the three rivers that empty into Monterey Bay: the Salinas, Pajaro, and San Lorenzo. The amount of sediment contributed annually from sediment washed out of eroding cliffs and from gullies of smaller streams and creeks is minor in comparison.



With shaded relief as background, the mudbelt thickness is shown by contours and suspended mud transport directions are shown at four locations, as measured by current meters and turbidity sensors that recorded for one year.

Samples of this mud were collected from the seafloor to determine its source and to measure how rapidly it is accumulating. The rate of accumulation was determined by measuring profiles of the isotope 210Pb (Pb is lead, which has a half-life of twenty-two years and hence can be used to date relatively young sediment on the seafloor). The surprising finding was that accumulation rates for the muds are higher than would be expected from the rates of supply from the three rivers and other mud sources. Therefore it appears that most, if not all, of the mud delivered to the Sanctuary by the rivers is captured and deposited on the midshelf and very little escapes to deeper areas across the shelf break or down the canyon. To better understand the movement of particles in the Sanctuary and the ultimate origin of the mud deposits, current meters and other instruments were anchored to the seafloor and suspended in the water column over the belt of mud between Davenport and Santa Cruz. Measurements over a one-year period during 1997-98 at these moorings found that the mud is being transported northwestward, as far as Año Nuevo and perhaps farther, toward San Francisco.

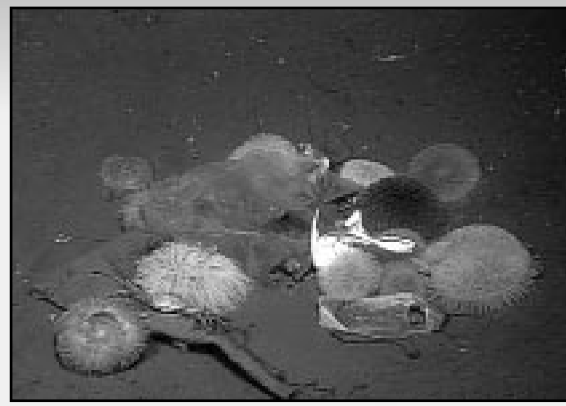
Certain areas of the continental shelf have escaped inundation by this mud blanket. Near shore in shallow water, where the pounding surf and wind-induced currents produce high-energy bottom conditions, mud that may be deposited by winter floods is rapidly re-suspended and transported away. Seaward of the mud accumulation zone, on the far outer shelf where water depth exceeds ninety meters, lies a zone of outcropping bedrock, sands, and hardgrounds that probably are all remnants from an environment when sea level stood at a position much lower than it is today. Coincidentally, that outer shelf area is also a zone of high energy conditions resulting from horizontally moving water masses and possibly breaking internal waves (very long-period waves that occur below the surface and oscillate at boundaries of very slight density differences deep in the water column).

Surrounding the Monterey Peninsula and southward, there is little evidence of significant mud accumulation on the shelf. In these areas coarse sand deposits (mostly very coarse sand and perhaps some gravel) are found out to depths beyond 100 meters. The intricate and curvilinear patterns of the boundaries around these coarse sand deposits indicate that dynamic processes, not fully understood, are responsible for maintaining the geometry of these deposits.

– Stephen L. Eittreim, Michael E. Field, and Marlene Noble
U.S. Geological Survey

Pockmarks Discovered Offshore of the Big Sur Coast

Seafloor mapping using a multibeam echosounder conducted during the summer of 1998 by Monterey Bay Aquarium Research Institute has revealed a 600 km² area of seafloor that is peppered with large circular depressions known as pockmarks. This newly-discovered pockmark field lies about 35 kilometers offshore of Cape San Martin on a gently inclined slope that ranges in depth from 900 to 1,200 meters. Individual pockmarks range in size from 130 to 260 meters in diameter and are 8 to 12 meters deep. The pockmarks are formed within soft silty-clay muds similar to those found along many continental margins. The full extent of the field was not mapped and most likely extends southward for some distance.

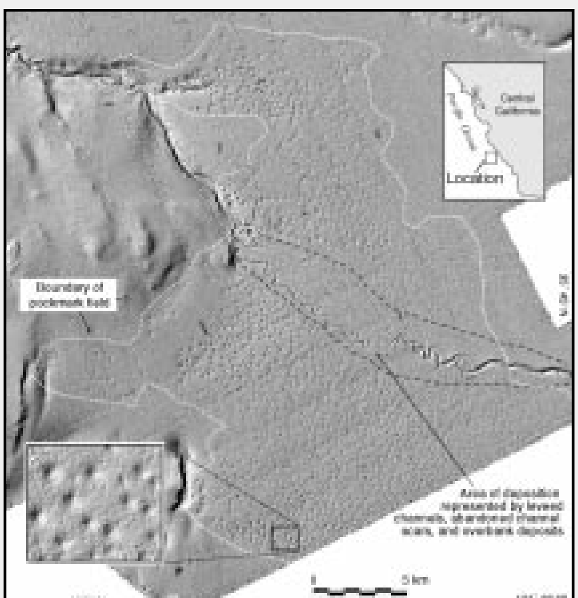


Charles K. Paull © 2000 MBARI

Small debris accumulations were found in the centers of many of the pockmarks. Benthic animals such as the pom pom anemone (Liponema sp.) and crabs were commonly found associated with the debris piles.

Pockmarks were first recognized and described in 1970 on the Scotian Shelf (offshore from Nova Scotia, Canada) and have since been found to occur in a variety of marine environments worldwide. They are particularly apparent in the North Sea, the Arabian Gulf, and other shallow seas, but have also been found in water depths up to 3,000 meters. Pockmark sizes range from less than 1 meter up to 200 meters across and from 0.5 to 20 meters in depth. As more areas of the seafloor are mapped with new generation high-resolution sonars, it is likely that more deep water pockmark fields will be discovered.

While pockmarks are generally thought to be formed by the forcible discharge of gas or fluids through the seafloor, it is likely that multiple mechanisms are responsible for their formation. The study of pockmark formation and evolution is currently an area of active research. The age and mode of formation of the Sur pockmarks have not yet been determined, but geomorphic evidence indicates that a portion of the field has been buried by channel overbank deposits and is therefore older than those deposits, which could be several thousand years old.



Shaded relief map of the Sur pockmark field based on EM300 multibeam data.

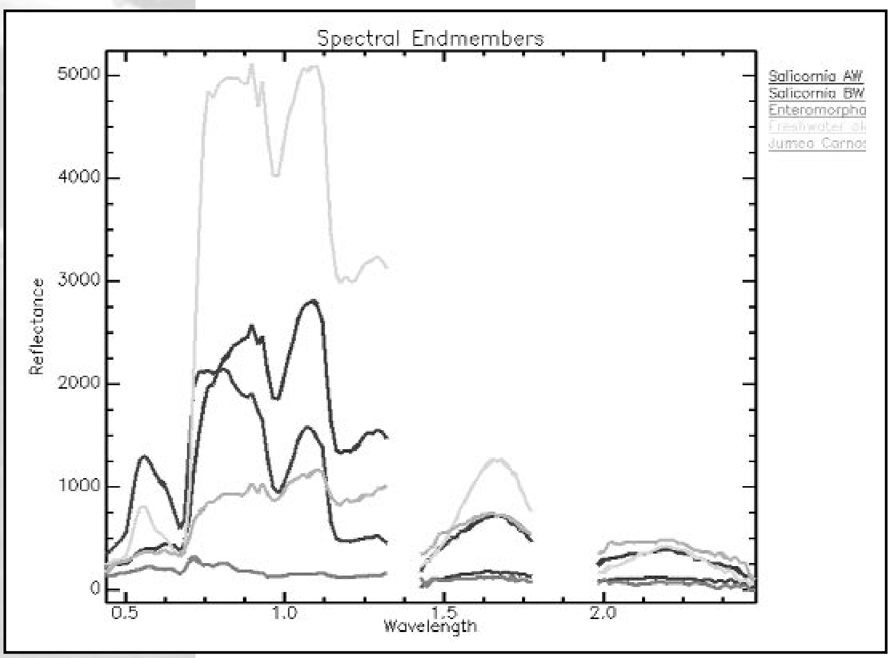
-Norman Maher
Monterey Bay Aquarium Research Institute

Hyperspectral Imaging: A New Tool for Coastal and Marine Conservation

Simply by existing at the land-sea-air interface, coastal habitats are extremely sensitive to innumerable natural and human-related disturbances. Unfortunately, investigations of environmental disturbance are often hampered by incompatibilities between the temporal and spatial scales of most natural processes and the more constrained human scales on which scientists and managers usually work. Ecologists tend to gather data from micro-scale samples (such as quadrats, transects, or experimental plots spanning up to tens of meters) and are usually limited by time, effort, and personnel availability. Managers tend to focus on macro-scales (such as jurisdictional boundaries, land parcels, or watersheds) providing a larger but less detailed overview. It is usually most difficult to work effectively at the scales where micro- and macro- processes intergrade: the scale of multiple interacting species, populations, and communities (tens of meters to tens of kilometers).

Recent developments in optical remote sensing include hyperspectral imaging, a technique that provides the larger-scale, comprehensive view needed by managers while retaining much of the ecological detail necessary to map and monitor aquatic and terrestrial species and to detect human impacts. Hyperspectral images consist of simultaneous readings of reflected energy in many (often >100) narrow (five to fifteen nanometers) contiguous spectral bands from ultraviolet to infrared wavelengths (350 to 2,500 nanometers). Hyperspectral imagers record a complete spectrum of reflected light for each pixel of the image, which, depending on the altitude of the sensor, can be smaller than one meter. Because different wetland plants, algal mats, seagrass and kelp beds, biogenous sands, and muds all absorb and reflect light differentially, according to their biochemical and mineral constituents, they can be identified spectrally. In addition, reflectance spectra of terrestrial plants are known to vary consistently under different environmental conditions – such as increased nutrients or drought – often related to human activities. These spectral changes induced by different environmental conditions open the exciting prospect of detecting human impacts in coastal and aquatic ecosystems in addition to terrestrial environments.

In October 1999 we imaged more than 400 km^2 around Monterey Bay, using HyMap, an Australian airborne hyperspectral imager with two- to three-meter pixel resolution. Twenty-four overlapping flightlines covered all of Elkhorn Slough, its entire watershed, the coastal strip and nearshore waters of Monterey Bay, and part of Fort Ord. We re-imaged

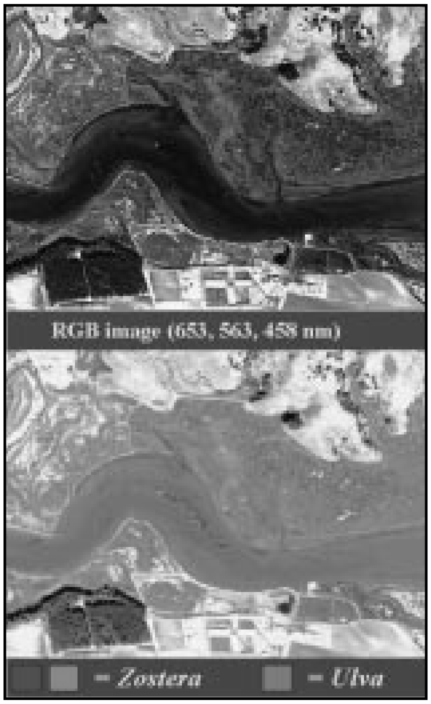


Selected spectral signatures of biological substrates used for supervised classifications in the South Marsh, Elkhorn Slough.

Subset of an atmospherically corrected HYMAP flightline, showing the high spatial resolution of the imagery.

Elkhorn Slough and its immediate surroundings in May 2000, providing data for comparison between seasons and over time. We are also using a portable hyperspectral radiometer to compile a library of spectral signatures of common biological and physical substrates gathered in the field. This library is helping us to understand natural variation in spectral responses within and among species and to detect possible consistent spectral shifts due to human-related impacts (such as agricultural runoff) into the Slough waters.

We have successfully mapped the ecologically most important species in test areas of Elkhorn Slough, including the distributions of some native and invasive species in the



Supervised classification (bottom panel) showing eelgrass distribution in the main channel of Elkhorn Slough.

Slough's south marsh. The October 1999 imagery provides extensive baseline information for future monitoring of critical habitats for many rare and endangered species of birds, invertebrates, and fish that reside permanently or seasonally in the area. For example, because of the critical role provided by eelgrass meadows as nurseries for a variety of marine fauna and their widespread decline in recent years, monitoring their distribution rapidly and objectively, as can be accomplished with hyperspectral imagery, is fundamental to their conservation.

We have also been exploring the use of hyperspectral imagery for water quality monitoring in the Slough, motivated by the long-term water quality data that show an unequivocal and dramatic increase in water nitrate concentrations in recent years. We examined spectral signatures in the imagery from two beds of the dominant wetland succulent *Salicornia virginica* (pickleweed) in areas bathed by waters differing in nitrate concentrations by an order of magnitude. Preliminary results indicate spectral shifts that correlate with water nitrate levels and that are similar to changes in reflectance spectra that have been reported for terrestrial vegetation responding to nitrogen fertilization. A comprehensive map of pickleweed spectra developed with hyperspectral imagery would provide managers with knowledge of large-scale patterns of water nutrient distributions not readily apparent from the finite number of monitoring stations available in the Slough today.

All currently-operational hyperspectral imagers are carried on aircraft, but the first experimental hyperspectral satellite (the EO-1 spacecraft carrying NASA's Hyperion imager) was successfully launched in November 2000. The extremely fast pace at which this technology is evolving will soon provide satellite-borne hyperspectral sensors with resolution capabilities that today are available only from low-flying aircraft.

This work, a collaboration between the University of California Santa Cruz and the Lawrence Livermore National Laboratory, is part of a three-year project funded by the Cooperative Institute for Coastal and Estuarine Environmental Technology.

– Daria Siciliano and Donald Potts
University of California Santa Cruz

Vegetative Buffer Strips

Water quality in many surface waters in the contiguous forty-eight states fails to meet the goals of the Clean Water Act of 1972. The severity of the problem is illustrated by the nutrient-rich water (largely derived from rainfall runoff from farms) entering the Gulf of Mexico from the Mississippi River. The river has created a plume in the Gulf, called the 'dead zone,' which can be 7,000 square miles in size. Fortunately, water quality in Monterey Bay is good compared to the Gulf of Mexico, since it is well mixed with the Pacific Ocean. Nevertheless, surface waters in Pajaro Valley, the Elkhorn Slough Estuary (in areas with limited mixing with the bay), and Salinas Valley have elevated nitrate levels.

Vegetative buffer strips can successfully reduce pollutants generated by rainfall runoff from entering surface waters. Vegetative buffers are areas of vegetation that capture pollutants physically or transform them to non-mobile (such as soil organic matter) or gas (such as di-nitrogen, nitrous oxide) forms. Their success is best documented along the Atlantic Coastal Plain, but has been promoted in many states.

With funding from the National Oceanic and Atmospheric Administration, vegetative buffer strips were established in Elkhorn Slough to test their efficacy in removing sediments and nutrients before they entered the Slough. Three treatments – an annual grass, a mix of native perennial grasses, and an "unplanted" (weedy) treatment – of buffers were established to receive runoff from row crops.

All buffer treatments successfully reduced sediments within the first few meters of the buffers after above-ground biomass had become well established. Sediment removal was due to increasing water infiltration and slowing runoff velocities in the buffers that allowed sediment deposition.

However, nutrient capture is more complicated because its removal is biologically mediated. In contrast to the Atlantic Coastal Plain, rainfall along the Monterey Bay coast is restricted to the winter months; thus processes that remove nitrogen vary dramatically on a seasonal basis. I found that nitrogen was captured by growing plants and soil microbes in the winter and spring, which suggested that grass buffers assimilate nitrogen from agricultural runoff. In contrast to the winter and spring, plant material and soil microbes died in the summer and fall. Because of their death, nitrate and ammonium forms of nitrogen, which were previously captured in the spring, were released into the soil. High concentrations of soil nitrate in the fall can be carried to the Slough after the first rainfall events through subsurface flow. Results from all three treatments suggest that nitrogen retention by vegetative buffers in California may not be as successful as grass buffers in other parts of the country.

Nitrogen cycling in soils is one source of the trace gas nitrous oxide – a greenhouse gas. In the buffers established, the estimated trace gas emissions were extremely high. Therefore, even though nitrogen is being removed from groundwater before entering Elkhorn Slough, some of the nitrogen is converted to a greenhouse gas. Vegetative buffers convert a water pollutant into an atmospheric pollutant, although the significance of this source of nitrous oxide is currently under investigation. This study should be used to highlight some limitations for using vegetative buffer strips to reduce nitrogen pollution. Instead, vegetative buffer strips should be seen as only one potential strategy and used in concert with other strategies to control nitrogen losses from agricultural fields.

–Marc Los Huertos
University of California Santa Cruz

"Snapshot Day": Volunteers Take the Pulse of Sanctuary Watersheds

On Earth Day 2000 the Monterey Bay National Marine Sanctuary helped lead the charge in the largest simultaneous water quality monitoring effort to occur in California. More than 120 trained volunteers participated in "Snapshot Day," a Sanctuary-wide volunteer monitoring event designed to increase public awareness about water quality issues affecting watersheds that drain to the Sanctuary.

Armed with test tubes, thermometers, buckets, and cameras, volunteers fanned out into the Sanctuary's eleven major watersheds, from Pacifica to Cambria. By early afternoon, volunteers had tested eighty-nine rivers and creeks at 122 different sampling sites, spanning over 300 miles of the central coast. They monitored for air and water temperature, dissolved oxygen, pH, conductivity, nutrients, and bacteria levels.

The results showed overall water quality in many of the Sanctuary's watersheds to be very good. The volunteer data did indicate problems, however, in several watersheds. Eighteen sampling sites displayed high levels of fecal coliform bacteria, indicating waters unsafe for contact. Sixteen sites were found to have high levels of nitrates or phosphates, which can have negative impacts on aquatic life. These contaminants were found in both urban and rural locations. Several rivers and creeks also showed low levels of oxygen, which all aquatic animals need to breathe.

The data collected from Snapshot Day help establish much-needed baseline information about the health of Sanctuary watersheds as well as flagging potential problem areas. Currently, fewer than 5 percent of California's water bodies are tested on a regular basis by government agencies, due to lack of funds and/or staff. The information collected from Snapshot Day in 2000 and subsequent years can be used by resource managers to help make planning decisions and protect Sanctuary resources better.

Snapshot Day was organized as part of the Monterey Bay Sanctuary Citizen Watershed Monitoring Network, established by the Coastal Watershed Council, the Center for Marine Conservation, the Regional Water Quality Control Board, and the California Coastal Commission in partnership with the Sanctuary's Water Quality Protection Program. The Network supports the year-round efforts of approximately twenty existing volunteer monitoring groups throughout the Sanctuary and its watersheds. Its goals are to ensure high quality data, to facilitate public and agency use of that data, and to increase public stewardship of local waterways within the Sanctuary's watersheds.

For a more detailed look at Snapshot Day results, see the Snapshot Day Report on the Sanctuary's Web site: www.mbnms.nos.noaa.gov/Resourcepro/network.html.

–Susan Pufahl[1], Kaitilin Gaffney[2], Maya Conrad[3], and Ross Clark[4]

[1]Monterey Bay National Marine Sanctuary
[2]Center for Marine Conservation
[3]Coastal Watershed Council
[4]California Coastal Commission

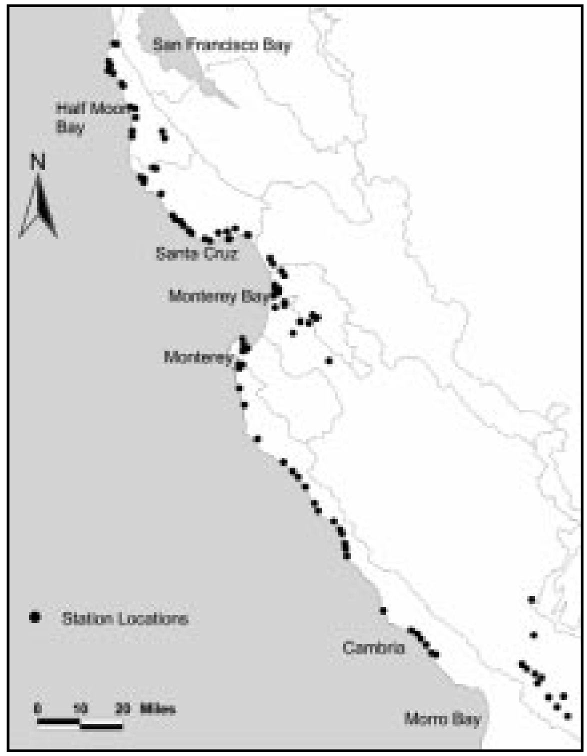


Figure 1: Snapshot Day 2000. Locations of all Snapshot Day stations. Stations are depicted as a dot (●). The watershed boundaries are depicted on the figure.

Roller Coaster Year for Caspian Terns at Elkhorn Slough

For the first time in five years, hundreds of Caspian terns, the world's largest tern, nested at Elkhorn Slough. For several years in the early 1990s, the colony had thrived on an island in the Slough's restored South Marsh. Then, in 1995, disaster hit and few chicks hatched and even fewer fledged. Research by J. Parkin suggested that the crash was due to DDT and other contaminants entering the watershed during heavy flooding. In the following years, only a few terns nested on the island, and these abandoned it after their eggs were destroyed by an unknown predator.

This year, the terns were back in large numbers, with high hatching success. In late June there were about sixty-five active nests, most with a single small chick. Unfortunately, the colony was attacked by raccoons (identified by footprints) at the end of July. Our subsequent survey revealed about forty chick carcasses strewn about the abandoned island, and only four of the largest fledglings appeared to have survived. The threat of pesticides is diminishing, thanks to successful efforts to control agricultural erosion in the watershed. Now, methods must be developed to keep raccoons from the island, so that these spectacular birds can again breed in large numbers at Elkhorn Slough.

– Bruce Lyon, Department of Ecology and Evolutionary Biology, UCSC
– Kerstin Wasson, Research Coordinator, Elkhorn Slough Reserve

© 2000 Bruce Lyon

Both adults and chicks vocalize frequently, so the tern colony is a raucous place.

Examples of Endangered and Threatened Species in the Sanctuary

Before an animal species can receive protection under the Endangered Species Act, it must first be placed on the federal list of endangered and threatened wildlife. An "endangered" species is one that is in danger of extinction throughout all or a significant portion of its range. A "threatened" species is one that is likely to become endangered in the foreseeable future. More than 55 percent of all the species federally listed as threatened or endangered reside in California. Twenty-six of these reside within the Sanctuary. One Sanctuary resident, the American Peregrine Falcon, brings a hopeful sign for the future. It was removed as a threatened species in August 1999 due to the species' recovery but will be monitored closely for the next five years. The tidewater goby is currently under consideration for delisting in the future.

ENDANGERED AND THREATENED SPECIES

Organism	Habitat and Time of Year of Most Common Sightings	Federal Status *(Date Listed)*	Population at Height	Current Population	Current Trend in Population (+/-)	Major Initial Causes of Mortality
CETACEANS						
Sei whale *(Balaenoptera borealis)*	Deep water during upwelling	Endangered *(02-Jun-70)*	256,000 (world)	57,000 (world)	–	Commercial whaling
Blue whale *(Balaenoptera musculus)*	Deep water during upwelling	Endangered *(02-Jun-70)*	228,000 (world)	1,716 (California)	+	Commercial whaling
Finback whale *(Balaenoptera physalus)*	Deep water during upwelling	Endangered *(02-Jun-70)*	300,000-65000 (world)	40,000 (Northern Hemisphere)	–	Commercial whaling
Humpback whale *(Megaptera novaeangliae)*	Water >300m during upwelling	Endangered *(02-Jun-70)*	>100,000 (world)	10,000 (world)	+	Net entanglement; collisions with ships; noise disturbances; pollution; and competition with fisheries for prey
Right whale *Balaena glacialis)*	Water >300m during upwelling	Endangered *(02-Jun-70)*	100,000 (world)	200 (Pacific Ocean)	+	Commercial whaling; ship collisions; and net entanglement
Sperm whale *(Physeter macrocephalus*)	Water >600m during upwelling	Endangered *(02-Jun-70)*	>2 million (world)	N/A	+	Commercial whaling
PINNIPEDS						
Guadalupe fur seal *(Arctocephalus townsendi)*	Sanctuary sightings are rare	Threatened *(16-Dec-67)*	20,000 - 100,000 (Pacific Ocean)	7,400 (Pacific Ocean)	–	Commercial hunting; coastal development; and competition with fisheries for prey
Steller sea lion *(Eumetopias jubatus)*	Año Nuevo/ mid-August	Threatened *(5-Apr-90)*	282,000 (Pacific Ocean)	500 (California)	–	Reduced prey availability; disease
FISSIPED						
Southern sea otter *(Enhydra lutris nereis)*	Inshore and kelp forests/ year round	Threatened *(14-Jan-77)*	20,000 (Pacific Ocean)	2,300 (California)	+	Commercial hunting
LAND MAMMALS						
Salt marsh harvest mouse *(Reithrodontomys raviventris)*	Coastal salt marshes/ year round	Endangered *(13-Oct-70)*	N/A	< 2,000 (California)	N/A	Loss of habitat due to land development, water treatment plants, and flooding
BIRDS						
American Peregrine Falcon *(Falco peregrinus anatum)*	Beaches, dunes, and Elkhorn Slough/ year round	Delisted *(5-Aug-99)*	1,000 pairs (western U.S.)	167 pairs (western U.S.)	+	Pesticides causing thin egg shells
California Condor *(Gymnogyps californianus)*	Near Big Sur/ year round	Endangered *(11-Mar-67)*	N/A	50 (in wild)	+ slowly	Human-related habitat loss and reduced food supply
California Brown Pelican *(Pelicanus occidentalis californicus)*	Along coast/largest concentration in mid-summer	Endangered *(13-Oct-70)*	N/A	4,500 breeding pairs	stable	DDT causing thin egg shells
California Clapper Rail *(Rallus longirostris obsoletus)*	Tidal slough/year round	Endangered *(13-Oct-70)*	N/A	< 1,000 (California)	N/A	Loss of habitat due to urban runoff; contamination of food supplies
Western Snowy Plover *(Charadrius alexandrinus nivosus)*	Dry stretches of beaches/ Mar.- Sept.	Threatened *(05-Apr-93)*	N/A	1,386 (world)	–	Loss of nesting habitat
Marbled Murrelet *(Brachyramphus marmoratus)*	Coastal waters/year round	Threatened *(30-Sept-92)*	60,000 (California)	2,000 - 5,000 (California)	–	Habitat disturbances including logging in nesting areas and oil spills; and fishing net fatalities
TURTLES						
Green sea turtle *(Chelonia mydas)*	Early fall after upwelling	Threatened *(28-Jul-78)*	N/A	200-1,100 nesting females on US beaches	N/A	Commercial harvesting; caught as incidental catch during commercial shrimp trawling
Leatherback sea turtle *(Dermochelys coriacea)*	Early fall after upwelling	Endangered *(02-Jun-70)*	N/A	29,000-40,000 (world)	–	Disturbance of nesting grounds; egg harvesting; hunted for oil; eating plastic waste

Endangered and Threatened Species (continued)						
Organism	**Habitat and Time of Year of Most Common Sightings**	**Federal Status *(Date Listed)***	**Population at Height**	**Current Population**	**Current Trend in Population (+/-)**	**Major Initial Causes of Mortality**
Pacific Ridley sea turtle *(Lepidochelys olivacea)*	Early fall after upwelling	Threatened *(28-Jul-78)*	N/A	N/A	–	Commercial harvesting
Loggerhead sea turtle *(Caretta caretta)*	Early fall after upwelling	Threatened *(28-Jul-78)*	N/A	N/A	–	Caught during shrimp trawling; coastal development
FISHES						
Chinook salmon - winter *(Oncorhynchus tshawytscha)*	mid-water ocean; rivers to spawn	Endangered *(03-Feb-94)*	N/A	N/A	–	Habitat degradation; dams; drought
Chinook salmon - fall/late fall *(Oncorhynchus tshawytscha)*	mid-water ocean; rivers to spawn	Candidate *(16-Sep-99)*	N/A	N/A	–	Habitat degradation; dams; drought
Chinook salmon - spring *(Oncorhynchus tshawytscha)*	mid-water ocean; rivers to spawn	Endangered *(15-Nov 99)*	N/A	N/A	–	Habitat degradation
Coho salmon - central California *(Oncorhynchus kisutch)*	mid-water ocean; rivers to spawn	Threatened *(31-Oct-96)*	N/A	N/A	–	
Steelhead - central California *(Oncorhynchus mykiss)*	river basins	Threatened *(18-Aug-97)*	N/A	100 -1300 (<1% of the height of abundance)	–	Habitat degradation due to hydropower development; dams; increased sedimentation
Steelhead - south/central California *(Oncorhynchus mykiss irideus)*	river basins	Threatened *(17-Oct-97)*	N/A	N/A	–	Habitat degradation
Tidewater goby *(Eucyclogobius newberryi)*	river mouths; estuarine waters	Endangered *(04-Feb-94)*	N/A	N/A	+	Habitat loss; pollution

Compiled by Jennifer Makowka, Monterey Bay National Marine Sanctuary.
N/A = Data not available

Status of Steelhead and Coho Salmon in Coastal Watersheds Entering the Sanctuary

We are very close to losing coho salmon from coastal streams of the Monterey Bay National Marine Sanctuary. The only remaining streams in the Monterey Bay region having adult coho salmon runs in most years are Scott and Waddell creeks, located in northern Santa Cruz County. They have been lost from the larger San Lorenzo River and Soquel Creek watersheds, and a recovery plan is underway. Steelhead populations are faring better than coho around the Sanctuary. Since the drought of 1987-92, higher annual rainfall has allowed increased juvenile populations in most watersheds with some population stability. Most of the major coho and steelhead watersheds entering the Sanctuary are described briefly below.

In **Scott and Waddell** creeks, coho populations have been severely reduced by natural phenomena such as drought and late winter storms as well as water diversions, erosion induced by logging, and a toxic chemical spill on Waddell Creek. The mouth of Scott Creek is negatively impacted by the Highway 1 bridge, which often delays the opening of the sandbar to allow upstream migration and causes premature sandbar closure in the spring. Adult coho populations are unstable at 100 to 200 in Waddell and 100 to 500 in Scott Creek. Steelhead, with their more flexible life history for spawning and rearing, are faring better at stable adult populations of 200 to 400 in each creek.

Courtesy of Pacific Northwest National Laboratory.

Steelhead swimming upstream.

The San Lorenzo River watershed is impacted by the flood control channel through Santa Cruz; the artificial breaching of the summer sandbar at the river mouth, which destroys lagoon nursery habitat; water diversion, which makes spawning migration difficult, if not impossible; and accelerated logging without adequate regulation and enforcement. The San Lorenzo River supports approximately 2,500 steelhead adults and 150,000 juveniles.

The Soquel Creek watershed is threatened by suburban sprawl in the lower valley, with proposed winter water diversion and increasing amounts of impermeable surfaces that increase winter storm flows, washing away steelhead nests and reducing summer base flow important for rearing juveniles. Increased logging without adequate environmental protection has accelerated erosion and sedimentation. The lower five miles of Soquel Creek have lost substantial riparian vegetation to stream bank erosion, and few steelhead use this reach for rearing, presumably due to high summer water temperatures and poor spawning success. Soquel Creek supports 500 to 800 adult and 50,000 juvenile steelhead.

The large **Pajaro River watershed** is being devastated by human development outside Santa Cruz County. Municipal water diversion, reservoirs, and agricultural pumping have drastically reduced rearing habitat throughout. Steelhead habitat exists only in the upper headwaters of tributaries. Thus, successful adult passage to spawning grounds and successful smolt passage to Monterey Bay are critically important. The lower reaches of most Pajaro tributaries go dry in summer. If they become dewatered earlier in spring, smolt migration will become even more tenuous. During the past drought, only hatchery augmentation maintained the Pajaro steelhead population, which probably numbers in the low to mid hundreds as adults.

Though the steelhead run of **the Carmel River** has rebounded from near extinction since the drought to 500+ adults counted at the San Clemente Dam in the late 1990s, the population is maintained by an active rescue effort. This involves relocating juveniles from the lower river to perennial habitat below San Clemente Dam each summer/fall, as municipal well pumping dewaters the lower valley. Adults must be trapped and trucked above Los Padres Reservoir in winter to access 15+ miles of the best habitat. Spawning and rearing habitat in the lower watershed has become severely degraded from sedimentation caused by increased agricultural development (vineyards) and is further threatened by sediment to be released from behind San Clemente Dam.

In **the Santa Rosa Creek watershed**, juvenile steelhead in the lower valley are restricted to shallow pools – primarily under woody debris and overhanging willows – and in the upper canyon, to deeper pools, hiding under banks protected by riparian trees and under large boulders. Potentially increased water development that would further reduce summer base flow is a concern here. Recent agricultural conversion from cattle grazing to vineyards may result in increased stream sedimentation with reduced summer base flow. The juvenile population has increased steadily since the drought, to about 50,000, with a probable adult run of 200 to 400 fish in this important southern watershed.

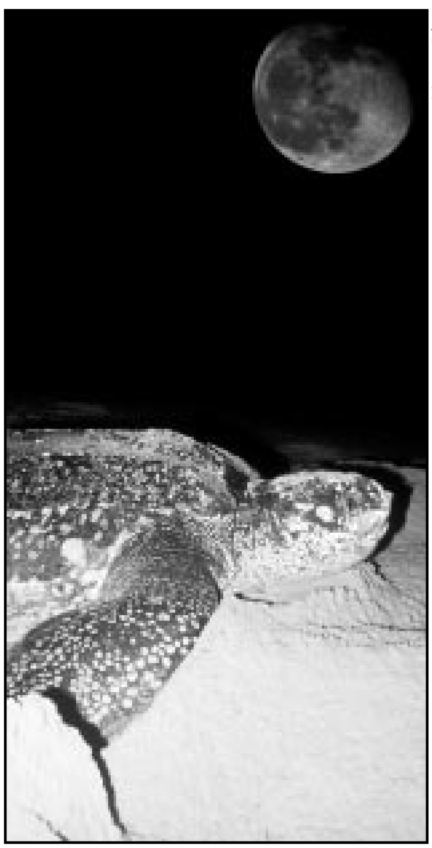
Although juvenile steelhead numbers have improved, coho have been lost from major watersheds and risk extinction within the Sanctuary. Coho and steelhead habitat is threatened throughout the Sanctuary from increased water development, urbanization, flood control projects, marine mammal predation, agricultural conversion, and destructive logging practices. The California Forest Practices Rules must be strengthened, and long-term monitoring and maintenance of erosion control measures should be instituted after timber harvest to allow further coho and steelhead recovery. No-cut buffers should be established and enforced along all watercourses in all timber harvest zones, residential areas, and agricultural lands to protect remaining habitat.

– Donald Alley
D.W. Alley & Associates, Aquatic Biology

Following the Leatherback Sea Turtle

One of the greatest mysteries of the sea turtle world is where the pelagic leatherback (*Dermochelys coriacea*) spends its time. The leatherback is the largest turtle in the world and has the widest geographic range of any reptile. It is found in all of the world's major oceans and has been observed from the Arctic Circle to the edges of the Antarctic convergence zone. Leatherbacks are also one of the deepest diving animals known – descending to depths in excess of 1,300 meters. We have monitored individuals as they circumnavigate entire ocean basins – distances of more than 10,000 kilometers – in a single year. To observe or study leatherbacks is extremely difficult, however: not only do they range across open oceans, they rarely stop swimming and they spend more than 80 percent of their lives underwater. For these reasons, their activities in the open sea remain poorly understood.

Yet understanding the oceanic movements of this turtle, and applying this knowledge to related management issues, is critical to its survival. The leatherback is the world's most endangered sea turtle, with populations in the Pacific Ocean declining at a disastrous rate. Since 1980 leatherback populations in the Eastern Pacific have dropped by more than 90 percent, and the accidental killing of leatherbacks by high-seas commercial fishing fleets is a major contributor to that decline.

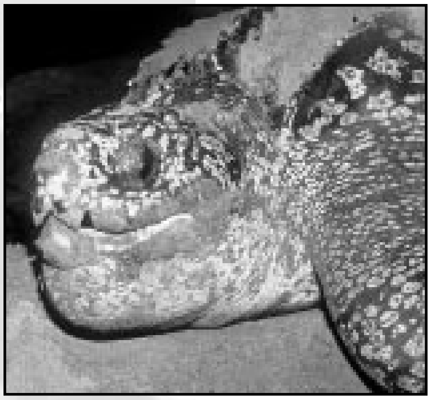

© Scott A. Eckert

Female leatherbacks come ashore at night to lay eggs on beaches.

Without a clear understanding of the habitat needs and migratory pathways of this species, we are unable to develop sound methods to reduce this source of mortality. One study suggests that if current trends continue the leatherback will become extinct in the Pacific Ocean within the next ten years.

Satellite telemetry has become a vital tool in our efforts to understand this species' use of the oceans. In our studies, we have monitored the movements of female leatherbacks from nesting beaches in the Atlantic and the Pacific and discovered that these turtles make extraordinary post-nesting migrations of tens of thousands of kilometers, sometimes along distinct oceanic corridors. However, getting access to the turtles in order to attach transmitters is challenging. In all past studies transmitters were attached to females during nesting (when the turtles were on land and therefore accessible). Further, due to technical challenges most tracking cycles have been limited to less than a year in duration, with our longest track covering eighteen months – whereas in the Pacific leatherback females only return to nest every three years. Where do they travel in the intervening years and what habitats are important to this global wanderer? These are questions that we have yet to answer.

This summer, with the financial support of our home institutions (National Marine



Charles K. Paull © 2000 MBARI © Scott A. Eckert

Leatherback sea turtle.

Fisheries Service and Hubbs Sea World Research Institute) and Chevron Oil Company and with the logistical support of Moss Landing Marine Laboratory and the Monterey Bay National Marine Sanctuary, we accomplished an exciting breakthrough. For the first time in the Pacific, transmitters were placed on leatherbacks at sea. We captured, tagged, and released two mature females while they were foraging on jellyfish in the Sanctuary. Genetic analysis has revealed that both turtles originate from Western Pacific nesting beaches, possibly in Indonesia. As this is written, both turtles appear to be headed directly to their natal areas in Asia on what we hope is a pre-nesting migration. Each transmitter is sending us data that are important to understanding habitat use, including water temperature, the depth and duration of dives, and the length of time spent at particular depths. If we are successful at tracking these turtles all the way home, it will represent the first time leatherbacks have been tracked during their migrations prior to nesting, as they move from foraging grounds in the eastern Pacific to their nesting beaches in Asia. *(To follow these leatherbacks with us, visit our Web site at: www.hswri.org.)*

– Scott A. Eckert[1] and Peter H. Dutton[2]
[1]Hubbs Sea World Research Institute
[2]Southwest Fisheries Science Center

Marine Mammals

Northern Elephant Seals — Autonomous Pinniped Environmental Samplers

Small debris accumulations were found in the centers of many of the pockmarks. Benthic animals such as the pom pom anemone (Liponema sp.) and crabs were commonly found associated with the debris piles.

Northern elephant seals are part-time residents on rookery beaches in the Monterey Bay National Marine Sanctuary, where they spend up to four months per year. The remaining time is spent on foraging trips in the open North Pacific Ocean or near the coast of Alaska *(see Figure 1)*. Research at UC Santa Cruz to understand the behavior and movements of northern elephant seals has utilized small electronic tags that archive and store temperature and depth data for later retrieval after the animal is recaptured. When combined with position data from Advanced Research and Global Observation Satellite (ARGOS) tags, the temperature and depth data provide valuable information on the seals, including habitat preferences, physiological data, environmental data, and movement patterns. The results have unraveled much of the mystery surrounding where the northern elephant seals go in the North Pacific and how they use the oceanic environment in foraging.

Data collected to learn about the seals can also tell us something about the ocean. Oceanographers go to great lengths to collect oceanographic data and compile it into databases used to characterize the ocean. These archived data are used for a variety of purposes, including input to ocean models, weather prediction, and analysis of climate change. While more and more surface data are taken by satellites and buoys, data from below the surface often require sensors deployed from ships. Expendable bathythermographs, or XBTs, for example, can be dropped from oceanographic vessels or from "ships of opportunity" like freighters or tankers. XBTs measure the temperature as they fall through the water and transmit the data back to recording devices. The resulting temperature profiles are sparsely distributed in time and space, providing poor coverage for most of the ocean; moreover, the data are expensive to collect from ships. During their long foraging trips, northern elephant seals dive continuously, with little time spent at the surface. Dives typically last twenty minutes and go routinely to depths of 600 meters (1,920 feet). The potential volume of oceanographic data that a single elephant seal could collect on a single foraging trip is immense.

Kip Evans © 1999 MBNMS

A male and female elephant seal at Point Piedras Blancas rookery.

Elephant Seal Populations

		1997	1998	1999	2000
Año Nuevo	Births[1]	2,684	2,797	2,362	2,263
	High count[2]	5,358	4,588	—	—
Other Big Sur Beaches	Pups to weaning[3]	500	120	420	220
Piedras Blancas	Births[4]	1,200	1,650	1,900	1,850
	High count[5]	5,000	5,000	4,000	5,000

[1] estimated production (for 1999: 87% of all females; for 1997-1998: 95% of all females); lower production in 1998 reflects an apparent adverse impact of the previous year's El Niño.
[2] high counts occurred in February 1997 and April 1998; not taken in 1999
[3] approximate number that survived to weaning
[4] approximate number of births
[5] occurred during the spring molt

Sources:
Año Nuevo: 1999 – Dan Crocker, University of California Santa Cruz;
1997, 1998, and 2000 – Pat Morris and Guy Oliver, University of California Santa Cruz
Piedras Blancas and Other Big Sur Beaches: Unpublished data, provided by Brian Hatfield, USGS, Piedras Blancas Field Station; not to be cited without the permission of the author.

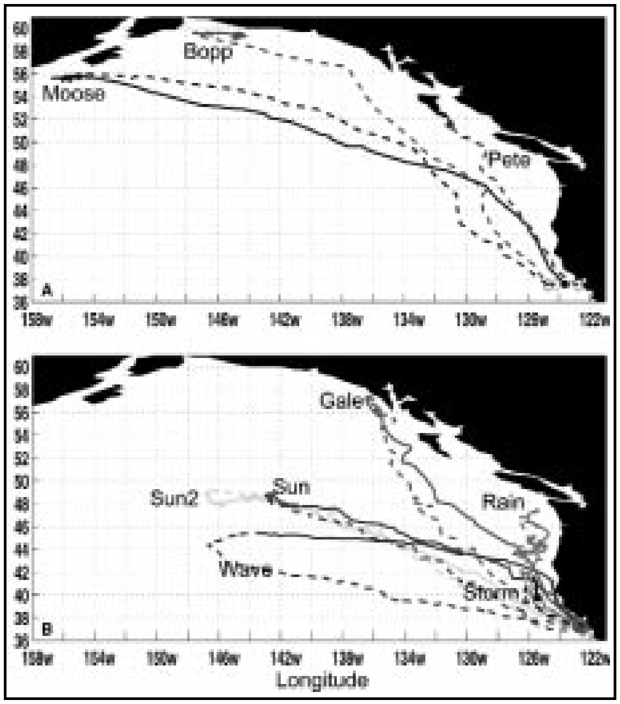


Figure 1: Tracks of northern elephant seals tagged at Año Nuevo on their foraging trips to the North Pacific and Gulf of Alaska. The top panel represents males tracked in 1997; the bottom panel, females tracked in 1998-99. Note the apparent differences in foraging areas. Outward tracks are solid lines, return tracks dashed. All animals made complete return trips, but only those parts of the track with both temperature and satellite-based position data are shown.

We reasoned that if properly instrumented, calibrated, and archived, the elephant seal tags could provide oceanographic data for parts of the ocean where these are sparse or lacking. Thus, our objectives were to evaluate existing temperature profiles taken from northern elephant seals and, if the data met quality standards adequately, to add these records to the National Oceanic and Atmospheric Administration (NOAA) World Ocean Database.

Taking this step with data collected by animal tags has been hindered in the past by the accuracy of the sensors and geographic position where the measurements were taken. The newer generation tags have greatly improved measurement accuracy, and we determined that the quality of seal-collected temperature data are on par with that from XBTs. The position data from ARGOS, while not up to the standards of oceanographic buoys, meet that of several other platforms used. Thus, the seal data met the requisite criteria. We carefully evaluated data from foraging trips of six female and three male elephant seals tagged in central California between March 1998 and March 1999. Temperature and depth data, measured and stored every thirty seconds, were retrieved after the animals returned to the rookery months later. Portions of the track where both ARGOS and temperature-depth data were available from these nine animals *(Figure 1)* show differences between males and females. A comparison of temperature profiles from seal temperatures at the surface showed excellent correspondence with other sources of surface temperature data and similarity with other sources of subsurface data. These data were put into NOAA's World Ocean Database under a new category – "APBT," for auto-nomous pinniped bathythermograph. A total of 75,665 APBTs over 41,702 kilometers of seal trackline came from these nine seals alone.

This work shows that biological autonomous sampling systems used in behavioral studies have potential to contribute oceanographic data in a cost-effective manner. The northern elephant seal represents but one species covering portions of the northeast Pacific Ocean. Research programs presently exist on a variety of species, including southern elephant seals and other pinnipeds, tunas and billfishes, sharks, seabirds, marine turtles, and whales. With improving technology, such tags will be applied to even more marine animals and the approach described here can be applied to other species to improve ocean data availability.

Gray Whale Calf Census Data*

Year	Calves	Est. % of total pop.
2000**	279	1.0
1999**	427	1.6
1998**	1,388	5.1
1997	1,431	6.5
1996	1,146	5.1
1995	619	2.6
1994	945	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

Bird Populations

Population Change of Common Murres: Perspectives from the Farallon Islands

Bordering the northern boundary of the Monterey Bay National Marine Sanctuary, the largest Common Murre colony in central California occurs on Southeast Farallon Island (SEFI). The Farallon population may once have numbered close to a million birds but is now a fraction of its historic size due to commercial egg collecting, chronic and large-scale oil spills, pesticide contamination, over-exploitation of prey resources, and mortality in fisheries. Variability in forage fish and zooplankton availability linked to the El Niño phenomenon and longer-term climate change may also limit population growth. With the multitude of factors influencing this population, how can we separate natural and man-caused population fluctuations?

Research on the Farallones has revealed striking fluctuations in population size *(Figure 1)*. The population increased from the early 1970s to early 1980s, declined precipitously between 1982 and 1988, demonstrated a short-term increase in the early 1990s, but has experienced limited growth (or even decline) in recent years. What explains these changes? In the 1970s there was a slight drop in population size in 1978, but in general numbers increased at about 8 percent per year from 1972 through 1982, reflecting high levels of prey availability during a period of moderate mortality.

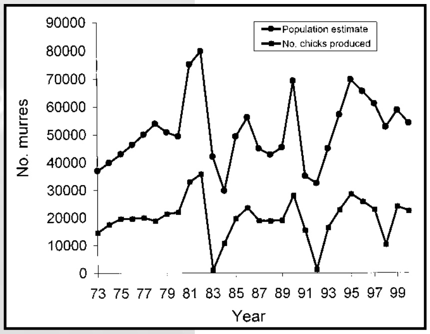


Figure 1: Common Murre breeding population size and number of chicks produced per year.

However, during the early 1980s, a near-shore set gillnet fishery caused substantial mortality through drowning of adult and sub-adult birds. Estimates indicate that upwards of 100,000 birds were drowned in this fishery. Major oil spills in the region in 1984 (*Puerto Rican*) and 1986 (*Apex Houston*) also caused significant mortality. There were also indications that the overall prey base was changing, thereby limiting opportunities for the birds to switch to alternative prey. For example, in years prior to 1989, murres alternated the chick diet between juvenile rockfish (mostly *Sebastes jordani*) and northern anchovy (*Engraulis mordax*). The availability of some species of juvenile rockfish has declined in this ecosystem, especially in the last decade, and this change is clearly evident in the food habits of murres on the Farallones. In the 1990s, while much of the set gillnet fishery was closed, a small fishery persisted in southern Monterey Bay and was responsible for an average of about 1,200 deaths each year. An emergency closure of fishing by this method within the foraging range of the murres in Monterey Bay, imposed by the California Department of Fish and Game in summer 2000, may help to resolve this mortality if it becomes a permanent law. Oil spills and chronic oil pollution have also continued to take a toll. For example, during the fall and winter of 1997-1998, hundreds of "tar balls" and oiled murres were found on beaches in the Gulf of the Farallones and Monterey Bay National Marine Sanctuaries.

Entering the fourth decade of research on murres and other marine birds on the Farallon Islands, the prognosis for conservation is good if we can effectively manage human-related mortality factors. Although the ecosystem has undergone change that might have limited growth in the 1990s, indications are that the ocean is changing again back to the cold-water regime that characterized the system in the early 1970s. This purported "regime shift" may result in a resurgence of certain prey populations that would help support the large murre population in the region.

– William J. Sydeman
Marine Science Division,
Point Reyes Bird Observatory

Beachcast Seabirds within Monterey Bay

The Monterey Bay National Marine Sanctuary's beach monitoring program, Beach COMBERS (Coastal Ocean Mammal / Bird Education and Research Surveys), began its fourth year documenting monthly deposition of dead marine birds and mammals on sandy beaches within the Monterey Bay area. Since the program's inception in May 1997, Beach COMBERS volunteers have spent almost 1,500 hours counting and marking beachcast seabirds and marine mammals found on designated beach segments, covering fifty-one kilometers of sandy beaches within and around Monterey Bay.

Counts of beachcast seabirds during January-October 2000 were more variable and over two times higher than during the same period in 1999, but lower than totals for 1997 and 1998 (*Figure 1*). The greatest deposition occurred during April and was dominated by Western Grebes (*Aechmophorus occidentalis*) and Clark's Grebes (*Aechmophorus clarkii; Figure 2*). The spring deposition of grebes was the third major deposition event detected by the monitoring program since its inception. Previous deposition peaks differed in the timing and composition of birds found beachcast. The first peak occurred during August-September 1997 and was dominated by Common Murres (*Uria aalge*). An increase in set gillnet fishing effort in southern Monterey Bay was suspected to be the primary cause of that deposition. The second peak, spanning nearly five months during the spring and summer of 1998, was composed of a wide assemblage of seabird species and was likely related to local El Niño conditions and a toxic diatom bloom within Monterey Bay.

The sharp spike in grebe deposition this year was not confined to the Monterey Bay area. U.S. Geological Survey biologist Brian Hatfield reported that deposition of Western / Clark's Grebes during February-April 2000 was significantly higher than the twenty-year average at beaches near Point Piedras Blancas (in the southern part of the Sanctuary). Volunteers monitoring beaches in the Gulf of the Farallones National Marine Sanctuary, to the north, also reported high numbers of beachcast grebes. The cause of the widespread event is unknown; however, all birds necropsied at the California Department of Fish and Game, Oil

Scientists are working to restore Common Murre colonies at several sites throughout the Sanctuary.

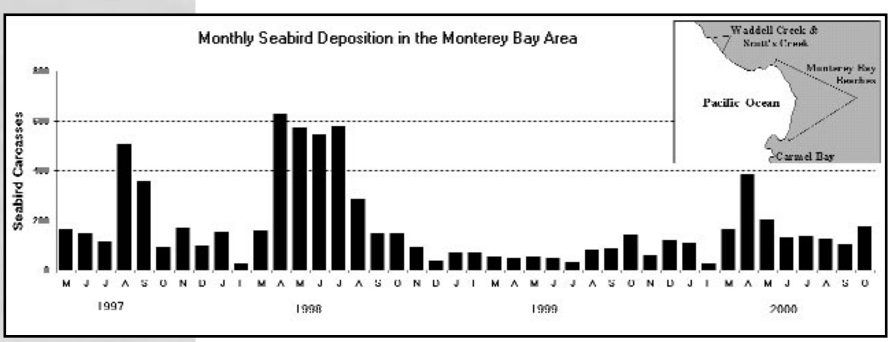


Figure 1: Monthly seabird depostion in the Monterey Bay area during May 1997 - October 2000.

Spill Prevention and Response (CDFG-OSPR) facility in Santa Cruz were severely emaciated and many were immature. Biologists at the International Bird Rescue and Research Center reported very high reproductive success for Western and Clarke's Grebes during the summer prior to the spring beachcast event. Because mortality is high for first year grebes as they migrate from fresh water lakes to the ocean, it is likely that the increased deposition during the spring of 2000 was simply a reflection of the very successful 1999 breeding season.

Beach COMBERS volunteers will continue to collect fresh beachcast seabirds for necropsy by personnel at CDFG-OSPR and graduate students at Moss Landing Marine Laboratories. We anticipate that necropsied seabirds will improve our ability to assess causes of death and increase our understanding of the health of nearshore habitats. We greatly appreciate the dedication of the many highly-skilled volunteers who make this monitoring project possible.

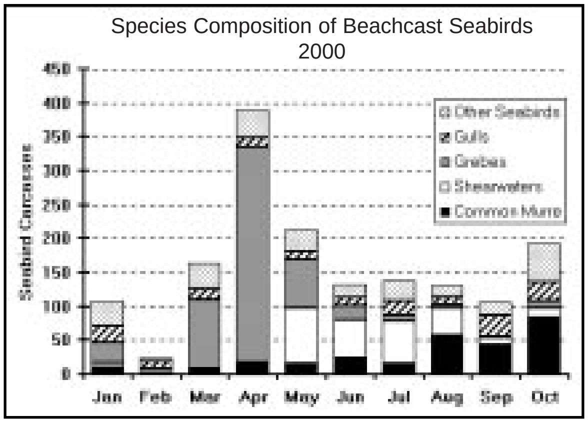


Figure 2: Species composition of beachcast seabirds in the Monterey Bay area from monthly samples recorded during January - October 2000.

–Scott R. Benson
Moss Landing Marine Laboratories

Harvested Species

Squid Fishery

The California market squid, *Loligo opalescens*, plays a critical role in the Monterey Bay ecosystem. These animals are of ecological interest for their dual role as both predator of krill and other species and prey of fishes and marine mammals. They are terminal spawners, living twelve to eighteen months (although recent research suggests a life span as short as nine months) before moving inshore to the sandy bottom to spawn and then die. They are vulnerable to changes in environmental conditions, especially water temperature. With the onset of warmer ocean temperatures, squid abundance drops dramatically, but seems to rebound eighteen months later.

The commercial fishery for squid, initiated by Chinese seiners in Monterey Bay in the 1860s, grew modestly through the twentieth century to an average annual catch of 10,000 tons by 1980. The fishery is part of the annual round of the local wetfish fleet, which uses purse seine gear to catch sardine, mackerel, and anchovy as well. A Southern California squid fishery emerged in the 1960s and since the early 1980s has far outstripped Monterey's landings.

The fishery has recently undergone important changes in technology used, fishing strategies, markets, and regulations. In the late 1980s thirty-year prohibitions on the use of attracting lights and purse seines off Monterey were lifted, leading to the broad adoption of these techniques. Today, fishermen use purse seine nets to catch aggregations of squid, attracted to the surface at night by boats equipped with powerful lights. Following the 1992-93 El Niño, international markets for squid expanded. Local landings, which occur from late spring through summer, remained fairly steady, but many Monterey squid fishermen expanded their operations in the winter Southern California fishery around the Channel Islands and along the coast. Meanwhile, as one of the West Coast's last open access fisheries, squid attracted fishermen facing declines in other fisheries from Alaska to Southern California. By 1996 squid ranked first in tons and value landed in California.

The squid fishery has recently undergone important changes in technology used, fishing strategies, markets, and regulations.

Although the fishery's growth has been concentrated in Southern California, questions have been raised about the fishery's overall ecological and socio-economic sustainability. Prior regulation had been piecemeal (and limited to Monterey Bay), with limits on the use of lights, the prohibition of purse seines, and weekend closures. As the fishery grew, Monterey Bay fishermen led the call for limited entry. SB 364 (Sher), passed in 1997, established a $2,500 permit for market squid vessels and light boats and a three-year moratorium on entry into the fishery; called for a three-year study of the fishery; and provided for the creation of a Squid Fishery Advisory Committee and a Squid Research Scientific Committee to advise the California Department of Fish and Game (CDFG) on research and interim and long-term management measures for the fishery. Interim measures include logbooks, extension of the weekend closure to Southern California, and shielding requirements and wattage limits for squid-attracting lights. In April 2001 CDFG will present a report on the fishery, with recommendations for a conservation and management plan, to the Legislature.

Just as SB 364 passed, the 1997-98 El Niño set in. Local landings dropped from more than 9,000 tons in 1997 to seventeen tons in 1998. And while the Southern California squid fishery rebounded strongly in 1999, the Monterey fishery has recovered more slowly. Only 300 tons were landed in area ports in 1999, and 2000 landings remained depressed. Indeed, the 1997-98 El Niño provided a powerful reminder of the close connections among the squid, the environment, and the human communities that depend on them for their livelihood.

– Caroline Pomeroy
University of California Santa Cruz

California's Nearshore Finfish Fishery

In 1998 the Marine Life Management Act (MLMA), also known as the Keeley Bill or AB1241, was passed by the California legislature and signed into law. In 1999 the state provided $5.2 million to fund this legislation. California is now prepared to make some significant changes in the way it manages its fisheries, due to this important legislation.

The MLMA requires that the State of California take several actions, including:

1) Transference of many fishery management authorities from the state legislature to the California Fish and Game Commission (CFGC)
2) Development of a master plan for implementing the MLMA
3) Development of management plans for California state fisheries
4) Development of a plan for dealing with emerging fisheries as they become operational in California
5) Preparing an Annual Status of California Fisheries Report by September 1, 2001
6) Adoption of management plans for the white sea bass and the nearshore fishery (including the live fish fishery) by January 1, 2002.

In September 2000 some interim regulations became effective that protect nearshore fish populations until the California Department of Fish and Game (CDFG) can complete the process of developing a nearshore fishery management plan. Among these interim regulations are a fishery control date (a cut-off date for new entrants into a fishery) set at December 31, 1999 and a moratorium on new permits. In December the CFGC adopted further interim regulations to, among other things: set optimum yields for major species; reduce the harvest guidelines to a 50 percent ten-year average; allocate reductions to recreational versus commercial catches along a twenty-year average; raise size restrictions for certain species; and set up a system of in-season monitoring and correction. The CFGC is considering a further proposal to limit commercial fishing for some species to rod-and-reel or handline.

Parallel to the process of developing interim management measures, the CDFG has been meeting with fishermen and other interested individuals and organizations around California to ensure industry participation in the development of the Nearshore Fishery Management Plan. CDFG expects to have a draft plan available to the public by July 1, 2001. If all goes smoothly, that plan can be adopted by the CFGC about six months later.

Finally, because all rockfishes (*Sebastes spp.*) are covered under the Pacific Fishery Management Council's (PFMC) Groundfish Fishery Management Plan (FMP), it is necessary that the State of California coordinate closely with the PFMC and the National Marine Fisheries Service to ensure conformity with federal regulations. For example, last summer the rockfish limits were cut dramatically under the PFMC's groundfish plan. This had a significant ripple effect through the nearshore fisheries that the state manages, including the commercial live fish and sportfish fisheries. Also adopted were some temporary seasonal and regional closures on rockfishes. Interestingly enough, data indicate that these rockfish landing limitations may have had the effect of shifting the nearshore fishery to non-rockfish species.

While the Monterey Bay National Marine Sanctuary's regulations do not control commercial and recreational fisheries, it develops policy positions on such issues and gives advice to the state and federal agencies involved in fisheries regulation. As such, the Sanctuary intends to continue following the issue as it develops. Previously, it has asked the Research Activities Panel (RAP) to help the staff follow this issue. The RAP, particularly Dr. Gregor Cailliet of Moss Landing Marine Laboratories, has been doing so and keeping the staff apprised.

– Aaron King
Monterey Bay National Marine Sanctuary

Exotic Species

Exotic Invaders in Elkhorn Slough: Who Are They and Where Did They Come From?

Large bays with international ports are known to harbor diverse populations of exotic species. For example, about 150 non-indigenous invertebrates have been documented in San Francisco Bay, 100 in Pearl Harbor, and fifty in Puget Sound. These invaders arrived by various means, but recently the most significant mechanism of introduction has probably been ballast water, which is pumped into vessels at one port and discharged at another. As a result, the fauna of many large bays has become homogenized, losing much of its regional character as native species are replaced or marginalized.

While biological invasions of large bays have received much attention lately, very little is known about the extent of this problem in smaller embayments. Are estuaries without international shipping safe from exotic invaders?

In a nutshell, our study at Elkhorn Slough revealed that the answer is a resounding "no." We have recently documented fifty-five exotic invertebrate invaders in the Slough. Of these, twenty-four had not previously been known to occur there. We carried out a rather modest search for invasive invertebrates and have calculated that we collected one new exotic species for every 1.5 hours of search effort (*Figure 1*). Therefore, more hours spent searching will doubtless turn up more exotic invertebrate species. In addition, there are likely to be many other exotic species in other groups that we did not examine (dinoflagellates, fishes, bacteria, etc.).

Overall, exotic species account for only about 10 percent of the Slough's rich invertebrate fauna. However, due to the incredible abundance of some of these species, we suspect that they account for a far more significant proportion of the total invertebrate

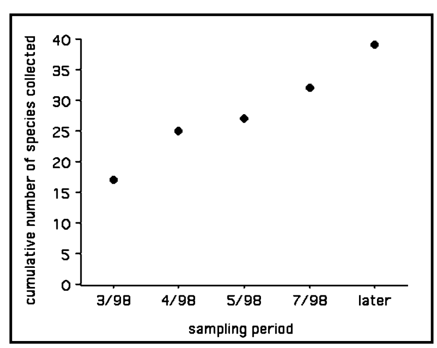


Figure 1: There was no decline in the cumulative number of exotic species collected at Elkhorn Slough over time (each sampling period represents only about ten hours of search effort), suggesting many more invaders remain to be found.

biomass. For instance, the Japanese mud snail, *Batillaria attramentaria,* is found in virtually every high intertidal area of the Slough, often in great densities (*see next article*). Another conspicuous invader of the Slough is *Hymeniacidon sinapium*, a bright orange sponge that forms massive aggregations on Slough mudflats and channels (*Figure 2*). The filtering activities of this sponge may be influencing planktonic communities at the Slough. European green crabs (*Carcinus maenas*) also occur in the Slough. Voracious predators, these crabs have been shown to alter clam and worm communities at Bodega Bay dramatically. As a final example, the burrows of a small isopod resembling a pill bug, *Spheroma quoyanum*, riddle almost every bank around the Slough and likely increase the already high erosion rates in the Slough. Exotic invaders at the Slough therefore have the potential to influence native communities and physical habitat structure negatively.

Some exotic species found in Elkhorn Slough were introduced with oysters, which were cultured there from the early 1900s to the 1970s. Japanese and Atlantic oysters were imported, and other creatures inadvertently hitched a ride with them. However, new introductions have continued unabated in the fifty years since oyster-culturing dwindled and ceased.

Due to the similarity in exotic species composition between the Slough and San Francisco Bay (about 90 percent of the invasive species found in the Slough are also found in the Bay), we suspect that most of the recent introductions into the Slough occurred indirectly via the Bay, rather than directly from distant waters. Many exotic species are first introduced to this coast at major harbors via international shipping. After becoming established and abundant, they may then spread up and down the coast, for instance on the hulls of regional boats or as larvae travelling by natural currents.

The effect of international shipping, including ballast water dumping, is thus not limited to areas with major harbors but rather reverberates up and down the coast to smaller and more isolated estuaries. Appropriate management to limit future invasions involves not only minimizing direct transport vectors that bring exotic species from distant shores to major ports – for instance by treating ballast water – but also requires measures such as frequent cleaning of small boats to reduce intraregional transport from port areas to other smaller embayments.

– Kerstin Wasson[1], Chela Zabin[2], Laura Bedinger[3], Cristina Diaz[3], and John Pearse[3]
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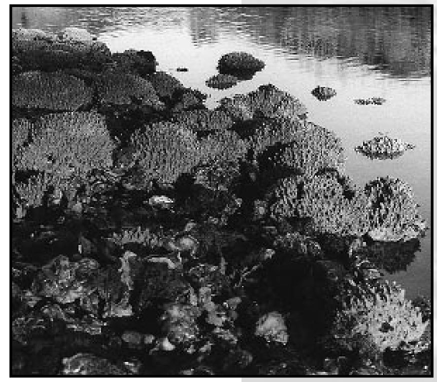

Figure 2: Massive aggregations of an invasive sponge, Hymeniacidon sinapium, in the Elkhorn Sough Reserve.

A Battle between Snails Elucidates Details of Biological Invasion

A non-native Japanese mudsnail, *Batillaria attramentaria*, was introduced to Elkhorn Slough and other sites along the West Coast of North America fifty to seventy years ago with imports of Japanese oysters. *Batillaria* has been displacing a highly similar native mudsnail, *Cerithidea californica* (sometimes called the "California horn snail"), in several salt marshes along our coast, such as Tomales Bay and Bolinas Lagoon. *Cerithidea* however no longer exists in Elkhorn Slough; its absence there is suspected to be due to competitive exclusion by *Batillaria.*

Batillaria achieves superiority over *Cerithidea* through a combination of three major advantages. First, *Batillaria* is a better competitor for the diatoms that each species grazes off the surface of the marsh mud. Notably, *Batillaria* processes its food more efficiently and can thus convert the shared, limited food resource into snail tissue at a faster rate than *Cerithidea*. Second, both snails are susceptible to infection by trematode parasites, but *Batillaria* is typically infected at a lower rate. Because these parasites disable a snail's reproductive system, this lower infection in *Batillaria* equates to a major advantage in the number of eggs that a *Batillaria* individual can produce in its lifetime compared to a *Cerithidea*. (Interestingly, one of the parasites infecting *Batillaria* is itself a non-indigenous species, thus adding to the growing list of non-indigenous species in Elkhorn Slough.) Finally, *Batillaria* has a lower background mortality rate; that is, *Batillaria* simply has a lower probability of death than *Cerithidea* of the same age.

In order to test the relative importance of *Batillaria's* three advantages over *Cerithidea*, we defined the biology and interactions of the snail species as connected mathematical expressions. Output of this mathematical model of the snails' interactions identified which advantage was most responsible for the exclusion of *Cerithidea* by *Batillaria*, and thus suggests means of human intervention that may more successfully control or delay the impact of the exotic species.

In certain pockets of Elkhorn Slough Batillaria achieves its densest populations (up to 10,000 snails/m^2) in its entire non-native distribution along the North American Pacific coast.

The model indicated that displacement and ultimate local exclusion of *Cerithidea* by *Batillaria* takes between fifty-five to seventy years. Historical and museum records and analyses of long-term population patterns corroborate this result, indicating that the model accurately captures the biology of the species. Importantly, the long time to *Cerithidea* exclusion highlights that, over short time scales, harmful invaders may appear quite innocuous. Additionally, the model indicated that competition and susceptibility to parasites are relatively weak mechanisms in driving the overall success of *Batillaria*. Rather, we learned that *Batillaria's* lower background mortality rate plays the key role governing its displacement of *Cerithidea*. Therefore, creative management techniques can focus attention on equalizing species-specific differences in mortality to neutralize *Batillaria's* invasion most effectively.

Despite the impending local extinction of *Cerithidea* and an immediate increase in the invader's population, all aspects of *Cerithidea's* biology in the model were disconcertingly slow to exhibit signs of impact from the invasion. Most of *Cerithidea's* biological parameters (such as density, population biomass, egg production, mean size, proportion parasitized, and individual growth rate) took at least twenty to twenty-five years from *Batillaria's* first introduction to show significant declines. With such a pronounced delay between an invader's introduction and the manifestation of its harmful effects, biological monitoring programs currently used to prioritize intervention for imperiled native species appear inadequate. Rather, the studies of *Batillaria-Cerithidea* interactions indicate that mechanistic field experiments and mathematical modeling of native-invader interactions may provide a better, earlier warning of impending invader impact on native biota.

– Jeb Byers
University of California Santa Barbara
University of Washington

Site Profile

Año Nuevo Island

In the early hours of a calm, clear morning, the view of Año Nuevo Island from the mainland reserve is one of apparent tranquility. The slow rumble of breaking surf may mask the cacophony of sounds, the outline of a single lumbering sea lion may distract from the carpet of pinnipeds beneath. The island is in fact teeming with creatures trying to take advantage of prime real estate. Over the past thirty years, while the island itself has noticeably decreased in size, its attraction as a hotspot for seabirds and pinnipeds has continued to grow.

As long as there have been systematic monitoring efforts, the island has been used for breeding by four species of sea and shore birds. Western Gulls are by far the most populous of the feathered contingent, their nests dominating the majority of the island's terrace. Approximately 800 pair build nests on vegetated areas, dirt patches, boardwalks, and structures left behind by previous human visitors. In recent years, Westerns have even spilled over onto the island's beaches, though nests are vulnerable to trampling by pinnipeds and high tide flooding.

About twenty to thirty Pigeon Guillemots make their reproductive living in the small cracks of the island's protected cliffs. A few find their way into nest boxes recently erected for other seabird species. This preference for crevices means that guillemots do not compete for space with gulls, but also that the island's population is limited by habitat availability. Counts during the 1970s revealed sixty to eighty nesting birds; the currently lower numbers may reflect the considerable erosion that the island has suffered in the past twenty years.

Pelagic Cormorants also utilize a unique nesting habitat, generally preferring narrow cliff edges. About ten pair have found a suitable substitute along the eaves of the old lighthouse keeper's residence, a once-grand two-story house abandoned in 1948. Erosion may take its toll on these subtidal foragers as well: last winter saw the northeast foundation of


© Scott Davis

California sea lion showing its close encounter with a white shark.

the house lost to the unrelenting surf. As the structure makes its way into the sea, the cormorants' ledges will disappear with it.

Black Oystercatchers are the fourth long-time resident breeders of Año Nuevo Island. They prefer to lay their cryptic eggs in driftwood clumps high on the island's beaches. Their abundance is limited because they establish large territories during much of the year. Less than ten pair nest on the island, and they face the growing pressures of predation by gulls and disturbance by pinnipeds.

While those seabirds in the minority work to maintain their foothold, the past two decades have brought four new arrivals to the Año Nuevo Island breeding scene. In the mid-1980s, Rhinoceros Auklets began establishing a presence on the island, each pair digging a burrow in which to lay their single egg. These birds were once very abundant along the West Coast, but by the 1860s had disappeared in California. In the 1960s, rhinos returned to the nearby Farallones, and have since made their way to Año Nuevo. To encourage their recovery, researchers have installed more than fifty nest boxes around the island. This additional habitat appears to be a successful conservation tool – about fifty to ninety pair have nested on the island in recent years.

The Brandt's Cormorant has also joined the ranks of recent arrivals. Beginning in 1994, breeders established a colony that has since grown to approximately 400 pairs. Their success can be attributed to mobs of aggressive males that arrive early in spring, displacing gulls and stealing nest material. Brandt's nest only a neck-length apart, excluding other species that wish to compete for habitat. Since the 1970s, Brandt's Cormorant colonies have declined on the Farallones, their main breeding grounds. Año Nuevo may represent an area of abundant resources where adventuresome pairs can establish themselves and thrive.

Cassin's Auklets have come to take a stand on the island as well. The first pair arrived in 1997, and since then the breeding population has grown by a pair each year. Cassin's dig smaller and shallower burrows than the Rhinoceros Auklets – erosion can therefore expose them much more quickly. Researchers have erected tiny nest boxes for these equally small burrowers, in an effort to encourage reproduction.

Finally, a lone pair of courageous Heerman's Gulls have braved the challenge of reproducing amongst the larger Western Gulls. Since the mid-1990s, what is believed to be the same


© Scott Davis

Often white sharks will spyhop (lift their head out of the water for a closer look).

pair has returned repeatedly in an attempt to raise their young. To date, they have successfully fledged chicks only in 1996, but the occasion represented the first record of Heerman's breeding in northern California.

Whether these additional species represent truly new arrivals or recolonization after a temporary absence is uncertain. The former presence of Coast Guard personnel likely affected use of the island as a seabird rookery, and the current presence of these birds may represent a return to former distributions.

The disappearance and return of the northern elephant seal, however, is an entirely certain story. Due to unrelenting sealing pressure during the first half of the 1800s, these huge lumbering creatures were presumed extinct by 1869, even though breeding rookeries had ranged from Point Reyes to Baja California. A remnant population hidden on Guadalupe Island has since made a remarkable comeback, bringing the total population to more than 140,000. The first two pups born were born at Año in 1961, and today about 500 females give birth on the island.

While elephant seals blanket the beaches during winter, summer is the season for Steller sea lion reproduction. Researchers estimate 160 to 180 pups born this past year; unfortunately, Año is a fragile outpost for this threatened species, as their numbers have been declining on the island in recent years. Finally, a small


© Scott Davis

Año Nuevo Island showing the old Coast Guard house.

but stable group of about fifteen harbor seals also share the island for birthing grounds.

Though they do not use the island for reproductive reasons, two other species deserve mention because their presence can be so overwhelming during late summer. Both California sea lions and California Brown Pelicans journey up the coast as their breeding seasons wane in southern and Baja California. The signature barks of more than 10,000 sea lions drown out much of the island's activity, and individuals can even be seen hauled out on top of male elephant seals, for lack of beachfront property. They have taken over the lighthouse keeper's residence, their agility allowing them to master the staircase to the second floor. Between 1,000 and 3,000 pelicans arrive during this same period, roosting on any available space that they can find amongst the last of the breeding seabirds.

While one cannot miss the arrival of sea lions and pelicans, one last creature is often cruising the island's waters unnoticed. The white shark population peaks between October and February, when elephant seals are most abundant. Local researchers have tagged more than fifty sharks in recent years, and have learned that most of them are adult females over fifteen feet long! Though individual sharks only stay in the area for a few weeks each season, several sharks have returned for winter meals year after year.

Though each species has its own story, Año Nuevo Island may be most fascinating for the multitude and complexity of interactions that govern its residents' lives. The bustle of thousands of huge pinnipeds produces constant pressures on seabirds trying to maintain breeding habitat. The seabirds themselves must fight for space and nesting material, both within and among species. Meanwhile, all of the island's inhabitants are subject to the powers of wind and waves, which are continually stealing pieces of the tiny haven treasured by so many.

– Michelle Wainstein
University of California Santa Cruz

The author thanks Scott Davis, Pat Morris, Guy Oliver, and Julie Thayer for generously providing much of the above information.

Human Interactions

The Long-Liner

For thousands of years people have made their living from fishing in Monterey Bay. The first fishermen were the Rumsien Ohlone, the native people of Monterey. Going back almost five thousand years, this peaceful community fished the bay in small boats made of tule (a reed that grows throughout the Monterey Peninsula), using a variety of fishing methods. These included nets made of string from the stinging nettle plant, traps made of willow, harpoons with bone points, as well as hook and lines using fish hooks made from abalone and mussel shell. The Rumsien people were also the first divers to harvest food from the bay, as attested to by evidence uncovered in ancient burial sites encountered in recent years. Some of the males had what is known as "surfer's ear," a bony growth that closes off the ear


J.B. Phillips Collection, Maritime Museum of Monterey

The Giamanco family boat, GERALDINE, with rockfish. Point Sur, April 20, 1937.

opening, indicating that they spent a lot of time in the cold water of Monterey Bay. Nearly every species of fish that swam in the bay was caught and used, and sea otters, sea lions, and seals were used not only for food but to make blankets and capes from their pelts.

The bay has changed over the years. Different cultures brought their own expertise and fishing methods from home, boats got bigger, and technology has made things faster and easier.

When Vince Giamanco's family came to Monterey at the turn of the twentieth century, the sardine fishery was in its infancy and the bay was pristine. The Giamancos plied the bay for rockfishes and albacore; they were long-liners and hook and line fishermen.

Vince Giamanco was five years old when he began to catch rockfishes with his father, Antonino. (In the Sicilian community a boy is considered a man at seven.) A typical day began at 2 a.m. when Vince, his older brother, and their dad walked the three blocks from their home to the Monterey Wharf. From there they took their small 32-foot jig boat out to the fishing grounds – usually between the Bixby Creek bridge and Point Sur. This area was known as "the ranch." If Vince was lucky, he could get some sleep during the four- to five-hour trip. The boat had no radio, depth finder, or fish finder, and Mr. Giamanco didn't need them; he had decades of experience fishing these waters.

At dawn they started to lay out their long line gear, anywhere from ten to fifteen baskets with 250 hooks each. For the next eight hours they pulled in rockfishes – chilipeppers, black cod, and, in the spring, bocaccio. "Sometimes you had a chilipepper on every hook and a

© MBNMS

While by no means comprehensive, this chart indicates the great extent to which the Sanctuary plays an integral role in the lives of people throughout California's central coast. Further examples can be found, throughout the report, regarding: volunteers *(pages 13,19)*, whale watching *(page 18)*, fishing *(pages 20-21)*, and exotic species *(pages 21-22)*.

ACTIVITY	DETAILS
Visitors to State Parks and Beaches Contiguous to the Sanctuary (Estimates)[1]	San Mateo County coast - 1.4 million paid day users Santa Cruz County coast - 1.7 million paid day users Monterey County coast - 317,563 paid day users Hearst Beach in San Luis Obispo County - 213,000 paid day users State Park Districts provided the following estimates for free-use locations: Asilomar State Beach & Conference Center - 547,641 Marina State Beach - 1,368,177 Monterey State Beach - 739,929 Other State Beaches in Monterey County - 746,183 Cambria's State Beaches - 250,000
Whale Watchers and Pleasure Boaters[2]	Whale watch and sea life cruises - 36,120 people Sail and yacht charters - 16,000 people *Please note: these numbers represent a few, but not all, whale watch and pleasure boat charters in Monterey and Santa Cruz.*
Kayakers[3]	Estimated number of kayak trips via rentals or tours - 23,100 *Please note: these numbers represent a few, but not all, kayak shops in Monterey, Moss Landing, Santa Cruz, Cambria, and San Simeon.*
Surfers[4]	Estimated number of regular surfers on the Monterey Peninsula - 300 annually Estimated number of surfers from Pleasure Point, Santa Cruz to Capitola - 300 daily Estimated number of surfers/windsurfers from Cambria to Big Sur - 5,000 annually
Divers[5]	Estimated number of diver days using equipment rentals, air fills, tours, and entrance fees - 26,660 *Please note: these numbers represent a few, but not all, dive shops in Monterey, Santa Cruz, San Simeon, and Cambria.*
7th Annual Great American Fish Count	Total locations - 22 Total bottom time - 43 hours, 56 minutes Total species completed - 52 Total surveys counted - 62, with blue rockfish most frequently sighted (81% of dives); other species frequently sighted were painted greenling, black and pile perch, and kelp rockfish.
Fishing Licenses by County[6]	see below
2000 Coastal Cleanup[7]	Coastal Cleanup beach debris collected, by county: **Marin** - 7,896 lbs. trash; 2,492 lbs. recyclables; 1,044 volunteers **San Mateo** - 19,212 lbs. trash; 3,577 lbs. recyclables; 1,725 volunteers **Santa Cruz** - 3,400 lbs. trash; 1,480 lbs. recyclables; 2,268 volunteers **Monterey** - 9,126 lbs. trash; 1,465 lbs. recyclables; 1,516 volunteers **San Luis Obispo** - 2,500 lbs. trash; 700 lbs. recyclables; 644 volunteers *Of special note, approximately 120 recreational divers, as well as Navy and Sanctuary divers, collected more than 5,000 lbs. of trash and recyclables at Monterey Harbor.*

Fishing Licenses by County[6]

	Commercial fishing licenses:	Charter boat licenses (recreational fishers):*
Marin	167	17
San Mateo	214	10
Santa Clara	201	2
Santa Cruz	179	7
Monterey	504	5
San Luis Obispo	383	2

**One charter boat company was hired by approximately 7,800 recreational fishers during 2000.*

ACTIVITY	DETAILS
Volunteer Docents	Estimated contacts with the public: Save Our Shores Sanctuary Stewards (Santa Cruz and San Mateo) - 75,000 BAY NET (Santa Cruz and Monterey Peninsula) - 33,000 Friends of the Elephant Seal (San Luis Obispo County) - 100,000
Sanitary Exceedances and Unauthorized Discharges[8]	Reported sanitary exceedances and unauthorized discharges, by county: **Marin** Effluent exceedances in watershed - 0 Effluent exceedances w/direct discharges to Sanctuary - 0 Unauthorized discharges in watershed - 0 Unauthorized direct discharges to Sanctuary - 0 **San Mateo** Effluent exceedances in watershed - 0 Effluent exceedances w/direct discharges to Sanctuary - 0 Unauthorized discharges in watershed - 0 Unauthorized direct discharges to Sanctuary - 0 **Santa Cruz** Effluent exceedances in watershed - 27 Effluent exceedances w/direct discharges to Sanctuary - 0 Unauthorized discharges in watershed - 10 Unauthorized direct discharges to Sanctuary - 1 **Monterey** Effluent exceedances in watershed - 9 Effluent exceedances w/direct discharges to Sanctuary - 0 Unauthorized discharges in watershed - 16 Unauthorized direct discharges to Sanctuary - 9 **San Luis Obispo** Effluent exceedances in watershed - 0 Effluent exceedances w/direct discharges to Sanctuary - 23 Unauthorized discharges in watershed - 3 Unauthorized direct discharges to Sanctuary - 0
Beach Postings and Closures[9]	By county: **Marin** - no beach closures or postings from Rocky Point to Point Bonita **San Mateo** - no information available **Santa Cruz** - 1 beach closed due to sewage spill for 2 days; 7 beaches posted due to high bacteria counts for a total of 50 days; 4 beaches posted permanently due to fecal contamination from dense bird populations; 2 beaches posted for rainwater infiltration and 1 beach posted seasonally **Monterey -** 2 beaches closed on 4 occasions due to sewage spills and 7 beaches posted due to high bacteria counts on 24 occasions **San Luis Obispo** - no beach closures or postings from Cambria north to the Monterey County border
Vessel Incidents with MBNMS Response	1/00 - 40-foot fishing vessel took on water and sank off of Big Sur; Sanctuary coordinated salvage operation and defueling. 5/00 - 96-foot shrimp boat ran aground near Moss Landing; Sanctuary coordinated salvage operation and defueling. 10/00 - Small, single engine airplane crash off of Monterey; Sanctuary responded and assisted in salvage operations. 10/00 - 55-foot fishing vessel ran aground at Point Pinos; Sanctuary coordinated salvage operation and defueling.
Enforcement Actions under the Marine Sanctuaries Act[10]	See below

Enforcement Actions under the Marine Sanctuaries Act[10]

Type of Investigation	Completed	Cases Open	Pending
Unlawful discharge into MBNMS	4	5	2
Altering seabed/Abandoning structure	0	2	1
Take of marine animal or seabird	5	0	1
Low flying aircraft violations	0	0	50
Operating PWC* in MBNMS closed area	2	0	0
MBNMS permit violation	1	1	1

*Personal watercraft

Sources:
1 - CA State Parks Districts: Bay Area, Santa Cruz, Monterey, San Simeon, and Cambria Chamber of Commerce
2 - Monterey Bay Whale Watch, Randy's Fishing Trips, Santa Cruz Sportfishing, Chardonnay Sailing, O'Neill Yacht Center, Pacific Yachting and Sailing
3 - Kayak Connection, Venture Quest, Sea For Yourself, Beyond and Back Kayak Adventures, California Kayak Co.
4 - On the Beach Surf Shop, Paradise Surf Shop
5 - Aquarius, Dive N' Kayak Safaris, Dave Clayton (SAC Dive rep.)
6 - CA Department of Fish and Game
7 - California Coastal Commission
8 - Regional Water Quality Control Boards
9 - County Environmental Health Departments
10 - NOAA Enforcement

bocaccio trying to eat it – two fish on one hook," Vince says. "The bocaccio could weigh seven to eight pounds and the chilipepper, two to three pounds; in no time at all, the boat was loaded." Other times when the fish were biting, the fishermen laid out between twenty-five and thirty lines and left them alone. When the fish stopped biting, the men hauled in four to five hundred pounds of fish per line. It was not unusual to bring in four tons on a single trip.

On the way home, Vince and his brother "pinned" (placed the hooks) and baited the baskets for the next day – a process that could take the whole trip. Once back in Monterey, they sold their catch and, if they were lucky, were home by 5 p.m. They made a very good living.

As Vince grew up, so did the fishing industry. Vince likes to say, "those were the old days. I don't think you can catch ten fish in the same area today." The biggest change came, he believes, in the form of gear: nylon nets and drag boats changed the rockfish fishery, and not for the better. The weighted nylon nets were often lost in the bay. "In my opinion, that killed fish for ever and ever," Vince says. "The nylon net never deteriorates." The drag boats pounded the sandy bottom in eighty to ninety fathoms outside the rock-beds, four or five boats working every day, disturbing the natural habitat. "It disturbed them so badly that we couldn't fish there anymore," he says.

Much has changed since Vince started fishing, including regulations, catch limits and, of course, the designation of the Monterey Bay National Marine Sanctuary. He still thinks fondly, though, of those early mornings spent aboard his father's boat long-lining for rockfishes.

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Maritime Museum of Monterey

Kip Evans © MBNMS

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