Ecosystem Observations

for the Monterey Bay National Marine Sanctuary

2003

National Marine Sanctuaries™
Monterey Bay

© 2003 Richard Ternullo/Monterey Bay Whale Watch

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Welcome

When we started *Ecosystem Observations* about five years ago, our main goal was to provide the public with a sense of what is learned each year in, and about, the ecosystem protected by the Monterey Bay National Marine Sanctuary. "Make the connection" between citizens and the natural resources of the sanctuary became the mantra of everyone working at the sanctuary. Through the many published stories over the years in *Ecosystem Observations*, our colleagues, scientists, and users have shared their observations about the incredible marine and coastal ecosystem of the sanctuary.

This year, the sanctuary's research team joined the ranks of our region's overachieving marine scientists and carried out five important research and monitoring cruises (*see p. 4*). Since the time we published the first *Ecosystem Observations* in 1999, our research team has grown from one and a half to at least eight scientists and several interns. This year's initiation of multiple research cruises reflects a growth in our research team, in terms of capacity for field work, scientific competency, and internal team work. Our marine science colleagues know that organizing and launching a week-long offshore research project is daunting. For the uninitiated, it is like the planning and packing you did for your last vacation, only there are no Wal-Marts or convenience stores on the corner if you forget something. Now do that five times in one summer.

Clearly, like with everything else accomplished by sanctuary staff, partnerships were critical. All of these cruises had extensive collaborations with literally dozens of other individuals, agencies, and institutions. But I am highlighting the research team's accomplishments, over the other incredible accomplishments this past year by other sanctuary staff, because *Ecosystem Observations* is about sharing what was learned.

Years ago, I had the hope that our research team would be a peer of the many other talented researchers in the region, not only sharing ideas but actually getting their feet wet in the ocean. I feel this year we met that vision and are now, more than ever, able to share and contribute to the knowledge of the vast, mysterious, and sometimes quite familiar resources of the Monterey Bay National Marine Sanctuary.

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

2003 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 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 operations. A summary of each program's major accomplishments and activities for 2003 follows. This year's report also includes a review of activities surrounding the Joint Management Plan Review (JMPR).

Sensitive habitats and species, a long stretch of adjacent, populated coastline, and multiple uses of the marine environment all lead to a variety of resource protection issues in the sanctuary region. The goal of the Resource Protection Program is to initiate and carry out strategies to reduce or prevent detrimental human impacts.

Effective protection requires partnerships with many other agencies and organizations. This year the activities and partnerships of the Resource Protection team involved conducting evaluations and leading a multitude of stakeholders in the planning and review of a range of issues for the JMPR, including marine protected areas, tidepools, dredge disposal, wildlife disturbance, motorized personal watercraft, coastal armoring, desalination, trawling habitat impacts, krill harvesting, beach closures, and water quality. Many key partnerships were strengthened through these groups, and we began drawing on them for the long-term task of carrying out the draft plans.

Enforcement took on a new focus as we recruited a uniformed officer who improved our outreach capabilities, visibility in the field, and ability to enforce sanctuary regulations. The new officer already has sixty cases under investigation, ranging from harassment of marine mammals and unauthorized sanctuary discharges to low-flying aircraft. Two trainings were conducted for forty enforcement partners from the California Department of Fish and Game (CDFG), California State Parks, and local governments to provide information on the sanctuary and cross-deputize rangers who will enforce sanctuary regulations. It was a busy year for emergency response as well, with seventy calls requiring either follow-up or site visits, including field work to ensure adequate removal of fuel and oil from vessel groundings.

The Resource Protection team reviewed fifty-four permit requests (37 approved; 5 pending; 7 no permit required; 3 withdrawn or abandoned; 2 denied), issuing permits or authorizations for activities such as seabed disturbance, discharges to the sanctuary, and overflights below 1,000 feet in restricted zones. Various conditions were imposed on these activities to reduce or eliminate threats to the sanctuary. We also reviewed and commented on a variety of projects, plans, or policies under development by other agencies to ensure that they adequately protected sanctuary resources. Plans reviewed ranged from municipal issues such as seawalls, to county general plans, to state fishery management plans.

The Water Quality Protection Program and its many partners continued efforts to reduce contaminated runoff in the sanctuary's watersheds and complete a detailed evaluation of the implementation of four completed plans. Carrying out the sanctuary's Agriculture and Rural Lands Plan, staff at the Monterey Bay Sanctuary Foundation, the Natural Resources Conservation Service, County Farm Bureaus, Resource Conservation Districts, and others collaborated with local farmers and ranchers in thirteen watershed working groups to improve sediment, nitrate, and pesticide management. In our local cities, we conducted six technical trainings with public works and planning staff on management practices to reduce contaminants in urban runoff.

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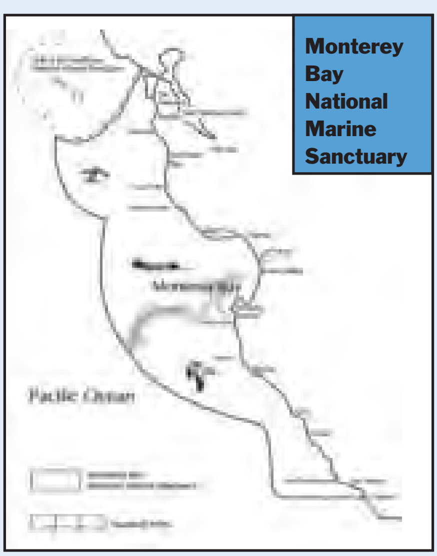
Sanctuary volunteers conducting watershed monitoring

By offering a variety of trainings and regional events, the Sanctuary Citizen Watershed Monitoring Network continued to involve a large number of volunteers in water quality monitoring activities. The popularity of our annual Snapshot Day led to its expansion into a state-wide coastal event this year, and the 155 volunteers who collected water samples in the sanctuary's watersheds found many areas high in nitrates and coliform bacteria. Urban Watch, a summertime volunteer monitoring program conducted with local cities, included toxicity analyses for the first time, in collaboration with Granite Canyon Laboratory. First Flush, a volunteer event to monitor contaminants flushed off streets by the first heavy rains, expanded to four cities: Pacific Grove, Monterey, Santa Cruz, and Half Moon Bay. This program found very high levels of mortality for fish larvae and mussels exposed to contaminants from our local storm drains. Staff have been working with local cities and counties to use these data to identify sources, reduce levels of contamination, improve permit programs, and target public education.

As we head into 2004, the Resource Protection team will continue our existing efforts and move ahead with initial phases of implementation for the many new plans in the JMPR. We look forward to continuing joint efforts with our partners to protect



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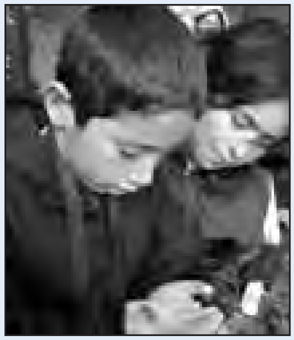
The goal of our Education and Outreach Program – to promote understanding and stewardship of the sanctuary – is carried out, in large part, through interpretation. Historically, interpretation has come in the form of giving meaning to the resources and sharing it in a form that is pleasing and understandable to others. Interpretation of our natural resources, the issues facing them, the research we conduct to understand them, and how we can all protect them is at the heart of the Education and Outreach Program. This year, interpretation took on new meaning – that of actual translation from the English language to Spanish, in the form of our MERITO (Multicultural Education for Resource Issues Threatening Oceans) program.



Student Silvino Suarez identifies a crab during a crab monitoring project at Elkhorn Slough Reserve.

© Karen Grimmer for NOAA/MBNMS

Piloted in late 2002, MERITO has blossomed into a very active and highly participatory program for the Latino communities in the Monterey Bay region. With funding support from the National Marine Sanctuary Program headquarters, we hired two dedicated staff who were able to: reach more than 5,500 Spanish-speaking individuals with direct programming; develop and field-test a full-year middle school curriculum focused on watershed and ocean protection; provide in-the-field experiences for 180 Hispanic community members; translate and print materials for use at Elkhorn Slough; publish a bilingual marine-themed storybook – *Coralito's Bay*; launch a dual language web site; develop assessment methods for all MERITO programming; host two internships through California State University Monterey Bay (CSUMB); and secure funding to train twenty-five Hispanic-serving teachers in marine resource issues.

Marine issue interpretation continued through the year (in English too) through a variety of new programming. The very popular Threatened & Thriving poster series was joined by a complementary lecture series. Local artist Kirsten Carlson's artwork is stunning and clearly represents the six threatened and six thriving species highlighted by the program. This popular topic was also chosen as the theme for this year's *Sanctuary Currents* Symposium, *Threatened and Thriving Species of the Monterey Bay National Marine Sanctuary*. The symposium, co-hosted by the Association of Monterey Bay Area Governments and CSUMB, was the largest to date and drew clear connections between actions on land and their consequences at sea.

Interpretation of resource issues continued in the tidepools with the adoption of a student-centered intertidal monitoring program – LiMPETS (Long-term Monitoring Program and Experiential Training for Students). The program, developed and initiated by UCSC professor emeritus Dr. John Pearse, has been adopted by all five national marine sanctuaries on the West Coast, bringing teachers and students into the field to monitor the intertidal zone at specific locations. A dedicated web site exists (http://limpets.noaa.gov), and it will be followed by a database that will allow students along the West Coast to input and compare data collected over time at their sites and others.

Families explore and learn about sanctuary wildlife during MERITO's kayak day.

© Michelle Templeton for NOAA/MBNMS

Interpretation of data became a new focus for the education team this year, with the September exploration of the *Montebello* (a Union Oil tanker, sunk by a Japanese submarine in 1941, that lies just south of the sanctuary boundary near Cambria). It became clear that having an education staff member as part of the expedition was the best way to help us report on the expedition's activities. By understanding what takes place on such cruises, we can showcase some of the exciting research the sanctuary is conducting and help everyone make the connection between the value of research and its role in protecting the sanctuary. We hope to participate fully this next research season and bring even more of the sanctuary to the public.

Finally, and with great excitement, the sanctuary chose a location for its proposed interpretive center – in Santa Cruz – to be developed with various partners. This is an exceptional opportunity for the program to showcase this sanctuary and the larger sanctuary system, encourage stewardship, and promote the many ways to enjoy this resource. Concurrently, two smaller interpretive facilities are in initial planning stages, one in the southern region at William R. Hearst Memorial State Beach and the other to the north at Pigeon Point Light Station. These smaller facilities are being developed in partnership with California State Parks and should be open by the fall of 2004 for all to enjoy.

SANCTUARY REFLECTIONS AWARDS

PRESENTED AT THE 2003 SANCTUARY CURRENTS SYMPOSIUM:

Public Official: *Lieutenant Tim Olivas, California Department of Fish and Game*

Citizen: *Mr. Ed Cooper (posthumously)*

Conservation: *Ms. Kaitlin Gaffney, The Ocean Conservancy*

Education: *Dr. John Pearse, University of California Santa Cruz*

Science/Research: *Dr. Jim Harvey, Moss Landing Marine Laboratories*

Business: *Seaside Company of Santa Cruz*

Organization: *Elkhorn Slough Foundation*

Special Recognition: *Coalition of Central Coast County Farm Bureaus*

At an intense pace, the research team continues to provide information to resource managers and the public, while conducting research to learn more about the sanctuary ecosystem.

This year, the Research Program worked closely with the Sanctuary Advisory Council (SAC), working groups, and the general public in revising the sanctuary management plan. It is clear from this work that much basic science still must be done, and that we will have to monitor trends in natural resources in order to develop and evaluate the best ways to manage the sanctuary. While developing our new management plan, we continued to address questions such as how the invasive alga, *Undaria*, is spreading up the California coast and if it can be removed from Monterey Harbor (*see p. 21*). Another effort, now complete, was supporting the study of effects of human access to the rocky shores of Point Pinos (*see p. 7*). What we've learned at Point Pinos and in Monterey Harbor is being incorporated into our revised management plan, so these lessons can be applied throughout the central California coast. At the national level, the federal government is planning to develop an integrated ocean observing system in which buoys and other instrumentation will provide real-time and predictive assessments of ocean currents and other parameters, somewhat like weather reports. Look forward to reading more about this in future *Ecosystem Observations* issues, as – because of the aggregation of world-class marine research institutions in the sanctuary region – this area has been selected for two pilot ocean observing projects: the Center for Integrated Marine Technology and the Center for Integrated Coastal Observatory Research and Education.

The ability to share central California monitoring information among a range of interest groups, from the general public to scientists, has made great strides with the release of the Sanctuary Integrated Monitoring Network (SIMoN) web site (*see www.mbnms-simon.org*). This portal provides general information on sanctuary habitats, relevant maps and figures associated with these habitats and important sanctuary issues, summary information on more than fifty monitoring projects, education links, and much more. We have a great opportunity in our sanctuary because of the wealth of information gathered by our many regional scientists; however, this also provides a great challenge in organizing the information so that it is available in a form that can be located and used easily. Scientists and decision makers are already using the site extensively, but we want to hear more from the public. Let us know your monitoring information

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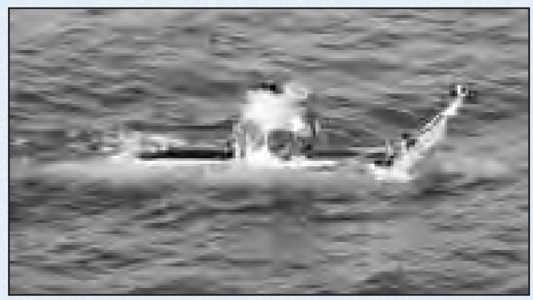
Sanctuary Research Cruises

In partnership with many other research institutions, the sanctuary research team organized and participated in five major research cruises in 2003. Using NOAA's 224-foot R/V *McArthur*, we completed geologic mapping of the Partington Canyon area, off the Big Sur coast. This information will help us characterize an area proposed for communication cable routes, link onshore and offshore sediment movement processes that are critical to understanding impacts of potential dumping options for the maintenance of Highway 1 (*also see p. 6*), and provide a habitat basis for ongoing discussions on the appropriateness of designating



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no-take reserves. Also along the Big Sur Coast, we used the Channel Islands National Marine Sanctuary's 62-foot R/V *Shearwater* to begin a detailed assessment of kelp forests and rocky shores that may be impacted by landslides and road maintenance operations. This information will be used in developing the Big Sur Coast Highway Management Plan. With MBARI's 117-foot R/V *Western Flyer*, 110-foot R/V *Pt. Lobos*, and remotely operated vehicles, a diverse team of scientists completed an environmental assessment on a science cable linking a hydrophone on the Pioneer Seamount to Half Moon Bay. This information is being used to develop national policies on cable laying in marine sanctuaries and to make a decision on the fate of this cable. The two-person submersible *Delta* was used in a combined mission with NOAA Fisheries and the Cordell Bank National Marine Sanctuary. Objectives of this cruise included initiating long-term monitoring of fish and invertebrate populations, assessing changes in fish populations by comparing results with previous surveys in Soquel Canyon, mapping deep-sea habitats, and assessing the structural status of the *Montebello*. The location of long-term monitoring stations will be determined based on this initial survey, and we found that the *Montebello* has not been leaking oil. The diverse expertise of sanctuary staff and the outstanding scientists and research institutions in the region make it possible to address management needs for information on complex issues such as these.

needs and desires by viewing the web site and clicking on a comment button (at the bottom of every page). Help us make this a community site – the first place we all look when we want information on the health of our sanctuary.

The staff has been busy developing and tracking other SIMoN-sponsored efforts. These include a new mapping project to characterize shallow (less than eighty meters) regions of the sanctuary; assessing the impacts of the Duke Power plant's offshore, warm water plume; developing a model of water circulation in Elkhorn Slough; describing the plankton and mudflat organisms of Elkhorn Slough; ongoing sanctuary-wide surveys of kelp forest canopies, including testing new aerial imaging systems; and completing the sixth year of our Beach COMBERS volunteer program, in which we continue to learn about our offshore sanctuary by surveying beachcast marine birds and mammals along our beaches. The sanctuary facilitates research by providing program funds, obtaining grants to pass along to our partners, and simply making people aware of interesting questions; however, this year we have taken advantage of our in-house expertise to become more active in a series of research cruises (*see p. 4*). Results from all of the above work was presented at seven

Joint Management Plan Review

A busy year unfolded as we continue our review of the sanctuary's management plan. All staff contributed to the review, hosting numerous meetings to develop a set of action plans that will eventually make up a new management plan for the sanctuary. Beginning in January

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More than 350 people attended a public hearing in Santa Cruz to provide review and comment on the action plans for the Joint Management Plan Review.

2003, we organized and facilitated sixteen different working groups, who provided key recommendations on a wide range of issues identified as priorities during the review's scoping phase in 2002.

Working groups comprised of staff, stakeholders, SAC members, and content experts characterized each issue – developing strategies and proposed actions for coastal development, ecosystem protection, water quality, partnerships, administrative operations, wildlife disturbance, and many other issues. A total of 223 experts and stakeholders participated in sixty-six meetings to develop the first draft of action plans. During the summer, these plans were presented to the public and the SAC for their review and comment. After much deliberation, the SAC provided sixty-eight specific recommended modifications to the action plans. All together, the working groups and SAC recommended 567 specific actions for inclusion in the new management plan.

In the coming months, the staff will incorporate these recommendations and put the finishing touches on the action plans, completing a draft management plan. We will release this document along with a Draft Environmental Impact Statement in the fall of 2004, and the public will be invited to attend hearings to provide comment on both. A final management plan is scheduled for release in 2005.

A management plan is the guiding document for each sanctuary, identifying how it will operate over the next five to ten years. The plan sets priorities for resource protection, education, and research programs as well as resources, staff required, regulatory goals, and implementation priorities. This is the first time the management plan for the Monterey Bay National Marine Sanctuary has been reviewed since its designation in 1992. The National Marine Sanctuaries Act requires that each sanctuary periodically review its management plan, ensuring that it will continue to conserve, protect, and enhance its nationally significant living and cultural resources. For more information about the JMPR, please visit http://sanctuaries.nos.noaa.gov/jointplan/.

Program Operations

Our Program Operations team continued to provide necessary administrative and operational support, allowing us to stay focused on our mission and goals. In an ongoing effort to expand outreach and education in the southern region, we were offered an opportunity by California State Parks in San Simeon to rent and refurbish a building at William R. Hearst Memorial State Beach to serve as a new sanctuary office and interpretive facility. Our patrol vessel *Sharkcat* has two new engines to monitor permitted activities and support education and research efforts better.

Our staff worked closely with the SAC, dedicating a majority of time to the JMPR. In June we presented the SAC with a series of action plans addressing each priority management issue. At least 350 community members attended a public hearing in late July, voicing their opinions about the plans to the council. In all, 176 public comments were received. During deliberations over three days, the SAC provided its recommended modifications to the plans, which staff will incorporate as they produce a draft management plan.

Other topics addressed by the SAC included reauthorization of the National Marine Sanctuaries Act, future membership composition of the council, and cruise ships. Several new members joined the SAC this year, including new representatives from the CDFG, California State Parks, and the U.S. Coast Guard. New at-large and tourism alternate seats were also appointed.

The Monterey Bay Sanctuary Foundation continued to support the sanctuary's mission, playing an integral role in the administration and management of the Sanctuary Integrated Monitoring Network (SIMoN). SIMoN staff grew this year to include two scientists, an outreach specialist, and a data analyst, and we all celebrated as the new SIMoN web site (www.mbnms-simon.org) was launched in October.

As we come to the close of another busy year, we look forward to the continued support of our volunteers and partners as we carry out the sanctuary's mission. For more information about the

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CONTRIBUTED ECOSYSTEM OBSERVATIONS

BEACH SYSTEMS

Sediment Yield from Big Sur Coastal Landsides

Along the Big Sur coastline in central California, the rugged Santa Lucia Mountains descend abruptly into the Pacific Ocean, creating one of the steepest coastal slopes in the contiguous United States. Weak rocks and steep topography provide ideal conditions for frequent large landslides. In addition, this region experiences both high amounts of precipitation and high wave energy in the winter months. All these factors combine to produce an area of chronic landslides that may block, undermine, or damage Highway 1, at the edge of the coastal slope.

The California Department of Transportation (Caltrans) is responsible for maintaining the Highway 1 corridor and for providing safe access for both local residents and tourists. Prior to the establishment of the Monterey Bay National Marine Sanctuary, road-opening measures sometimes involved disposal of some landslide material and excess material generated from slope stabilization onto the seaward side of the highway. It is assumed that this disposed material, either directly, or indirectly through subsequent erosion, was transported down slope into the adjacent ocean. In addition to the landslides that initiate above the road, natural slope failures also occur on the steep slopes below the road, delivering material to the base of the coastal mountains where it is eroded and dispersed by waves and nearshore currents. As a result, any coastal slope landslide, whether through natural or anthropogenic processes, can result in sediment entering sanctuary waters. The disposal practices had the potential to disrupt biological communities by converting marine habitats from rocky substrate to soft bottom and increasing nearshore zone suspended sediment concentrations. However, natural landslide processes provide material for protection from waves at the base of the slope, and sediment entering the water provides nutrients and material for various nearshore habitats. Restricting any disposal may starve a system of necessary nutrients and sediments and actually increase the rate of cliff erosion.

Since 2000 the United States Geological Survey (USGS) has been conducting a study to provide an estimate of the historical volume of sediment (sediment yield) that enters the coastal system directly from coastal slope failures along nine sections of the Big Sur coastline (*Figure 1*). Its purposes are to provide background data for the sanctuary and the Caltrans Coast Highway Management Plan as well as to advance the fundamental understanding of coastal landslide input rates and processes along this stretch of coastline.

The primary tools used in this study are digital photogrammetry and GIS (geographic information systems). Digital photogrammetry involves a technique of processing aerial photographs with computer software to produce 3-dimensional topographic models of the terrain – digital terrain models (DTMs). DTMs from two dates are brought into a GIS where the DTMs are subtracted, and the volume changes are calculated. The spatial distribution of the terrain changes is also compared to the local geology. The historical aerial photographs chosen for the study are from 1942 and the recent photographs are from 1994, thus providing the base for determining a fifty-two-year sediment yield (the volume loss per linear extent of coast per year).

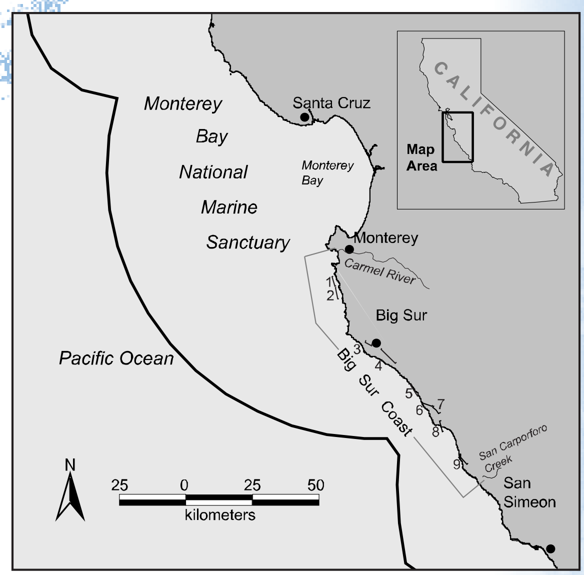


Figure 1: Location of the study sections along the Big Sur coast in central California. The numbers 1-9 shown on the map correspond to the specific study sections.

The results of the volumetric change analysis are shown in Figure 2 (*p. 7*). The average sediment yield for the Big Sur Highway 1 corridor is approximately 21,000 + 3,200 m^3 per kilometer per year (43,200 + 6,500 yd^3 per mile per year) based on the analysis for the completed nine sections. The rocks along the Big Sur coastline are a complex mixture of sheared rocks of the Franciscan Complex and granitic rocks of the Sur complex. The rocks of the Franciscan Complex tend to be weaker than those of the Sur complex. However, the lithology within the Franciscan Complex varies dramatically, and softer, highly sheared mélange is more prone to landsliding than the various sedimentary strata and volcanic rocks.

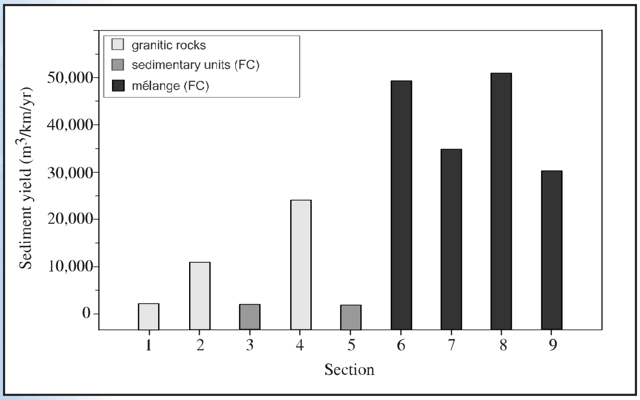


Figure 2: Relationship between sediment yield and lithology (physical characteristics) for the nine study sections of coastline. The sediment yield within the weak mélange is consistently greater than the yield in the stronger sedimentary units and the local granitic rocks. (FC = rocks of the Franciscan Complex)

Sections 1 and 2 have very low input rates for the coastline compared to other sections and are within the stronger granitic material (*see Figure 1*). Sections 6 through 9 have high input rates for the coastline compared to the other sections. Section 4, which lies within the stronger granitic material, demonstrates anomalously high input rates compared to the surrounding areas (sections 3 and 5). This high rate is attributed to the particularly large JP Burns landslide that occurred in 1983 and is therefore within the fifty-two-year time period of this analysis. A total of nearly 20 million cubic meters of material was removed by a combination of natural processes and slope stabilization. Sections 6 and 8 have the highest input rates for the coastline compared to other sections. The rocks along these sections of coastline are faulted and sheared rocks of the Franciscan Complex with a history of large historic landslides.

In 2000 the sanctuary and Caltrans determined that in order to deal with the issue of landslide material disposal along the Big Sur coast, it was necessary to understand the historical inputs to the coast from the chronic landslides. The results of this sediment yield study have been incorporated into the Caltrans Coastal Highway Management Plan and are being used by the sanctuary to investigate the possibility of controlled disposal of landslide material along selected coastline sites where valuable marine resources would be least affected. Future collaborative work between the sanctuary, Caltrans, and the USGS will involve high-resolution analyses of three specific landslide sites to understand not only how much material is entering the sanctuary waters but what the rates of input are and by what processes material is delivered to the nearshore.

– Cheryl Hapke
United States Geological Survey

Rocky Intertidal and Subtidal Systems

A Study of Visitor Impacts on the Intertidal Zone at Point Pinos, Pacific Grove

Point Pinos is a prominent rocky headland of the Monterey Peninsula in the Monterey Bay National Marine Sanctuary. Concerns have arisen that the marine life in the Point Pinos intertidal zone is being negatively affected by visitor use, from collecting and displacing organisms, trampling, and simply turning rocks.

The intertidal zone is the band of shoreline covered and uncovered by the sea between high and low tides. Some of the most diverse marine plant and animal communities occur in wave-swept rocky intertidal zones with outcroppings and tidepools, such as at Point Pinos. These shorelines have become increasingly popular for their educational, recreational, and scenic values and more frequently visited during low tides by schools, tourists, and the local public.

The intertidal zone has become increasingly popular for its educational, recreational, and scenic values.

During the summer of 2002 we sampled more than 150 species of invertebrates, algae, and intertidal fishes in multiple band transects and tidepools located in areas of high use at Point Pinos and nearby reference areas of lower visitation. We then statistically analyzed the data for differences in species abundances among areas to determine the levels of visitor impact. A lack of baseline data precluded a comparison to historical conditions. The assemblages studied included a mix of conspicuous species (e.g., turban snails, sea stars, hermit crabs, shore crabs, sea urchins, barnacles, limpets) and less obvious species (e.g., worms, chitons, small snails, abalone in cracks and crevices).

The impact assessment had to consider that biological differences among areas could be present that were not due to visitor use, but rather from natural variation. Therefore, conclusions from our one-time study that visitor use has altered species abundances along the Point Pinos shore required finding consistent, large differences between the visitor use and reference areas in a variety of species that are susceptible to visitor impacts. For example, purple sea urchins were significantly less abundant in tidepools sampled along the Point Pinos shore, relative to tidepools sampled in areas of less visitor use. However, the lack of reduced abundances among other species that are also highly prone to collecting (e.g., turban snails, sea stars, shore crabs, hermit crabs, abalone, limpets) lowers the likelihood that this particular difference was due to visitor impacts. In contrast, there were some apparent differences in algal cover among the areas studied. We found that chronic trampling had likely

Withering Syndrome in Black Abalone

Founded in 1999 by the David and Lucile Packard Foundation, the Partnership for Interdisciplinary Studies of Coastal Oceans (PISCO) is a consortium of four west coast universities that focuses on regional-scale, multidisciplinary research related to coastal rocky reefs. One research project funded under PISCO is the long-term monitoring of black abalone along the coast of California by researchers at UC Santa Cruz.* This program surveys fifteen sites from Point Conception to Bodega Bay, including eight in the Monterey Bay National Marine Sanctuary.

In 2001 PISCO reported on the pattern of mass mortality of the intertidal black abalone (*Haliotis cracherodii*) along the west coast of North America. Once the largest and arguably most important herbivore in intertidal systems along much of the west coast of the United States, the black abalone has experienced mass mortalities along California's coast since the mid-1980s. Mortality is due to infection by a pathogen that leads to a fatal wasting disease called "withering syndrome," in which the abalone's foot shrinks until it can no longer adhere to the substratum. The general pattern of mortality, once die-offs start, is that within a few months to a year the population decreases by more than 90 percent, with a few remnant individuals remaining healthy and persisting. Since the early 1990s the disease has migrated sequentially northwards along the coast of California. By 2001 the documented spread of population crashes due to withering syndrome extended to the southern boundary of the sanctuary. At that time the only extant large and healthy populations of black abalone resided in the sanctuary, and this is still the case.

Our monitoring has continued, and through the spring of 2003 black abalone populations throughout the sanctuary remained stable. Importantly, we continued to see recruitment of juvenile abalone at many of our sanctuary sites. Given that the last great onslaught of the disease happened in 1998, we were beginning to think that perhaps the northern populations might not be affected. Since movement of population crashes has been associated with warm water, we hypothesized that water temperatures from Cambria north may not be conducive to population crashes seen to the south. However, we may have to rethink this hypothesis. We have finished about half of our fall surveys and have noted population declines at all of the southern sanctuary sites. This has never happened before.

Whether this represents the beginning of a renewed spread of population crashes due to "withering syndrome" remains to be seen. However, the declines clearly point to the need for ongoing monitoring. For more information on the PISCO project, please visit www.piscoweb.org.

* Much of this work started prior to PISCO's founding. Other funding sources for this research include the Natural Sciences and Engineering Research Council of Canada, the Mineral Management Service, the UC Toxics Substances Research and Teaching Program, and the National Science Foundation.

– Peter Raimondi[1] and Lydia Bergen[2]
[1]Department of Ecology and Evolutionary Biology, University of California Santa Cruz
[2]Partnership for Interdisciplinary Studies of Coastal Oceans,

caused the coverage of some algae to be reduced in portions of the upper intertidal zone near access points.

Excluding visibly trampled areas, we found the Point Pinos intertidal zone to be as diverse as intertidal zones in neighboring shorelines with lower visitation. Overall, biological variation was found to be similarly high both within and among areas of high and low use. This variation also added to the difficulty of detecting greater visitor impacts. Furthermore, marine species in wave-exposed habitats are subjected to a variety of natural disturbances (e.g., wave shear, boulder rolling, sand scour) that are similar to visitor disturbances (e.g., rock turning, trampling). Consequently, it is often difficult to identify visitor impacts in this type of rigorous and heterogeneous environment where high natural biological variation and disturbances can mask the effects of visitor use.

The possibility exists that species at Point Pinos may at one time have been more abundant, but have decreased to the levels found in our reference areas. However, an incomplete knowledge of the historical biological baseline precludes knowing more on how Point Pinos has changed from visitor use versus natural causes. Furthermore, baselines shift, and such changes can only be identified when long-term monitoring data are available for comparisons.

Another possibility as to why greater impacts were not discerned may have been related to several resource conservation measures that were implemented one to three years prior to our sampling and which may have allowed some impacted species to recover. In 2002 the Pacific Grove Police Department increased resource enforcement and surveillance of illegal collecting at Point Pinos, and signage in three languages informing visitors not to disturb the marine life was placed along the shore. BAY NET, an Ocean Conservancy and sanctuary docent program, expanded its conservation awareness instruction to Point Pinos about a year before our study, complementing similar efforts by the Coalition to Preserve and Restore Point Pinos Tidepools, a public advocacy group. While fishing is still allowed in the area, and certain intertidal invertebrates may still be collected with a fishing license, all other intertidal collecting is prohibited, except with a scientific collecting permit authorized by the California Department of Fish and Game (CDFG). However, in 1999 the CDFG issued a moratorium on scientific collecting in the area.

This one to three year period may have been sufficient for some of the most rapidly reproducing and fast growing species, such as some algal species and smaller invertebrates, to recover. However, this period would not have been sufficient for full recovery in slower growing species with limited reproduction and propagule dispersal. These include owl limpets, abalone, and sea stars. The lack of substantial findings of adverse visitor impacts in the slower growing species may, in effect, indicate that impacts were not large to begin with, as the abundances of these species were not significantly different between Point Pinos and reference areas.

We estimate that approximately 50,000 people venture down into the Point Pinos intertidal zone annually. Many other shorelines experience greater levels of visitation into the intertidal zone, and resource managers in these areas are faced with similar issues of balancing resource conservation with continued access and uses. Accordingly, we feel that maintaining resource conservation programs at Point Pinos, including monitoring, is warranted in light of the findings of this study, because visitor use will likely increase in the future with natural population growth.

We thank the David and Lucile Packard Foundation, the City of Pacific Grove, and the sanctuary for funding the study and the Monterey Bay Sanctuary Foundation for project administration. The Point Pinos Tidepool Task Force Research Committee, a panel of local scientists and citizens, commissioned the study. We would not have completed our study without assistance from BAY NET, which conducted our visitor census surveys. The final report is available at www.mbnmsf.org or on CD from the City of Pacific Grove.

– Scott Kimura
Tenera Environmental

Open Ocean and Deep Water Systems

Tracking Ocean Sunfish, *Mola mola*, with Pop-Up Satellite Archival Tags in California Waters

As summer draws to a close and the tourist hordes thin, a bizarre visitor starts appearing more frequently in the Monterey Bay National Marine Sanctuary. The ocean sunfish, *Mola mola*, is sighted here year-round, however September through November provide the most likely chances for encountering these uniquely shaped open ocean travelers. With a strikingly abridged appearance, molas are the world's heaviest bony fish. We know they can grow to a weight of more than 2,250 kilograms (5,000 pounds), on a diet primarily of jellyfish. But exactly where these leviathans travel, feed, mature, and reproduce remains a mystery.

In 2000, with help from National Geographic, the Monterey Bay Aquarium, and others, a team began conducting mola research using genetics and satellite tagging technology. Genetic analyses have been conducted at the University of South Florida under the direction of Steve Karl with assistance from J. Todd Streelman and Anna Bass. I am joined on the domestic satellite tagging team by John O'Sullivan, Heidi Dewar, Chuck Farwell, Brett Hobson, and Eddie Kisfaludy. (*For individual affiliations, see www.oceansunfish.org.*)

Genetics

The genetic results thus far have been fascinating. Between the Atlantic and Pacific oceans, *Mola mola* populations appear clearly divided, while intra-oceanic differences between northern and southern hemispheres appear nominal. More extensive analyses of South Pacific and North Atlantic samples will further clarify these preliminary findings. Globally, we have located several significantly genetically divergent individuals from Australia and South Africa, and these likely represent two new ocean sunfish species.

The California *Mola mola* population analyses have yielded very interesting results. We looked at a special group of genes known as microsatellites, which are commonly highly variable in fishes and can provide a genetic fingerprint of individuals. Surprisingly, there are a larger number of individuals sharing similar fingerprints than expected. Although results are preliminary and there are several things that might cause this, it is consistent with early indications that the population size has recently been reduced – possibly due to fishing pressure. We must collect more data before we can be sure of the direct cause of the modest loss of genetic variation, but these findings advance our knowledge significantly.

Unfortunately, *Mola mola* make up more than 25 percent of the California drift net bycatch – the single largest species component, according to Rand Rasmussen of the Southwest Fisheries Science Center. While these low energy, passive fish appear to survive their time in the nets, we have little way of gauging the long-term survival of individuals that have been caught and released. With more extensive genetic analyses, we can start to decipher if these extensive incidental captures may be adversely affecting our California population.

Tagging

Tagging efforts (using pop-up satellite archival tags, PSATs) are revealing individual daily movements and diving behaviors. The tags record temperature, depth, and light intensity, from which location is deduced. At a preprogrammed time, the PSAT releases from the animal to the surface, where it transmits data to orbiting Argos satellites, which in turn relay the data to a ground station and to computers. The beauty of this technique is that it collects large amounts of data without bothering the fish again. In addition, since the tag is attached for several months to years, the fish has time to recover from the tagging event and presumably display normal behavior patterns.

In the fall of 2000 we tagged four individuals off San Diego and acquired data from one fish's movements between August 2000 and March 2001. This mola traveled south to the middle of the Baja peninsula, then returned north to Catalina Island, where the tag released on March 17 as planned (*Figure 1, opposite*).

The fish's dive behavior depended on location. In August it spent half its time in the upper five meters (80 percent above 40 meters).

Local researchers are part of a global effort to track ocean sunfish.

It rarely forayed into deeper water, below 200 meters. Moving south, its time in deep water increased. By October, it spent half its time between 10 and 40 meters and nearly a quarter of its time between 100 and 300 meters. In December it spent a quarter of its time between 40 and 60 meters and approximately 40 percent of its time below 200 meters. By March, returning north, the fish split its time between 10 and 20 meters and 100 to 200 meters.

While more than 60 percent of its time was spent in water above 10˚ C, the mola also frequented temperatures below 7.5˚ C more than 16 percent of the time. Together, these temperature/depth data suggest that the fish may have been making repeated forays to the deep scattering layer, returning to the upper waters to thermally recharge. Its decreased time in the upper five meters between October and March may be relate to surface wave action that typically increases during winter months. Additional tags and data will allow us to test these two hypotheses further.

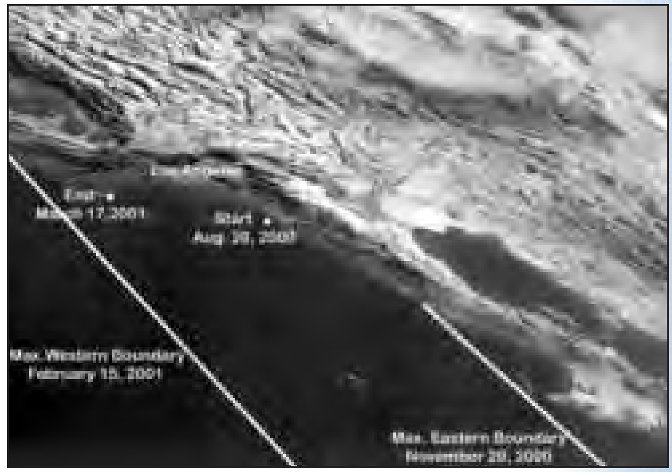


Figure 1. Movement of satellite-tagged Mola mola 18567 off the coast of southern California and Baja between August 2000 and March 2001. Lines indicate longitudinal limits of movement.

In August 2003 our team deployed another six tags off San Diego – five as part of the Tagging of Pacific Pelagics-Census of Marine Life Project (www.coml.org/descrip/topp.htm). These tags will release in the spring of 2004. Our ultimate aim is to combine tagging data with regional oceanographic data, fisheries observers' sightings, and aerial censuses to deduce how *Mola mola* are using the California current. We hope our long-term tracking work will shed insight into diurnal behaviors as well as seasonal movement patterns. With this knowledge, fishermen and managers may be able to reduce the amount of mola bycatch.

This California work is part of a global effort to track ocean sunfish and record species prevalence and distribution in all tropical and temperate oceans. To date, we have tagged twenty-two individuals in California, Japan, South Africa, and Australia, including five sharp-tailed mola (*Masturus lanceolatus*) in Taiwan. Next September we will tag *Mola mola* in Bali, Indonesia. Taken together, the genetic and tagging efforts are beginning to reveal the intimate details of the mysterious mola and its role in the open ocean ecosystem. For continuing updates and published papers, see www.oceansunfish.org.

– TIERNEY THYS
SEA STUDIOS FOUNDATION

New Ways to Get Energy from Light: Novel Microbial Processes in Monterey Bay

The oceans, including the waters of the Monterey Bay National Marine Sanctuary, abound with microbial life. Marine waters are teaming with microorganisms – about 1 million microbes in each milliliter of seawater. The vast majority of these tiny organisms are not contaminants or pathogens, but rather are central components of oceanic biota. Though small in size, the diverse biochemical and physiological activities of these microorganisms help to sustain the balance of energy, elements, and nutrients in the oceans. As Pasteur said so well, "The very great is achieved by the very small." In a very real sense these tiny microbial chemists help to maintain the oceanic ecosystem.

Despite the general importance of picoplankton (microbial plankton with cell diameters less than 2.0 μ), their biological properties are still not well understood. One reason is that it has been difficult to study these microbes in the laboratory using standard microbiological methods. Even when cultures are available, it is difficult to recreate the ecologically relevant biological interactions in a test tube. So, it has become necessary to redirect research efforts towards studying these microbes on their own turf. This involves the use of new strategies, techniques, and technologies, ranging from single cell analyses to stable isotope analyses, genomics, and physical biochemistry. The application of new techniques to study Monterey Bay picoplankton is leading to a deeper understanding of the biology and ecology of these tiny organisms.

Our National Science Foundation Microbial Observatory project, conducted at the Monterey Bay Aquarium Research Institute, is exploring the application of new technologies, developed in conjunction with the human genome project, to study natural microbial communities. It's now possible, using advanced biotechnologies, to recover and analyze large portions of microbial genomes directly from seawater, sidestepping the problem of poor recovery by cultivation. The DNA sequence of these microbial genomes can provide important clues about the nature and ecological function of naturally occurring picoplankton. For example, an entirely new type of light-driven energy generation was recently discovered using such genomic approaches to ecological questions, as described below.

There are several strategies for decoding the DNA of naturally occurring microbes. One approach is to capture and analyze very large DNA fragments (100,000 base pairs in size or greater), which can contain more than one hundred genes. Each gene encodes a functional protein, the building blocks that make up individual microbial cells. The decoding of these genes can lead to important clues about the properties and activities of microbes in nature. For instance, we decoded one large DNA fragment from an uncultivated marine bacterium (dubbed 'SAR86') that is abundant in Monterey Bay waters. Unexpectedly, we found a new type of photoprotein (a pigment containing protein that interacts with light) that we showed can be used by the microbes to generate cellular energy from sunlight. These photoproteins (known generally as rhodopsins) had never before been found in bacteria, so this was an unexpected finding: our newly applied genomic approach to environmental microbiology had revealed a new type of light-driven energy generation (phototrophy) in a very abundant planktonic marine bacterium. In fact, we can now show that these microbes and similar photoproteins are widespread in the sea, from polar regions to the tropical open ocean. A general take-home lesson here (also known from many other local studies), is that what we learn in Monterey Bay can often lead to useful insights about the oceans worldwide.

The initial discovery of the rhodopsin photoprotein was originally determined in laboratory studies. These showed us that indeed, the recombinant rhodopsin could generate energy from light. But do these laboratory experiments really tell us about natural oceanic processes? Once we had determined the biochemical properties of the novel rhodopsins, the search for this photoprotein in waters of Monterey Bay began. In natural picoplankton communities here, we found that the photoprotein was indeed present and functionally expressed in marine picoplankton of the bay. Further surveys in other locations, ranging from Antarctica to Hawaii, revealed that variants of the photoprotein are widely distributed in the world's oceans and that they come in different colors. In deep waters, these microbial rhodopsins appear 'tuned' to blue light, the light that is most abundant at greater depth. In shallower waters, the rhodopsins are 'tuned' to absorb green light, which is more available at the surface but not at depth. So, the rhodopsin-containing bacteria have adapted to different conditions throughout the photic zone, shallow and deep. They are an abundant component of the picoplankton and certainly contribute to picoplankton productivity throughout the world's oceans.

Many questions remain to be answered. Do the rhodopsin containing bacteria 'fix' CO_2, like plants? How much carbon and energy do these microbes contribute to the food web? Are these microbes entirely reliant on light for growth? Further work in the sanctuary is bound to help resolve some of these questions.

– Edward F. DeLong
Monterey Bay Aquarium Research Institute

Scanning electron micrograph of marine picoplankton, showing their very small size and different shapes. However, microbial diversity is not revealed by simple morphology, but rather by the complex and diverse physiology and biochemistry found within different microbial species.

"Big Red" – A Newly Discovered Jelly

Several years may pass between "discovering" and publishing the description of a new species. This time is spent making sure that the species discovered really is new to science and not described elsewhere, developing or renewing taxonomic expertise with the animals in question, and gathering as much information as possible about the "new" species. If we know its diet, habitat, physiology, genetics, etc., that information contributes to a thorough description of the species. Finally, one must write the description itself and submit the manuscript to a scientific journal for review and, one hopes, publication.

Monterey Bay Aquarium Research Institute (MBARI) recently described a new species in order to bring it to the attention of the scientific community, as it is relatively common, yet we know very little about its natural history. *Tiburonia granrojo*, or "Big Red," has a bell diameter up to one meter and lives 650 to 1,500 meters below the ocean surface. It looks like a big red spaceship cruising the ocean depths. Scientists first noticed this jelly off Gumdrop Seamount (about 100 kilometers west of Half Moon Bay) using MBARI's ROV *Tiburon*. Video observations of this unusual jelly were first recorded in the MBARI database in 1993 as the MBARI ROV *Ventana* captured a quick glimpse of the jelly. During a *Ventana* dive in 2001, Dr. Bruce Robison collected a small specimen, which has been deposited in the California Academy of Sciences collection. Working with colleagues at MBARI, Monterey Peninsula College, and the Japanese Marine Science and Technology Center (JAMSTEC), we recently described this new species of jelly. *T. granrojo* has a deep red color, lacks marginal tentacles, and has a varying number of oral arms. These characteristics led the researchers to generate not only a new species and genus description, but also a new subfamily (*Tiburoniinae*) in the family *Ulmaridae*, the same family as *Aurelia aurita*, the moon jelly.

Despite the relative abundance of *T. granrojo* in the Pacific Ocean, there are still many unanswered questions about this jelly. What does it eat? Who are its predators? How does it reproduce? We have an idea of where it lives and continue to document sightings, but we have much to learn about its role in the ecosystem. Since the description was published, we have heard from several researchers expressing their belief that they have also encountered this large medusa during submersible dives but had considered it to be *Stygiomedusa gigantea*, another previously described large red medusa without marginal tentacles. Such distribution information is useful and we hope to learn much more about this intriguing animal now that the description has been published.

– George Matsumoto
Monterey Bay Aquarium Research Institute

Monterey Canyon: Sediment Super-Highway to the Deep Sea?

The Monterey Bay National Marine Sanctuary encompasses some of the world's most spectacular physiography. One of the deepest and largest submarine canyons on the coast of North America is the Monterey Canyon, which is 470 kilometers long, approximately twelve kilometers wide (at its widest point), and has a maximum rim to floor relief of 1,700 meters. Imagine the Grand Canyon covered by ocean.

Monterey Canyon begins within 100 meters of the beach at the mouth of Moss Landing Harbor and can be traced down slope into more than four kilometers of water. Like most canyons on land, the shapes of submarine canyons indicate that erosional processes that are focused within their axial channels have carved them. The occurrence of huge volumes of sediment within the adjacent deep-sea fans documents that these canyons are major conduits that also funnel sediment from the continent into the deep sea. Similar submarine canyons scar the continental margins of the world. Unfortunately, little is known about the processes and rates of sediment transport and erosion within submarine canyons.

Our collective ignorance about the dynamics of submarine canyons has persisted into the twenty-first century because the oceanographic community has lacked adequate technologies to study submarine canyons effectively. Until recently, most of what was known about the morphology of submarine canyons was based on scattered echo sounder survey lines and rock samples from the sides of various canyons. Developments in multi-beam bathymetry have greatly improved the ability to image canyons and have made it clear that there is a well-defined axial channel between the steep sidewalls of Monterey Canyon. This axial channel is relatively flat-floored (≥2°) and has a series of bars and meanders that look like those in a terrestrial riverbed.

While the morphologic similarity between the axial channel in Monterey Canyon and a terrestrial river channel is striking, the canyon lacks the equivalent of the river. Unlike rivers, a regular down-slope flow of water is not known to occur within submarine canyons. Moreover, the water in the ocean is usually well stratified, which makes it difficult to sustain down-slope flows. Most of the existing measurements of the currents within submarine canyons suggest that the strongest daily flows travel up, rather than down, the canyon. Thus, the assumption is that periodically there must be energetic "events" that move material down slope. One analogy might be with avalanches in terrestrial mountains. The deposits that occur in the deep-sea fan at the base of the canyon also suggest that sand and even coarser materials only periodically come out of the canyon, because these deposits consist of isolated sand layers, interspersed within fine sediments. Still, only a few samples and limited environmental data have been collected within axial channels of submarine canyons.

In 2000 the Monterey Bay Aquarium Research Institute (MBARI) began an effort to study the active processes within Monterey Canyon, using the same techniques used to study a river system on land. This involves sampling the materials within the channel, monitoring how the channel shape changes with time, and measuring the physical conditions that occur within this environment. While these operations are relatively straightforward on land, access to the channel systems within submarine canyons is much more difficult. However, MBARI's remotely operated vehicles (ROVs) *Ventana* and *Tiburon* have made it possible to study the channels within the base of Monterey Canyon systematically. During the first two years of this project we have made a number of basic measurements and important observations that provide us with an unprecedented view of how Monterey Canyon operates.

A vibracoring system was built for use off ROVs. These corers work by inducing high-frequency vibrations in the core liner that in turn liquefy the sediment immediately around the core cutter, greatly reducing the sediment resistance and allowing long cores to be collected from coarse-grained sediments. ROV-based vibracoring operations have revealed that an essentially continuous tongue of sand extends from the beach down the canyon floor to a depth of about 1,400 meters. This tongue of sand, indistinguishable from the beach sands of Monterey Bay, is tightly restricted to the very axis of the canyon. The sediments on the flanks of the canyon, more than about five to ten meters above its axial channel, are predominantly fine grained. Thus, the processes that carry sand into the canyon are very narrowly focused within the canyon's axis. Moreover, carbon-14 dating has shown that the materials exposed on the floor of the upper canyon are relatively young, which suggests the canyon is filling rather than eroding. One sample was collected at thirty-two centimeters below the canyon floor from a sediment core taken in 1,400 meters of water in the axis of the canyon. This sample contained algae so fresh that it was still green; it had apparently been washed down the canyon recently.

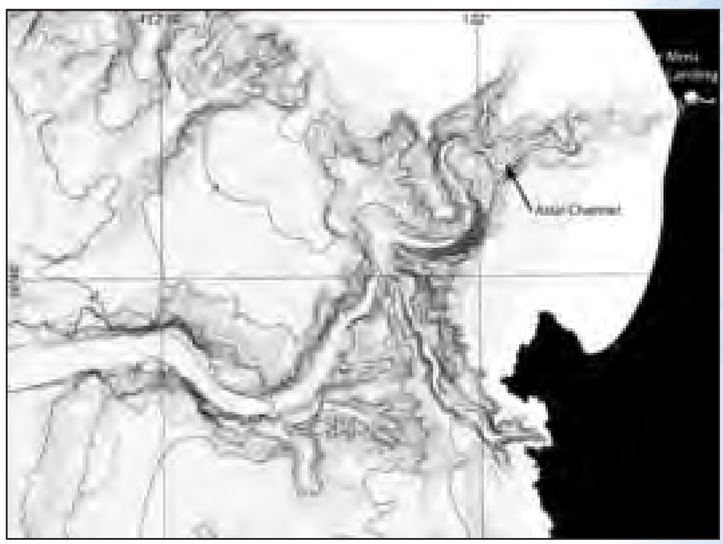


Figure 1. Contour and slope map showing Monterey Canyon. Contours interval is 500 meters, and the intensity of the shading is proportional to the slope of the seafloor. Note that a well-developed axial channel exists at the base of Monterey Canyon that has comparatively gentle slopes with respect to the slopes on the canyon's side walls. This channel is believed to be a major sediment transport conduit.

Pesticide residue studies demonstrate that fine-grained sediments have penetrated through the entire canyon and out onto the fan. Surprisingly, these fine sediments have passed through the canyon without substantial dilution. Thus, while the canyon is clearly an active sediment transport conduit, volumetrically significant quantities of old materials are not being eroded from the canyon sides, which would dilute the DDT-bearing sediments moving down through the canyon axis.

Four energetic sediment transport events were documented in the upper reaches of Monterey Canyon between December 2002 and March 2003. These events have been documented because robust instrument platforms were recovered after they had been washed considerable distances down canyon, damaged, and buried in up to two meters of sand. The frequency of these energetic events makes it obvious that the axis of the upper canyon is a very active sand and coarse sediment transport conduit. Developing instrument packages that can be deployed within the canyon axis to monitor the conditions that occur during these sediment transport events is an ongoing research objective.

– Charlie Paull
Monterey Bay Aquarium Research Institute

Wetlands and Watersheds

Phytoplankton, Biodiversity, and Invasive Species in Elkhorn Slough

Elkhorn Slough is well known for its rich flora and fauna, especially as represented by larger organisms that form conspicuous populations along the slough wetlands. However, the planktonic biota of Elkhorn Slough have not been so well characterized. As part of the Monterey Bay National Marine Sanctuary's SIMoN (Sanctuary Integrated Monitoring Network) project, scientists at Moss Landing Marine Laboratories (MLML) have begun a quantitative assessment of plankton community structure and function within Elkhorn Slough. One of SIMoN's primary missions is to document past and present sanctuary ecosystem characteristics for the purpose of monitoring environmental change. We report here our first observations addressing the phytoplankton of the slough.

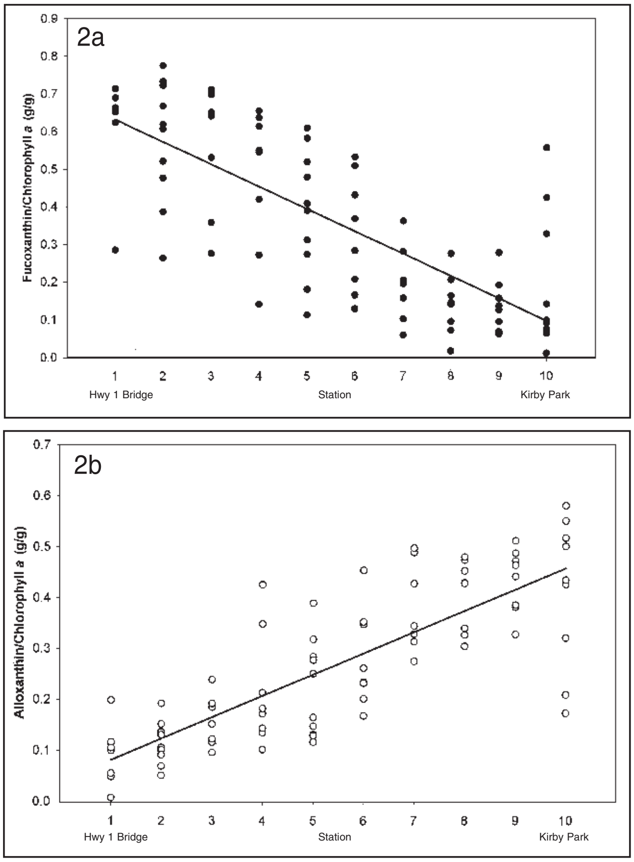
Ten sampling stations were established along the main channel of the slough from the mouth near the Moss Landing Harbor (Station 1) to the upper section past Kirby Park (Station 10). More than fifty sampling trips have now been completed during the first year (2002/2003) of our study, using small boat operations available at MLML. Using chemical (chromatographic) separation techniques, we analyzed water samples for phytoplankton pigments (chlorophylls and carotenoids), some of which by their presence indicate the occurrence of specific algal taxa. The taxon-specific pigments, discussed here, provide an indication of the algal diversity of the slough's phytoplankton community.

The information acquired so far has proven quite interesting. Without exception, all results have shown that the Elkhorn Slough phytoplankton community is divided into two assemblages: lower slough and upper slough (*Figures 2a and b*).

The lower slough, near Monterey Bay, is dominated by a rich diversity of coastal phytoplankton including dinoflagellates, cyanophytes, green algae, and most importantly, diatoms. The community effectively reflects the rich composition of phytoplankton found in the Monterey Bay source waters. The diatoms are easily tracked by their dominant carotenoid, fucoxanthin (the same carotenoid found in brown seaweeds). The upper end of the slough, inland of Parson's Slough, is characterized by high concentrations of alloxanthin, a carotenoid found only in the small algal group, Cryptophyta (less than twenty genera of cryptophytes are known). Cryptophytes are often present in Monterey Bay, however their concentrations are usually relatively low. Cryptophytes at the upper end of Elkhorn Slough, near Kirby Park, can make up more than 75 percent of all the phytoplankton biomass. Microscopic analysis shows that the planktonic flora of upper Elkhorn Slough is relatively species poor, dominated by only one or two species of cryptophyte.

To our knowledge, the division of Elkhorn Slough phytoplankton into two communities has not been previously known. However, all new observations suggest that the division is surprisingly persistent. For instance, the interface between the upper and lower algal communities can be seen to ebb and flood with the tide, without loss of resolution due to horizontal mixing. The community division has persisted through all four seasons sampled so far, including the high runoff period in winter. We are not sure how long the conspicuous phytoplankton community division has existed in Elkhorn Slough, but we are attempting to reconstruct that history through examination of the sediments.

The observation that Elkhorn Slough phytoplankton are grossly divided into a richly diverse bay-ward community and a relatively species-poor upper slough community poses interesting questions regarding the recent observations of introduced invasive species in the slough. Researchers at the Elkhorn Slough Foundation have listed more than fifty species of introduced marine invertebrates in the slough; interestingly, the most severe invasive conditions are noted in the upper slough. Most of these invasive invertebrates spend part of their early life within the planktonic habitat, and



Figures 2 a, b. Fucoxanthin and alloxanthin, representing diatoms and cryptophytes respectively, are referenced against chlorophyll a, a pigment common to all algae. Diatoms (fucoxanthin) are dominant in the lower slough (2a), whereas cryptophytes (alloxanthin) are dominant in the upper slough (2b). All data from 2003 are plotted collectively.

many feed on planktonic organisms after they settle as adults. One wonders whether the growing biomass of introduced benthic filter feeders in the upper slough could selectively remove the larger algal cells (e.g., coastal diatoms, dinoflagellates) originating from Monterey Bay, leaving small (<10 µ) cryptophytes to proliferate.

We have begun analyzing core samples from Elkhorn Slough sediments where the algal cells (and their carotenoids) settle and leave taxonomic markers of phytoplankton activity through time. Surface sediments are clearly tagged with the same distributional pattern of fucoxanthin and alloxanthin found in the water column. However, alloxanthin in the upper slough can be detected at least thirty centimeters into the sediment core, suggesting that the separation of phytoplankton communities may have existed even before the recent observations of invasive species, made only within the last fifteen years.

Numerous theoretical and experimental observations have suggested that species-poor systems are inherently unstable and possibly more prone to species invasions. Could the structure of phytoplankton community diversity through Elkhorn Slough affect the likelihood of new species invasions for organisms that exploit the planktonic habitat through various stages of their lives? Continued work will focus on understanding the processes (biological, chemical, and physical) that result in the maintenance of distinct Elkhorn Slough phytoplankton distributions. Possibly a relationship between the observed invertebrate species invasions and phytoplankton biodiversity will evolve.

– Nick Welschmeyer, Lawrence Younan, Andrew Thurber, and Gala Wagner
Moss Landing Marine Laboratories

Endangered and Threatened Species

The Recovery of California Brown Pelicans in the Southern California Bight

The California Brown Pelican (*Pelecanus occidentalis californicus*) is the western North American subspecies of a wider-ranging species. Large groups of pelicans roost at Año Nuevo Island, Elkhorn Slough, and Point Lobos, although they don't breed in the Monterey Bay National Marine Sanctuary. So population studies focused on other areas within the species' range can provide important information about the health and status of the pelicans seen in the sanctuary.

Because of reproductive failure discovered in the late 1960s, this subspecies was declared endangered in 1970. The 1983 Brown Pelican Recovery Plan (U.S. Fish and Wildlife Service, Portland, OR) delineated four breeding populations: the Southern California Bight (SCB), the lower west coast of Baja California, the Gulf of California, and the coastal estuaries along the western Mexican mainland coast south to Colima. There is much mixing among the populations, especially during the non-breeding season.

Much has happened since 1983. California Brown Pelicans have benefited from the conservation measures of the recovery plan. From the 1960s through the early 1980s, SCB population declines were caused by the effects of DDE (dichlorodiphenyldichloroethylene), the environmentally-persistent metabolite of DDT (dichlorodiphenyltrichloroethane). When industrial inputs of DDT were reduced by the mid-1970s, eggshell condition, DDE levels, and population performance of SCB birds improved. Yet the recovery for SCB birds has taken at least two decades.

We began studies of SCB populations in 1970, concentrating major efforts in California at West Anacapa Island (off Ventura), a part of the Channel Islands National Park and Channel Islands National Marine Sanctuary. SCB populations there have steadily improved from near extinction, so that by the early 2000s, breeding populations were back to, or even higher than, historical numbers. Our goals for the average size of stabilized breeding efforts in the U.S. and northwest Mexico breeding colonies have been (approximate numbers):

- Anacapa Island: 4,000 to 5,000 breeding pairs
- Santa Barbara Island: 500 to 800 breeding pairs
- Islas Los Coronados: 500 to 750 breeding pairs
- Isla San Martín: 100 to 300 breeding pairs
- Reproductive rates: 0.6 to 0.9 young fledged per nest attempt

During the 1960s and 1970s, numbers at both Anacapa Island and Islas Los Coronados went as low as 200 to 300 pairs, with no breeding at Santa Barbara or San Martín Islands; reproduction was almost zero for several years in the late 1960s. In contrast, today – in a good year – SCB populations approach or exceed our target numbers (above).

We have studied California Brown Pelicans in Mexico since 1971, where larger populations have continuously remained stationary. In colonies of the Midriff Region of the Gulf of California in a good year, there are 35,000 to 40,000 nesting pairs producing

An adult California Brown Pelican in full breeding plumage, photographed at Isla Pelícano, Puerto Refugio, Gulf of California. Two other subspecies in North America and three more in South America do not have the bright red pouch seen in this individual, which we consider to be one of several distinguishing morphological features of the "California subspecies."

an average of 0.8-1.2 young per nesting attempt. The Gulf is so important to pelicans that we have come to term the species, "the King of the Cortéz." South in the mangroves of western Mexico and on some offshore islands, 8,000 to 10,000 additional nesting pairs occur.

Breeding populations and productivity fluctuate around environmental conditions. This is related to the abundance and availability of food over periods long enough to raise viable young. For a California Brown Pelican raising young is a major investment, as it takes almost five months to establish nests and then raise young to independence. Varying food conditions naturally involve cyclical oceanographic phenomena, such as El Niño/Southern Oscillation (ENSO). When strong ENSOs occur, these birds stop or reduce their breeding efforts. ENSO events rarely cause extensive pelican mortality like that reported in Peru in many El Niño years, but pelican mortality in Baja California was noted in the record event (1997-1998). ENSO warming events have a reducing effect on the species' breeding effort and productivity; reproduction varies with the strength of each event. In some years, ENSO effects reach into the northern Gulf of California and north to the SCB. In others, the effect may only extend to the colonies of the Midriff area of the central Gulf.

These birds are affected by many other environmental factors, in addition to natural variations, that need to be considered in their conservation:

- Interactions with commercial fishing activities produce mostly negative effects but also the potential for short-term positive effects, through provision of "offal" and unwanted fish in some commercial catches (mostly in the Gulf of California).
- Nesting *and* roosting pelicans frequently abandon their nests and suffer other disturbances through various kinds of human-related disruptions. (Nesting pelicans need undisturbed places to nest and roost throughout the year.)
- Contaminants such as oceanic debris and spilled or discarded chemicals (e.g., oil products, persistent contaminants), as seen, can have devastating effects.

Protection of off-colony roosts might be the most immediate need off California because the major nesting colonies are secure (other than the SCB colonies to the south in Mexico), protected by the U.S. National Park Service, U. S. Fish and Wildlife Service, and California Department of Fish and Game. In the Gulf of California, the Mexican federal government also conducts a large program of seabird colony-site and island protection and management. But still, the major challenge throughout the range of California Brown Pelicans will be to develop management plans and marine sanctuaries for commercially and otherwise valuable species that will take into consideration the needs of seabirds and other marine wildlife as well as long-term ecosystem health. We currently recommend down-listing the species from "endangered" to "threatened" – to reflect the amazing recovery of pollution-reduced populations in the SCB – yet continuing to address the many other threats throughout their range.

– Daniel W. Anderson and Franklin Gress
Department of Wildlife, Fish, and Conservation Biology
University of California Davis

The Rise and Fall of Humpback Whale Numbers

Since the mid-1980s, biologists with Cascadia Research have been monitoring humpback and blue whales along the West Coast using photographic identifications of individual animals. For humpback whales especially we have been able to use these data to determine the species abundance and the population trends along that coast. We have documented not only the steady increase in humpback whale numbers but also apparent evidence of a recent sharp drop in the number of humpback whales.

Cascadia began its research in 1986, initially funded by the Gulf of the Farallones National Marine Sanctuary (GFNMS). The goals were to document the return of humpback whales to this newly formed sanctuary as well as to determine how many animals were using the sanctuary and to what areas they migrated. Humpback whales had been commercially hunted from whaling stations along the California coast up to 1966, and some of the last whaling occurred in the Gulf of the Farallones area. Commercial whaling had dramatically reduced humpback whales along California, and from the mid-1960s through the early 1980s they were seen in numbers only fairly rarely.

Humpback whale breaching

Early work was able to document information not only on humpback whales but also on the blue whales encountered frequently in our research. We determined that humpback whales use a much broader area than just the waters of the GFNMS. In fact, from southern California north to Washington was a discrete feeding area for humpback whales. Within this region there was quite a bit of movement and interchange, but there was little to no inter-change with the humpback whales that fed further north off British Columbia and Alaska. We were also able to identify that humpback whales along the California coast migrate mostly to the waters off Mexico and Central America (south to Panama) to breed and give birth.

Our catalog of humpback whales, identified by natural markings on the underside of their flukes, has grown steadily and now numbers more than 1,400. This is actually higher than the abundance we estimate, because the catalog spans more than fifteen years and not all these individuals were alive at the same time. We now have the vast majority of humpback whales that use west coast waters identified and have long sightings histories on many of these animals.

To estimate the true abundance of whales, we need to employ mathematical procedures called capture/recapture statistics. These involve models developed for use on a wide variety of species, including small mammals and fish, that try to estimate total abundance from repeated resightings of individuals known from tags (or in our case natural marks). In essence, these procedures allow us to estimate the abundance of all animals, those we have identified and those we have not. These procedures can be fairly simple to use but have a number of requirements in order to work properly, so they require careful consideration in sampling and how they are employed.

One problem with the initial humpback whale studies was the limited study area. The whales clearly ranged much more broadly than just the GFNMS, even during the summer months. By 1991, with support from Southwest Fisheries Science Center, a federal agency interested in estimates of humpback whale abundance, we had expanded our identification research of humpback whales (and blue whales) to the entire U.S. West Coast. We were attempting to get fairly broad and even coverage so that our new capture/recapture estimates would accurately estimate the entire population that feeds along the West Coast.

From 1991 through 1998 humpback whale abundance estimates increased steadily – from 569 to 1,016 (*Figure 1*). This represented an increase of 9 percent per year. The data looked very solid, showing a very consistent pattern. This was exciting news since this was not only a larger population of humpback whales than had previously been thought to be using California waters, but the increase was up near the maximum of what was possible for humpback whales.

Then came a big surprise: after 1998 the estimate dropped almost 30 percent, down to 709 whales. The following year, estimates increased only slightly, to 774 animals. The estimates from 1999 to 2001 represented the first substantial decline in numbers we had seen. Looking at the data in more detail revealed that this drop was caused by a dramatic mortality (or departure from the region) of animals occurring sometime between late 1998 and early 1999.

The two possible short-term phenomena suspected to be responsible for a decreased survival in humpback whales were the 1997-98 El Niño and the domoic acid outbreak in 1998. That particular El Niño was considered severe and resulted in lower upwelling and productivity off California from the spring of 1997 through the fall of 1998. Zooplankton declines appeared to be more severe in many areas in 1998. Lower prey availability for humpback whales during the 1998 feeding seasons could produce a lower survival of animals over the following winter fasting period. Domoic acid consumed in fish prey was determined to be the cause of a dramatic increase in California sea lion mortality in central California in 1998.

Our most recent estimates on humpback whales show that since the drop in 1998-1999, humpback whale numbers have been recovering and are now returning close to the levels they were before the recent decline. In fact, the most recent estimate took one of the largest recorded upward jumps.

Period	IDs Year 1	IDs Year 2	Match	Est.
1991-92	269	398	188	**569**
1992-93	398	254	173	**584**
1993-94	254	244	108	**572**
1994-95	244	331	100	**804**
1995-96	331	332	145	**756**
1996-97	332	267	105	**841**
1997-98	267	388	119	**868**
1998-99	388	331	126	**1,016**
1999-2000	331	230	107	**709**
2000-01	230	274	81	**774**
2001-02	274	315	83	**1,034**

Figure 1. Humpback whale abundance off the U.S. West Coast using capture-recapture estimates with annual samples.

While the impression has been that blue whales have undergone a similar increase along this coast, the data do not support this. It is clear that blue whales are more abundant now than they were in the 1960s or 1970s, but our data from the 1990s have not shown much of a change in the past ten years.

Despite the larger than expected numbers of both humpback and blue whales that feed along the West Coast, there is reason for vigilance. Blue whales, hunted widely in the twentieth century, remain at very low abundances in most of the other areas of the world where they were formerly abundant. The world-wide populations of both these species remain well below pre-whaling levels. There are also concerns about declines in plankton that have been noted in areas of southern California. California is fortunate to have some of the highest densities of humpback and blue whales in the world; this should be viewed not as something we take for granted but as a reason to protect these valuable waters.

– John Calambokidis
Cascadia Research

Marine Mammals

Killer Whales Have Extremely High Levels of PCBs and DDT

Killer whales feed and travel along the deep waters of Monterey Canyon, feeding upon diverse prey in this extremely productive region. Top predators, they are highly intelligent whales with culturally distinct patterns that live in family groups. Because of the close proximity of the canyon to shore in Monterey Bay and our consistent year-round boat surveys, killer whales are seen here more often than anywhere else along the California coast. Sightings are unpredictable but occur year-round, providing us with a unique opportunity to study these animals in an open ocean habitat.

At least three eco-types of killer whale occur in the eastern North Pacific: residents, transients, and offshores. All three types have been seen in Monterey Bay. Each eco-type differs genetically, in physical appearance, distribution patterns, vocalizations, and prey preferences. These types do not intermix even though they have overlapping ranges. Transient type whales are most frequently sighted in Monterey Bay and prey on marine mammals – including gray whale calves, California sea lions, elephant seals, harbor seals, Dall's porpoise, Pacific white-sided dolphins, and common dolphins. Each whale is identified by its natural markings, and we have identified 136 individuals to date.

Since 1987 we have studied the behavior and ecological patterns of these known transient killer whales. We work with other researchers along the West Coast to look for re-sightings of previously identified whales. This transient population ranges from southern California to Southeast Alaska, although whales that occur in Monterey Bay are primarily seen in the coastal waters of California.

Part of our research involves collecting a small amount of skin and blubber through biopsy sampling from a research inflatable, with a permit through the National Marine Mammal Laboratory, National Marine Fisheries Service (NMFS). Skin is used for genetic analysis, and the blubber is used to determine levels of toxic chemicals. This research is being incorporated into a project to compare persistent organic pollutants (POPs) from killer whales ranging from Russia and the Aleutian Islands, through central and southeast Alaska and down the West Coast to California. Gina Ylitalo, from the Northwest Fisheries Science Center, NMFS in Seattle, analyzes the blubber samples for toxins.

POPs include PCBs (polychlorinated biphenyls) and DDT (dichlorodiphenyltrichloroethane), which are highly stable organic compounds that were used (and are still used in some countries) as pesticides or by industrial companies. POPs persist in the environment, bioaccumulate through the food web, are fat-soluble, and are toxic to humans and animals. The long-range atmospheric transport of these chemicals to regions where they have never been produced represents a threat to the global environment. These chemicals are of particular concern to species at the top of the food chain – most significantly, killer whales.

Killer whales off California appear to be the most contaminated animals on earth.

PCBs were first produced in the 1920s and were the most lethal chemicals dumped into the environment. They were used as coolants and lubricants for electrical transformers and capacitors and in various industrial products. Monsanto Company, a large North American manufacturer of PCBs, made 635,000 metric tons before the ban in 1977. DDT is a pesticide that was used in many countries to control mosquitoes and was also heavily used by farmers to protect their crops. DDT was banned in the United States in 1972 but degrades slowly and remains in rivers and ocean sediments. Heavy rains throughout California still flush the chemicals into the oceans, and El Niño storms churn up sediments, releasing these chemicals.

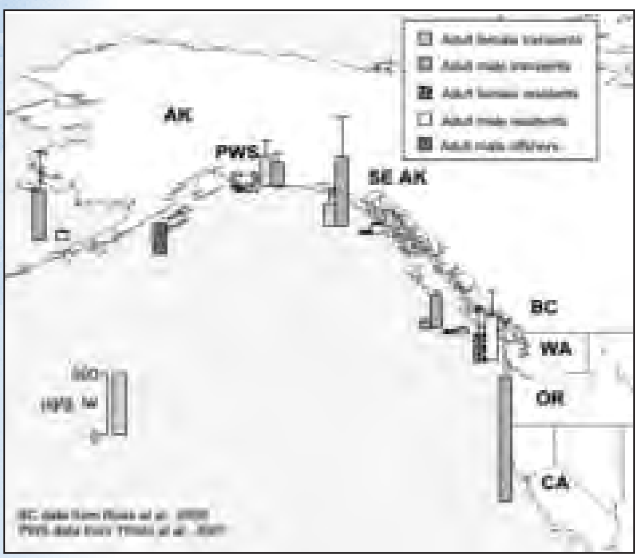


Figure 1. Eastern North Pacific killer whales: PCB concentrations

The Montrose Chemical Corporation in southern California was one of the world's largest manufacturers of DDT and disposed of thousands of tons of DDT waste into the ocean between 1949 and 1970. Several other industries also discharged PCBs. These polluted waters, near the Channel Islands, are the main breeding area for California sea lions, which are major prey for killer whales. Since DDT was banned, levels in California sea lions have greatly decreased but are still high compared to pinnipeds in other regions.

The adult male killer whales sampled in Monterey Bay carry very high levels of POPs – shockingly, the highest levels known for any marine mammal. Levels of PCBs in male transients ranged from 750 to 1,600 micrograms/gram lipid weight and the highest DDT levels were 8,700 micrograms/gram lipid weight. A female transient recently found dead off Washington (an identified whale from our California catalog) contained about 1,000 parts PCB. Comparatively, levels of PCBs from transient whales in British Columbia and Alaska, although still high, average three to ten times lower. Since resident whales are fish eaters, it is expected that their levels would be less than transients, but levels are still high enough to cause concern (*Figure 1*). These high values are much greater than those known to affect the growth, reproduction, and immune systems of harbor seals. As apex predators, killer whales typically have smaller population sizes than those of their prey. As such, an outbreak of a virus or disease could be disastrous to their survival if their immune systems are compromised.

California's pinnipeds and cetaceans, prey of the transients, are all known to have relatively high levels of POPs. Since transient killer whales are at the top of the food chain, they bioaccumulate these toxins from their prey. Female whales offload some of the toxins to their calves through milk, transferring up to 90 percent of their contaminants to their first born. Females first reproduce at around fifteen years, but after the age of forty to fifty they are post-reproductive and can then continue to accumulate these toxins. The males have no way of offloading these chemicals and continue to accumulate them throughout their lives. Killer whales are long-lived animals, with males living forty to fifty years and females, eighty to ninety years. The shorter male lifespan could be due to higher toxins in their bodies.

Killer whales off California appear to be the most contaminated animals on earth and are indicators of the health of the marine environment. Our long-term research will continue to sample toxin levels from more individuals and to monitor this population and their survival rates. Efforts to decrease these toxins worldwide and attempts to prevent continued contamination of the oceans, including looking for source points and researching clean-up methods, should increase.

– Nancy Black[1], Richard Ternullo[1], and Marilyn Dahlheim[2]
[1]Monterey Bay Cetacean Project
[2]National Marine Mammal Laboratory, NMFS

The “Invasion” of Sea Lions in Monterey Bay

The California sea lion (*Zalophus californianus*), one of the most obvious marine mammals off California, also occurs from Mexico north to British Columbia. California sea lions breed from June through July in southern California and Mexico, and adult males and juveniles often migrate north after the breeding season, whereas most females remain south. The population has increased dramatically since passage of The Marine Mammal Protection Act in 1972. There are an estimated 204,000 to 214,000 sea lions in U.S. waters and possibly an additional 80,000 to 100,000 animals along Baja California (*Figure 1*).

Increasingly, some people are concerned because sea lions are using marinas, docks, and other structures and affecting fisheries. California sea lions in Monterey Harbor and elsewhere have destroyed docks, sunk boats, damaged facilities, fouled spaces, and intimidated people. Certain sea lions have entered boats to steal fish, and one animal snatched a salmon from a boy and his father as they got their picture taken with their catch. California sea lions compete with many commercial and recreational fisheries along the California coast – directly, by causing entanglement and damage to fishing gear and loss of catch, and indirectly, by competing for resources.

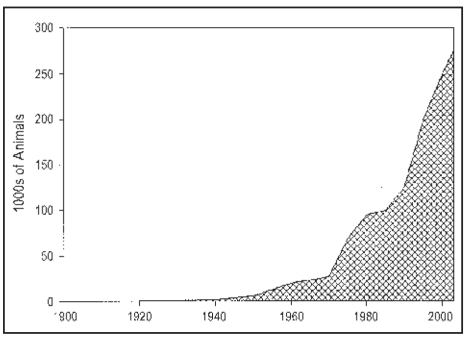


Figure 1. Population increase of California sea lions in U.S. and Mexican waters throughout the twentieth century

In Monterey Harbor, most sea lions are juveniles. These tend to stay in Monterey year round, whereas during most of the year adults are elsewhere. Typically, there is a peak in abundance off central California in August through October as the animals are moving northward and another peak in March through May as they head southward for breeding. Formerly, sea lions used the jetty and underneath the commercial wharf in the harbor; however, in recent years juveniles have become more bold and have invaded the beaches, finger piers, and moored boats within the harbor.

The increased use of Monterey Harbor and other marinas is probably due to an increasing population size, increased access to areas used by humans (e.g., breakwaters, docks, vessels, floats), and changes in food supply, all of which attract animals into this area. They are also attracted to some harbors where fish carcasses are thrown into the water. (This happens to a limited extent in

© Jim Harvey

Sailboat in Monterey Harbor with thirty-five to forty unwanted crew members

Monterey Harbor but probably has not caused the population increase here.) During the 1983, 1992, and 1997-98 El Niño events, the number of sea lions increased along central California because prey was less available in the Southern California Bight. Whatever the cause, increasing numbers of sea lions are using harbors and associated structures and causing havoc.

We hypothesize that California sea lions respond to climate-induced shifts in productivity with shifts in their distribution and foraging behavior. The prey are variable in the numbers and locations where they occur because of seasonal differences; therefore, we suspect that there will be pronounced differences in the seasonal foraging behavior and seasonal food habits as sea lions follow ephemeral and locally abundant prey. After they leave the area, the animals can move great distances in search of prey resources.

Some of the resources sea lions seek are also popular with humans. California sea lions in the Monterey Bay area primarily eat market squid, anchovy, hake, sardine, and rockfishes. Some individuals, however, supplement their diet with salmon caught by fishermen. From 1997 to 1999 we examined the interaction of sea lions with the commercial and recreational salmon fishery in Monterey Bay and found that generally, 10 to 15 percent of the fish hooked are removed and eaten by sea lions, but it can be as great as 30 percent in an El Niño year (1998). The increasing sea lion population and the increasing number of individuals that have learned this behavior would predict that the problem will only worsen.

California sea lions stretching out along docks and breakwaters is a wonderful sight for some, bringing joy to many local residents and tourists. However, for others (e.g., marine operators, boat owners, fishermen) the increasing number of sea lions in the area only means trouble.

– Jim Harvey[1] and Mike Weise[2]
[1]Moss Landing Marine Laboratories
[2]University of California Santa Cruz

Bird Populations

Marine Birds in Nearshore Waters of Monterey Bay

Seabirds are the most visible fauna of the Monterey Bay National Marine Sanctuary and are often the only marine organisms that many visitors to the sanctuary encounter. Given the abundance and visibility of seabirds in Monterey Bay near shore, it is surprising that they have received relatively little scientific research attention. Monterey Bay is a hot spot for a considerable diversity of seabirds, especially during winter, the non-breeding season for most birds. Seabirds are especially abundant near shore, probably because nutrients from wave action and river input support a year-round food supply. I conducted at-sea surveys from 1999 through 2001 just outside the surf zone between Capitola and Monterey, to quantify the seasonal abundance of seabirds in the nearshore zone and to study several oceanographic factors that I thought might affect where each species was likely to occur.

Not surprisingly, overall density of seabirds within the nearshore zone (less than one kilometer from shore) was more than double the density reported for Monterey Bay as a whole. I recorded a mean density of more than 360 birds per square kilometer, whereas John Mason, a previous student at Moss Landing Marine Laboratories, found a density of 173 birds per square kilometer in a study area that included nearshore as well as offshore areas in Monterey Bay.

More than 50 percent of all birds in my study were Western or Clark's Grebes. These closely related grebe species nest during summer at freshwater lakes, primarily in northeastern California and the Great Basin. They migrate annually to coastal regions and winter in considerable numbers in Monterey Bay. In fact, as many as 10,000 grebes may winter locally, making Monterey Bay an area of regional significance for this species. Interestingly, Western and Clark's Grebes do not completely vacate Monterey Bay during summer. Numbers peak in spring, indicating that Monterey Bay is used as a pre-migration staging area, and some grebes (probably young non-breeders) remain through summer (*Figure 1*).

Other abundant winter visitors included California Gull, Surf Scoter, and Marbled Murrelet, all species that breed primarily north of Monterey Bay. During summer and fall, abundant species included Brandt's Cormorant, Western Gull (both local breeders), and Sooty Shearwater (visitors from New Zealand, during their non-breeding season). Also abundant during the fall were California Brown Pelican, Elegant Tern, and Heermann's Gull, all species that breed primarily in Mexico and disperse north after breeding, presumably to take advantage of abundant northern anchovies in Monterey Bay.

Of the oceanographic factors investigated with respect to seabird distribution, the most interesting is water clarity. Water clarity is extremely variable in nearshore Monterey Bay – sediment input from the Pajaro and Salinas Rivers results in plumes of very turbid water during the winter rainy season. Other researchers have hypothesized that plunge-diving species (like terns and pelicans, which forage from the air) should prefer clearer water than pursuit divers (like cormorants and grebes, which swim underwater in pursuit of prey). Theoretically, plunge divers need to be able to see their prey below the surface, whereas pursuit divers may benefit from increased turbidity, which prevents the prey from seeing them coming. I used a transmissometer (an instrument that sends a beam of light through the water to measure light transmittance) mounted of the side of a 17-foot skiff to monitor water clarity and seabird distribution simultaneously.

Contrary to the hypothesis, plunge-diving species occurred more often in the most turbid water and less often in the clearest water available. Pursuit divers combined also occurred in more turbid water, but this pattern was not consistent among all pursuit-diving species: Brandt's Cormorants occurred more often in the clearest water available. Why? In reality, shallow plunge divers probably only need to be able to see about one meter below the surface of the water, since they rarely dive deeper than that. Both shallow plunge divers and most pursuit divers may benefit from some turbidity, preventing prey fish from detecting the predators at a distance. But Brandt's Cormorants, which forage on more sessile bottom fish, probably require greater water clarity to detect their prey – they are unlikely to encounter prey by diving blindly in murky water. A missing piece of the puzzle is prey abundance. It would be useful to know whether prey abundance is greater in turbid river plumes than in clearer water.

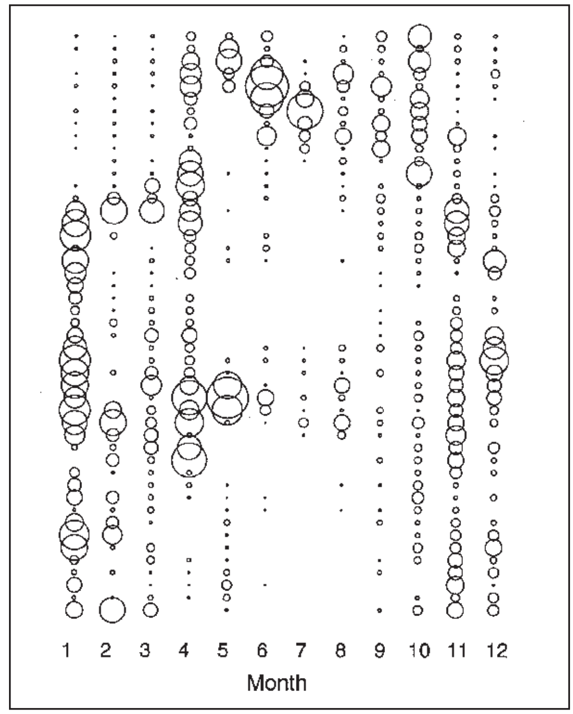


Figure 1. Mean distribution of Western/Clark's Grebes in Monterey Bay by month. Circles are scaled to mean abundance per one-kilometer transect segment, shown from north (top; Capitola) to south (bottom; Monterey) on the y-axis.

There is still much to learn about nearshore marine birds in the sanctuary. For example, the diet of Western and Clark's Grebes in marine waters of California has never been studied. We also don't know where many of the abundant seabirds in Monterey Bay nest – do the Western Grebes wintering here nest at Clear Lake in northern California, or at Great Salt Lake? Opportunities abound for additional research on seabirds in nearshore waters of Monterey Bay.

– Laird Henkel
Moss Landing Marine Laboratories and H.T. Harvey& Associates

Harvested Species

Trends in Fish Populations

This article is a brief synopsis of "Trends in Fisheries and Fishery Resources Associated with the Monterey Bay National Marine Sanctuary from 1981–2000" by R.M. Starr, J.M. Cope, and L.A. Kerr. Copies are available from the sanctuary or on the web at http://montereybay.nos.noaa.gov/research/techreports/fisherytrends.html.

The physical environment in the Monterey Bay region is dynamic and greatly influences the size of resident fish populations (*see article, p. 20*). In the past twenty years, the ocean environment has been favorable for pelagic species, but less so for many bottom-dwelling species. As populations of pelagic species increased, populations of groundfish decreased, partly due to intensive commercial and recreational fishing. In the late 1990s laws such as the federal Sustainable Fisheries Act and California's Marine Life Management Act and Marine Life Protection Act were passed that mandated more conservative management of marine resources and established guidelines for rebuilding depleted populations.

Rockfishes, cabezon, greenling, and lingcod are commonly caught in nearshore rocky reef and kelp habitats. High catches in nearshore reef and kelp habitats in the 1990s appeared to have reduced abundance of some of these species in nearshore areas. There are now more restrictive regulations to protect fishes in these habitats. Because many of the nearshore species are shorter lived, they have the potential for faster recovery than deeper-dwelling species.

Nearshore soft-bottom habitats are home to many fishes and invertebrates. Population sizes of most of these fish species are unknown, but trends in fishery landings indicate that many of these populations are healthy in the Monterey Bay National Marine Sanctuary. The market squid, an important species living in nearshore soft-bottom habitats, dominates catches from these habitats. The population of market squid seems strong, but as commercial catches increase, so do concerns about squid conservation.

Yellowtail rockfish

Semi-pelagic rockfish species such as bocaccio, chilipepper, widow, and yellowtail rockfish made up 98 percent of the total commercial catch from rocky deep shelf and slope habitats in the sanctuary. Scientific stock assessments indicate stable or increasing trends in abundance for chilipepper, shortbelly, and yellowtail rockfish. The biomass of bank rockfish has declined, but it is not known if a problem exists with this heavily fished species. Lingcod and the bocaccio, canary, cowcod, and widow rockfish stocks have been declared to be overfished and are now managed under stock rebuilding plans.

Low stock sizes of rockfish species have been attributed to poor recruitment and excessively high rates of fishing, caused by overly optimistic estimates of allowable catch in the 1980s. Most of these deep-water rockfishes are slow growing, long lived, and have experienced high exploitation rates. Managers are concerned about the capability of these species to recover from high harvest rates, especially because some are prone to long periods of poor recruitment. There is evidence that oceanographic conditions may be changing back to a cooler, more productive environment in this region. If that proves to be true, we may see more rapid rebuilding of cold-water stocks.

Species groups caught in soft-bottom, deep-shelf, and slope habitats include shrimp, prawns, rockfishes, thornyheads, sablefish, and flatfishes. Coast-wide, many species in these habitats are considered to be fully exploited but not overfished. Some of the rockfishes inhabiting soft-bottom habitats show signs of depletion in northern California, Oregon, and Washington waters, but the population status of most of the rockfishes in soft-bottom, deep-shelf, and slope habitats in the sanctuary is not well known.

Population abundances of most species in open water habitats are greatly determined by large-scale environmental phenomena that affect the success of spawning and recruitment. The population of one of these species, the Pacific sardine, has been extensively managed for thirty years and has dramatically increased in the past twenty years. In 1999 Pacific sardine biomass in U.S. waters was estimated to be about 1.7 billion kilograms (3.8 billion pounds). This is the highest level in recent history, but still much smaller than in the sardine heyday of the 1930s.

Another pelagic species, the chinook salmon, is one of the most important species in both commercial and recreational fisheries in the sanctuary. It has been intensively managed for more than thirty years, and population size is influenced by oceanic conditions and the quality of inland habitats. Most chinook salmon caught in the sanctuary originate in the Sacramento River or its tributaries. Recent landings have been dominated by the robust fall run, while spring and winter run populations of chinook salmon are considered severely depressed.

In summary, the population status of a great many species harvested in the sanctuary is unknown. Available data, however, indicate that populations in shallow rocky habitats declined in the 1990s. In shallow soft-bottom habitats in the sanctuary, populations of many species appear to be strong. Fisheries are closed in many deep, rocky habitats in the sanctuary in an effort to rebuild populations of a few overfished species, which may increase pressure on nearshore species. The species that have been studied in deep, soft-bottom habitats seem to be at sustainable levels. Open water habitats contain many short-lived, pelagic species that are greatly influenced by environmental conditions. Abundances of several of these species in the sanctuary are rapidly increasing.

– Richard Starr[1], Jason Cope[2], and Lisa Kerr[3]
[1]University of California Sea Grant Extension Program
[2]University of Washington
[3]Moss Landing Marine Laboratories

The Monterey Bay Ocean Time-Series and Observatory (MOTO) Sheds Light on Multi-Decadal Basin-Scale Fluctuations of Anchovies and Sardines

To the lay world, Monterey Bay is famous as the setting for John Steinbeck's stories of Cannery Row and its superabundant sardine fishery. To the oceanographic world, Monterey Bay is equally famous for the devastating collapse of this fishery following World War II.

When the Monterey Bay Ocean Time-Series and Observatory program (MOTO) was started by the Monterey Bay Aquarium Research Institute (MBARI) in the late 1980s, it was never envisioned that MOTO might shed light on the rise and fall of the sardines. MOTO is a field program that includes regular measurements from moorings, satellites, ships, and more recently autonomous underwater vehicles (AUVs).

In the early years, MOTO data described the seasonal and baywide spatial pattern of the physics, nutrient chemistry, and primary production in Monterey Bay, providing an observational foundation and basic understanding of ecosystem dynamics within the bay. During the 1990s MOTO data described El Niño and La Niña and their impacts on Monterey Bay, leading to the realization that global climate fluctuations cause dramatic changes in our local ecosystems. And finally, following the 1997-98 El Niño, MOTO data indicated that Monterey Bay had cooled – only slightly, but still enough to affect local ecosystem dynamics significantly.

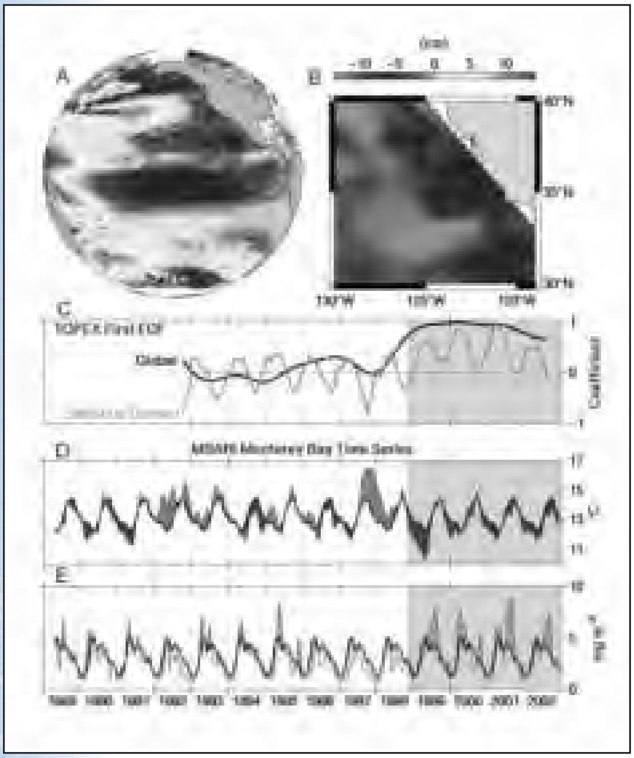


Figure 1. (A-C) Analysis of global sea level pattern observed from space. Satellite-derived sea surface height (SSH) has a characteristic spatial pattern globally (panel A) and for the California Current region (panel B). The coefficients on panel C indicate that SSH patterns for panels A and B change over time. Since late 1998 coefficients indicate lower SSH in the NE Pacific region. These changes are associated with cool surface temperatures (panel D) and high chlorophyll levels (panel E) observed as documented by MOTO in Monterey Bay. The changes indicate a change to cool conditions that may hold for twenty more years.

This cooling was linked to a shift in the 'Pacific Decadal Oscillation' (*PDO; Figure 1*), a newly-described basin-scale climate cycle with cool and warm phases of about twenty-five years. Could this cycle explain the fluctuations in sardines? It appears so. Both sardine and anchovy stocks – not only in Monterey Bay but throughout the Pacific – appear to fluctuate in phase with the PDO.

We recently reviewed these fluctuations in *Science* magazine. The period from around 1925 to 1950 was warm and dominated by sardines. The twenty-five-year warm periods have been referred to as El Viejo (the old man, a play on El Niño). A cool period from about 1950 to 1975, where anchovies dominated, followed. Since 1975 the Pacific had been warm again until the recent cooling.

Oceanographers have referred to the periods of rapid change between these warm and cool periods as regime shifts. If the regime has shifted, then the next twenty years will be cooler than average and rainfall in central California will also be lower than average, perhaps leading to extended periods of drought. But of course the shadow of global warming looms over the horizon. Was the warming in the 1980s and 1990s just associated with El Viejo, or is there a global warming component? Given the prognosis for a prolonged cooling, the next decade should provide an answer. The sardine variations were first reported in the early 1980s, and it was a decade or more later that scientists discovered fluctuations in air temperatures, atmospheric circulation, and ocean temperatures that were remarkably similar in phase and duration to the biological records. As a result, it has been suggested that a regime or climate shift may even be best determined by monitoring marine organisms rather than climate.

MOTO data are used widely by students and scientists interested in Monterey Bay and U.S. West Coast oceanography. We hope that it has provided a foundation upon which to build better methods and systems for long-term ocean observing. These large-impact, long-term fluctuations demonstrate the need for such observing systems, which will be required to separate the changes resulting from the ever-increasing pressure that human populations are exerting over the ocean from natural variability. Clearly natural and human-induced impacts will need to be considered in the management of our planet.

– Francisco P. Chavez, J. Timothy Pennington, Reiko Michisaki, and John P. Ryan
Monterey Bay Aquarium Research Institute

Exotic Species

What's New in Our Harbors?

Invasive species have received an increasing amount of attention in the last decade, and with good reason. The spread of species beyond their native range has the potential to produce severe, often irreversible impacts on agricultural, recreational, and natural resources. The term "invasive species" was formally defined by Executive Order 13112 in 1999 and refers to a species that 1) is non-native (or alien) to the ecosystem under consideration and 2) whose introduction causes or is likely to cause economic or environmental harm or harm to human health. Except for habitat destruction, invasive species are the biggest threat to native biodiversity and have contributed to the decline of 42 percent of U.S. endangered and threatened species. A recent estimate of the total cost of invasive species in the United States is more than $100 billion each year. In addition to these direct economic impacts are the ecological effects, many of which remain unknown.

The Monterey Bay National Marine Sanctuary covers hundreds of miles of coastline and encompasses a diverse array of marine habitats, ranging from the high intertidal zone to the depths of Monterey Canyon. However, not all of these habitats are equally susceptible to invasive species. It is well established that the spread of many invasive species is intimately linked with human activities (e.g., shipping), so it comes as no surprise that areas of high human activity receive the bulk of invasive species introductions. In particular, harbors and ports are "hot spots" for species invasion, due to their high levels of vessel traffic. Many species become attached to vessel hulls or are taken up in ballast water as larvae, then are displaced hundreds of miles to a new environment where they may become established.

In December 2002 the California Department of Fish and Game's (CDFG) Office of Oil Spill Prevention and Response prepared and submitted a report entitled *A Survey of Non-Indigenous Aquatic Species in the Coastal and Estuarine Waters of California* to the California state legislature as required by the Ballast Water Management Act of 1999. CDFG conducted the study to "determine the location and geographic range of non-indigenous species populations along the California coast." Such data are lacking for many areas, and this report now serves as a baseline to determine both the nature and extent of biological invasions and to evaluate the effectiveness of potential methods to prevent the establishment and control the spread of invasive species in California coastal waters.

The study indicated that all areas investigated, covering coastal California from Humboldt Bay to San Diego, have experienced some level of biological invasion. Researchers focused on seven major harbors and ports (e.g., San Francisco Bay, Los Angeles, and Long Beach Harbors), but also included minor ports, bays, and estuaries. Not surprisingly, the most invaded areas were major commercial ports. The report also noted that smaller ports (e.g., Monterey and Santa Cruz Harbors) also had significant numbers of non-indigenous species. In total, the survey reported 747 organisms that were "introduced or most likely introduced." Taxonomic experts felt confident that 360 of the 747 species were invasive. For the 387 remaining species, it was difficult to determine if they were native to California; some were introduced prior to extensive biological inventories and research in the 1900s, so their origins and native status remain a mystery. In addition, 126 of the organisms could not be identified to species, a common problem for many of the small, encrusting invertebrates.

In Monterey Harbor, CDFG divers collected 72 organisms from invertebrate communities found both above and within the seafloor bottom. Of these, 12 were nonindigenous, 25 native, 9 cryptogenic (i.e., it is not known if they are native or nonindigenous), and 26 could not be identified to species.

One species readily recognized as an invader is the seaweed *Undaria pinnatifida*. Native to Asia and commonly known as

The sea slug Hermissenda crassicornis (and its white, coiled egg cases) and a variety of hydroids, tunicates, and other encrusting invertebrates are typical of the fouling communities found on the sides of floating docks.

wakame, *Undaria* was first detected in southern California in the spring of 2000. Unlike native annuals that first appear in the spring and become reproductive in the summer, *Undaria* first appears in winter and becomes reproductive within two months. It is unclear how *Undaria* will impact California natives, but in other parts of the world it is seasonally very dense and may displace native species.

Based on the results of the report, CDFG made several recommendations, including: 1) ongoing surveys for nonindigenous aquatic species; 2) research on the pathways of introduction; and 3) more refined taxonomy to identify species conclusively. CDFG and the sanctuary are already working together to address these issues.

– Steve Lonhart
Monterey Bay National Marine Sanctuary and
Sanctuary Integrated Monitoring Network (SIMoN)

Human Interactions

Environmental Impact of a Submarine Cable: Case Study of the ATOC/Pioneer Seamount Cable

In recent years there has been an explosion of activity and interest in installing offshore cables for telecommunication and scientific purposes. Cables that are only one to two inches in diameter are able to transmit power and large amounts of data over long distances. The telecommunications industry is in the process of building an extensive undersea global network that connects continents and large urban centers. Scientists also want to use the power and data transmission capability of underwater cables, but for the purpose of studying coastal and marine environments. Whereas the traditional mode of marine data collection consists of sporadic shipboard surveys, cables allow scientists to set up instruments and experiments that collect and transmit data continuously. Constant monitoring promises to improve our understanding of the ocean and could lead to major new discoveries regarding marine systems. Due to the high degree of interest in installing cables in marine environments, there is also a need to understand the environmental impacts of cables on the seabed better. For this purpose, two National Oceanic and Atmospheric Administration (NOAA) divisions, Oceanic and Atmospheric Research and the National Ocean Service, teamed up with the Monterey Bay Aquarium Research Institute (MBARI) to study the environmental impacts of the ATOC (Acoustic Thermometry of Ocean Climate)/Pioneer Seamount cable.

The majority of the ninety-five kilometer-long ATOC/Pioneer Seamount cable lies within the Monterey Bay National Marine Sanctuary off Half Moon Bay and was placed on top of the seafloor during installation. The cable was used to transmit data from a passive hydrophone listening array on Pioneer Seamount to shore (*see Ecosystem Observations 2002*) and is currently broken. In order to investigate the environmental impacts of the cable scientifically and address National Marine Sanctuaries Program permit requirements, MBARI and NOAA scientists collected data from selected sites during three research cruises in 2002 and 2003 using MBARI's vessels and remotely operated vehicles.

One survey objective was to describe the physical state of the cable and observe its effect on the seafloor. The cable has become mostly buried in continental shelf sediments in water depths of less than 120 meters, whereas much of the cable remains exposed on the seafloor at deeper depths and on rocky terrain. The cable and the rocks were damaged in the nearshore area, where wave energy is greatest. Here, researchers found frayed and unraveled cable armor and vertical grooves in the rock apparently cut by the cable. Kelp was intertwined with frayed cable. Suspensions were seen throughout the survey in areas of irregular topography. Short (approximately ten centimeters high) suspensions were common over low spots in sediment substrates. However, the tallest suspensions (up to forty meters long and two meters high) were seen in rocky regions. Unlike in the nearshore rocky region, neither the rocks nor the cable appeared damaged on Pioneer Seamount. Multiple loops of slack cable, added during a 1997 cable repair operation, were found lying flat on the seafloor. Several sharp kinks in the cable were seen in an area subjected to intense trawling activity.

A variety of organisms living on or near the ATOC/Pioneer Seamount cable: basket star (Gorgonocephalidae), anemone (Metridium farcimen), rockfish (Sebastes sp.) and urchins (Allocentrotus fragilis)

Two crossings with other cables were also documented.

The main biological differences observed between cable and control areas were the number of organisms attached or adjacent to the cable. Anemones colonized the cable and were more abundant in cable transects at most soft sediment sites. Data extrapolation suggests that more than 50,000 anemones may live in the modified habitat created by the cable. Echinoderms and sponges were also seen living on the cable. Flatfishes and rockfishes congregated near the cable at some sites. Approximately 500,000 organisms may live on or near the cable. The cable may also have the subtle impact of concentrating shell hash and minor amounts of drift kelp. It has had no apparent effect on organisms living in the sediments.

Results and observations from this survey will aid decision makers regarding the ATOC/Pioneer Seamount cable's future and provide scientific data for shaping cable policy within sanctuaries.

– Irina Kogan

HUMAN INTERACTIONS

Visitors to State Parks and Beaches Contiguous to the Sanctuary[1]

San Mateo County coast – 934,126 visitors
Fitzgerald Marine Reserve – 100,000 visitors
Santa Cruz County coast – 13,497,816 visitors
Monterey County coast – 5,746,146 visitors
San Luis Obispo County coast, north of the sanctuary boundary – 444,229 visitors

Recreational Activities[2]

		Customers served	Whale watch	Sailing charters	Fishing charters	Number of boats
Kayak Shops						
Monterey Bay Kayaks	Monterey	19,200				
Surf Shops						
On the Beach Surf Shop	Monterey	950				
Santa Cruz Surf Shop Inc.	Santa Cruz	4,600				
Dive Shops						
Diver Dan's	Santa Clara	6,503				
Anderson's SCUBA	Pacifica	200				
Blue Water Divers	Sunnyvale	525				
Recreational Boat Charters						
Santa Cruz Boat Rentals	Santa Cruz	4,500		4,500	36	
Original Stagnaro's Fishing	Santa Cruz	4,300	800	1,500	2,000	1
Team O'Neill	Santa Cruz	4,350	4,000*	350	0	1
Monterey Bay Whale Watch	Monterey	24,300	24,300			3
New Capt. Pete	El Granada	1,650	150		1,500	1
Captain John's Deep Sea Fishing	Half Moon Bay	3,800	57		3,743	2

*educational trips

Fishing Licenses by County[3]

	Commercial fishing licenses:	Charter boat licenses (recreational fishing)
Marin	135	5
San Mateo	173	4
Santa Clara	123	2
Santa Cruz	121	3
Monterey	421	5
San Luis Obispo	306	2

2003 Coastal Cleanup[4]

Coastal Cleanup debris collected, by county:

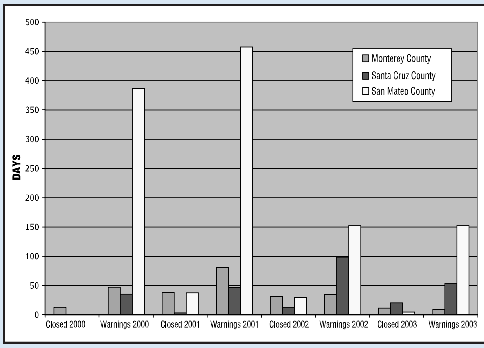
Marin – 7,019 lbs. trash; 1,231 lbs. recyclables; 603 volunteers
San Mateo – 20,977 lbs. trash; 4,694 lbs. recyclables; 1,293 volunteers
Santa Cruz – 8,572 lbs. trash; 4,492 lbs. recyclables; 2,741 volunteers
Monterey – 8,385 lbs. trash; 1,878 lbs. recyclables; 1,539 volunteers
San Luis Obispo – 6,900 lbs. trash; 2,000 lbs. recyclables; 1,400 volunteers

Volunteers[5]

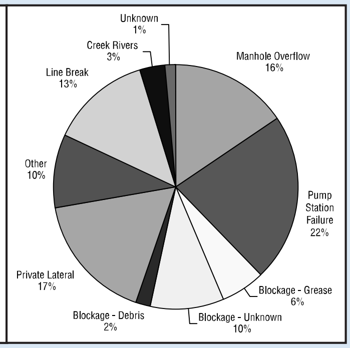
Año Nuevo State Reserve: 215 volunteers; 14,479 hours
BAY NET Monterey Bay National Marine Sanctuary Volunteer Network: 27 volunteers; 2,000 hours
California State Parks, Monterey District: 431 volunteers; 54,320 hours
California State Parks, San Mateo Coast Sector: 1,929 volunteers; 13,915 hours
California State Parks, Santa Cruz District: 800 volunteers; 45,000 hours
Coastal Watershed Council: 125 volunteers; 3,720 hours
Elkhorn Slough National Estuarine Research Reserve: 111 volunteers; 6,510 hours
Fitzgerald Marine Reserve: 100 volunteers; 5,329 hours
Friends of the Elephant Seal: 80 volunteers; 11,300 hours
Friends of the Sea Otter: 11 volunteers; 1,500 hours
Gulf of the Farallones National Marine Sanctuary Beach Watch (south of Golden Gate only): 50 volunteers; 6,000 hours
Maritime Museum of Monterey: 55 volunteers; 4,125 hours
Monterey Bay Aquarium: 914 volunteers; 133,146 hours
Monterey Bay National Marine Sanctuary Beach COMBERS: 76 volunteers; 1,248 hours
Monterey Bay National Marine Sanctuary TeamOCEAN: 25 volunteers; 332 hours
Monterey Bay Sanctuary Citizen Watershed Monitoring Network: 240 volunteers; 4,100 hours
Pigeon Point Lighthouse: 30 volunteers; 2,142 hours
Return of the Natives Restoration Education Project of the Watershed Institute, CSUMB: 3,131 volunteers; 10,323 hours
San Gregorio Environmental Resource Center: 20 volunteers; 700 hours
Save Our Shores, San Mateo: 606 volunteers; 2,554 hours; Santa Cruz: 55 volunteers; 800 hours
Seymour Center at Long Marine Lab, UCSC: 285 volunteers; 18,000 hours
Surfrider San Mateo County Chapter: 12 volunteers; 494 hours
The Marine Mammal Center: Monterey: 51 volunteers; 4,660 hours; Santa Cruz: 47 volunteers; 4,910 hours; San Mateo: 58 volunteers, hours not available

Total number of volunteers: 9,484 **Total hours donated:** 351,607
Total value of volunteer services (calculated at $15.00/hour): $5,274,105

Days of Sanctuary Beach Warnings and Closures by County 2000-2003[6]



Beach Closures Sources – San Mateo, Santa Cruz, and Monterey Counties[6]



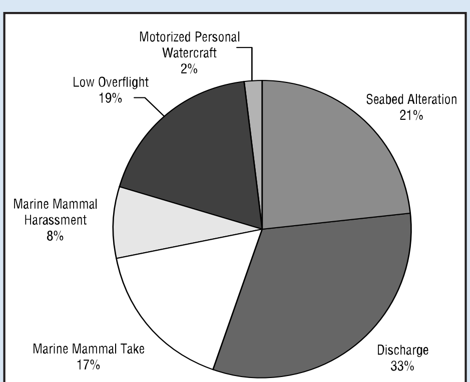
Vessel Incidents with Sanctuary Response[7]

Incident Type	Date Reported	Location	Cost to NOAA
Sinking (R/V)	1/23/2003	Monterey Bay	$50
Grounding (C/V)	2/1/2003	Creek mouth at Hidden Beach, Aptos	$950
Grounding (R/V)	3/26/2003	Pajaro River mouth, Zmudowski State Beach	$60
Grounding (R/V)	4/12/2003	Capitola Beach	$60
Grounding (R/V)	4/12/2003	Capitola Beach	$125
Grounding (R/V)	4/12/2003	200 yards east of Capitola Wharf	$60
Grounding (R/V)	4/12/2003	Capitola Beach	$60
Grounding (R/V)	4/12/2003	Capitola Beach	$60
Sinking (R/V)	4/14/2003	300 yards north of seaward tip of Monterey USCG breakwater	$125
Sinking (C/V)	4/20/2003	Near Cape San Martin	$300
Grounding (R/V)	4/22/2003	New Brighton State Beach	$0
Grounding (C/V), Discharge, Seabed Disturbance	6/2/2003	Half Moon Bay immediately south of the Pillar Point Harbor entrance	$450
Grounding (R/V)	7/5/2003	Moss Landing State Beach	$6,000
Grounding (R/V)	8/18/2003	Asilomar State Beach	$7,000
Sinking (R/V)	8/26/2003	Seaward of Santa Cruz boardwalk	$250
Sinking (R/V)	9/15/2003	Vicinity of Santa Cruz Small Craft Harbor mouth - seaward	$75
Grounding (R/V)	9/22/2003	Colorado Reef off Montara Beach near the Moss Beach Distiller .5-.75 miles offshore	$150
Sinking (R/V)	9/23/2003	Mooring field approximately 500 yards east of Capitola Wharf	$425
Grounding (R/V)	10/13/2003	Salinas River State Beach - 1 nm south of Moss Landing Harbor entrance	$150
Grounding (C/V)	10/30/2003	Del Monte Beach at the south end of Tide Avenue, Monterey	$600
			$16,950

R/V-Recreational vessel C/V-Commercial vessel

Enforcement Actions under the Marine Sanctuaries Act[8]

Profile of Documented Enforcement Cases, March-September 2003



These data represent only 52 formally documented cases by the NOAA Office for Law Enforcement and do not reflect all investigative actions or patrol contacts by NOAA enforcement personnel or enforcement actions by partner agencies. The data do not reflect total reported incidents or number of convictions within the sanctuary. It simply provides a relative comparison of the type of violations occurring within the sanctuary.

- *Marine mammal take cases were processed as actions under the Marine Mammal Protection Act instead of the NMSA*
- *Vessel groundings and sinkings are counted only as seabed alteration cases, though some also involved discharges*

Sources:
1 – California State Parks, San Mateo Coast Sector, Pigeon Point Lighthouse, Año Nuevo State Reserve; California State Parks-Santa Cruz, Monterey, and San Luis Obispo Districts; Fitzgerald Marine Reserve
2 – Businesses listed
3 – California Department of Fish and Game
4 – California Coastal Commission
5 – Organizations listed
6 – State Water Resources Control Board
7 – Monterey Bay National Marine Sanctuary
8 – NOAA Office for Law Enforcement

"Beach Closed": What Does It Mean?

Imagine – it's a sunny day and with kids and surfboards in tow, you march in the flip-flop parade down to the beach. But when the toes finally hit the sand, you encounter the dreaded "beach closed" sign. Despite the concern generated from such experiences, the general public doesn't have a firm understanding of why these signs are posted, what they mean to human or marine health, or what actions we can take to eliminate such events.

With respect to bacterial contamination, local jurisdictions can issue three distinct notifications: beach warnings, beach closures, or rain advisories. State law requires beach warnings when monitoring reveals that indicator organisms (bacteria that do not cause disease, but indicate that water may be contaminated with human or animal waste) have exceeded specified standards. Beach closures result from a sewage spill, and rain advisories are issued when significant rainfall has the potential to affect bacterial levels in the ocean. Bacteria detected in monitoring are most often the result of non-point source pollution – numerous, small diffuse sources including cracked main or lateral sewer lines, domestic pets, wildlife, homeless camps, septic systems, and even babies in diapers. In our region, warnings occur far more frequently than closures, indicating the importance of controlling non-point source pollution in addition to reducing the occurrence of sewage spills.

It's important to note that, even considering several shortcomings that are discussed below, nowhere are beaches more vigilantly tested for pollution than in California. State law requires weekly monitoring of heavily used beaches between April and October, and many health agencies go beyond state law to monitor these beaches throughout the year.

Unfortunately, limited testing methods and the complexity of the nearshore ocean environment reduce our ability to evaluate water quality and determine the specific sources of bacterial contamination. Sample analysis takes anywhere from one to three days to confirm the presence of indicator bacteria, and as a result the public may unknowingly swim in contaminated waters during this time. Conversely, when samples return from the lab indicating contamination, water may be posted as unhealthy even though by then it is clean. Further, the indicators cannot distinguish between human or animal bacteria, and the difference is important because people are more likely to become ill from human viruses and other pathogens than from those associated with animal waste. To respond to these concerns, health officials spend millions of dollars monitoring, posting, and performing sophisticated genetic analyses to determine where the bacteria originate.

Fortunately, the majority of illnesses associated with swimming in contaminated water are relatively minor. Gastroenteritis is the most common, and other minor complaints include ear, eye, skin, nose, and throat infections. Now consider the human health effects in terms of the animals that spend their entire lives in these occasionally contaminated waters. Studies have shown that filter feeders such as mussels, clams, and oysters can convey virtually all water-borne pathogens to animals that prey upon them, such as sea otters. Recent research into mortality among the threatened southern sea otter population suggests that a significant number of deaths may be attributed to protozoa found in cat feces that find their way to the ocean via urban runoff.

A lot of resources are used to evaluate water quality, reduce sewage spills, and reduce non-point source pollution. Health officials continue to monitor beaches and use the best available methods to characterize beach water quality and identify the sources of contamination so that public works agencies use their limited dollars effectively. But the bacterial contamination problem cannot be solved by public works agencies alone; it's going to require everyone's involvement. We are all part of the sanctuary and, as responsible citizens and oceangoers, we should all play an active role in preventing its contamination. (*See p. 23 for volunteer opportunities of all kinds.*)

– Chris Coburn
Monterey Bay National Marine Sanctuary

Socio-Economics of the Moss Landing Commercial Fishing Industry

Moss Landing is a vital part of the Monterey Bay National Marine Sanctuary's human environment. Moss Landing Harbor (MLH) recently ranked third in pounds landed and fourth in ex-vessel (dockside, before processing) revenues among commercial fishing ports in California. In addition, it hosts tourism and scientific research. Understanding the human dimensions of these activities as they interact with one another and the sanctuary is key to effective management. Our recent study of the MLH commercial fishing industry documented its social and economic characteristics, and the issues, needs, and concerns of its participants to inform Monterey County decision making about efforts to enhance the industry's economic vitality.

The commercial fishing industry at MLH includes about 125 resident and 175 non-resident fishing operations, 7 resident and dozens of non-resident fish buyers, and 9 local and many non-local fishery-support businesses. Total employment of the 38 commercial fishing operations, 4 resident buyers, and 3 resident support businesses we surveyed plus the harbor was more than 1,200. We estimated the direct economic value of commercial fishing at MLH to be $18-$25 million per year (real values, 2000 $), based on estimates for fishing operations ($6.7 million), buyers ($7.5 million), support businesses ($0.2 million) and the harbor ($10.1 million).

© Brad Damitz for NOAA/MBNMS

Moss Landing Harbor is a vital part of the sanctuary's human environment.

MLH's commercial fishing operations vary considerably in terms of vessel characteristics, fishing patterns, permits, and personnel. Most fish multiple locations and fisheries along the West Coast, Alaska, and/or the Western Pacific to adapt to environmental, economic, and regulatory variability and uncertainty. Major MLH fisheries include salmon and albacore troll, groundfish hook-and-line and trawl, coastal pelagic species (CPS, e.g., anchovy, sardine, squid) purse seine, and multiple species long-line and gillnet.

MLH's resident fish buyers include one live fish buyer, three CPS receiver/processors, and three multi-species buyers. In addition to receiving fish at MLH, many also process, wholesale, distribute, and/or retail seafood products (primarily) at other locations where necessary space and infrastructure are available.

Fishery-support businesses provide a range of goods and services to, and depend upon, the commercial fishing industry at MLH. In addition, the harbor provides amenities and essential services such as dredging.

Over the past twenty years, MLH's most important fisheries (by ex-vessel value) have been salmon, groundfish, and highly migratory species. More recently, environmental, regulatory, and economic factors have led to declines in vessels, landings, and ex-vessel revenues in these fisheries (although the number of salmon vessels landing at MLH has increased). In contrast, the CPS fishery has experienced a boom at MLH, driven largely by increased sardine landings.

Three sets of interdependent issues confront the MLH commercial fishing industry and related businesses. *Regulatory constraints* include fishery management actions such as increasingly stringent groundfish regulations as well as multiple and sometimes conflicting coastal management regulations and permitting procedures. *Short- and long-term economic challenges* include decreases in allowable catches for some species coupled with stagnant or declining prices, which together result in reduced revenues to support businesses and the harbor and limit those businesses' ability to provide goods and services to the community. Although fishery participants have adapted to many of these challenges, adaptation to their cumulative, persistent effects may be more problematic. *Infrastructure maintenance and development* are essential to safe and efficient harbor use, but are costly. Our report provides recommendations to the county for ways to help address these issues.

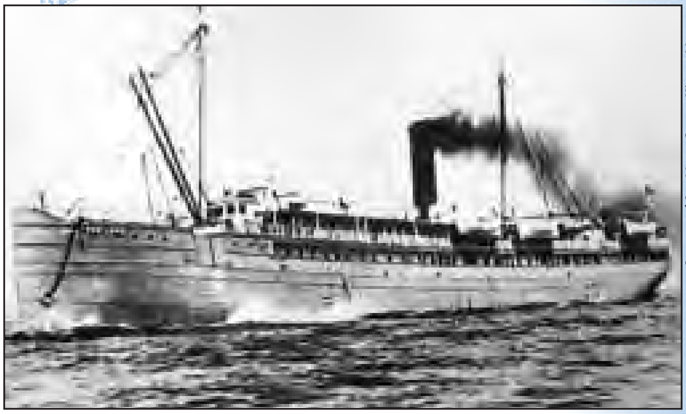
This study was funded by the Monterey County Office of Economic Development (OED). We gratefully acknowledge the cooperation and support of the OED, study participants, research assistants, and others who made this work possible. The report is available at http://www.montereycountybusiness.net/. Click on "Current Projects and Reports," then scroll down to "2003 Socio-Economic Impacts of the Moss Landing Commercial Fishing Industry."

– Caroline Pomeroy[1] and Michael Dalton[2]
[1]Institute of Marine Sciences, University of California Santa Cruz
[2]Institute for Earth Systems Science & Policy, California State University Monterey Bay

The *San Juan*

A vast array of shipwrecks dot the deep, moody waters protected by the Monterey Bay National Marine Sanctuary. Clipper ships, barques, schooners, and steamers alike have fallen prey to the region's unpredictable weather and rocky shoreline. More than 140 shipwrecks have been documented in the sanctuary between 1845 and 1935. They offer us vivid insight into our past.

The sinking of the *San Juan* was one of the worst maritime disasters to mark California coastal waterways. On August 29, 1929, just before midnight, the oil tanker *S.C.T. Dodd* rammed the passenger steamer in fog-obscured waters off Pigeon Point. The *San Juan* smashed like kindling wood and sank within five minutes.



Courtesy of San Mateo County History Museum

The San Juan underway

Believed to be the oldest ship in regular passenger service on the Pacific coast at the time of its demise, the *San Juan* carried seventy-three passengers and forty-four crew that night. During a sensational scandal following the collision, officers and crew of each vessel blamed the other for changing course and causing the accident. The wreck took more lives than any other in the area's history. Seventy-five men, women, and children from all walks of life were lost aboard the steamer. Most were trapped while asleep below deck.

Courtesy of San Francisco Maritime National Historical Park

Bringing survivors ashore

Passengers included Mrs. Willie Jasmine Brown, who had just mailed a letter saying, "I'd really rather take the train, but the boat is cheaper. The children need shoes." (The fare from San Francisco to San Pedro, California was attractively priced at $8 to $10 per person.) Others aboard were George Navarro, a teenage movie extra and aspiring actor who appeared in films featuring Ronald Coleman and Victor McLaglen; and Marjorie Pifer, who saved her son, the only child to survive the wreck, by throwing him onto the deck of the *Dodd* as the *San Juan* disappeared beneath the sea.

An iron-hulled steamer, the *San Juan* first entered the water in 1882 as a unit of the Pacific Mail Steamship Company. At 2,152 gross tons, a length of 283 feet, and a beam of 37 feet, the vessel was one of the largest ships in service. Part of a great network of early mail lines shuttling between Panama and West Coast ports, the Pacific Mail fleet enjoyed a reputation for efficiency and dependability. The fleet became known as the most universally popular steamship line in the world.

The Panama route was a vital artery of communication between America's eastern and western seaboards. Passengers, mail, and freight traveled the route more quickly and more safely than by any other means. A trip around Cape Horn could take up to six months. The overland route took up to forty days and was closed by storms in winter. Demonstrating their practicality for long voyages with greater speed and regularity than sailing vessels, steamers like the *San Juan* made the trip in eighteen to twenty-two days.

Steamers employed on the Panama route, such as the *San Juan*, changed little over time. Their chief distinguishing feature was a deck-house that extended from one end of the vessel to the other and contained rooms for passengers, officers' quarters, and staterooms. A hurricane deck formed a canopy over the entire length and breadth of the ship. This greatly increased deck space for travelers and was particularly welcome on vessels operating in tropical waters.

Having sailed the seas for more than forty years, the *San Juan* was one of the last of the fleet still in service when Pacific Mail sold its interest to the Dollar Line in the late 1920s. In later years, the *San Juan* operated along Pacific shores as part of the White Flyer Line. Local advertisements promised passengers "…a delightful way to travel. One fare includes comfortable berth, excellent meals, open-air dancing, promenade decks, radio music – all the luxury of ocean travel. A trip to be remembered. The economical way that entails no sacrifice."

Shipwrecks fascinate us because they represent dramatic moments in time. More importantly, they provide snapshots of people and industry at the precise instant the vessel went down. Shipwrecks are precious cultural resources to be appreciated and protected as a significant part of our nation's maritime history.

The National Marine Sanctuary Program maintains a shipwreck database to promote awareness and preservation of shipwrecks as a valuable part of our cultural heritage. To learn more about shipwrecks that occurred in this and other sanctuaries, visit http://channelislands.nos.noaa.gov/shipwreck/shiphome.html. It's a voyage worth taking.

Credits

Editor – **Jenny Carless**

Graphic designer – **Judy Anderson**

Production artist – **Chris Benzel**

Reviewers – **Andrew DeVogelaere, William J. Douros, Dawn Hayes, Liz Love, Daphne White**

Photographers – as noted, and:
Front cover: **Mike Johnson**
Back cover: **Mike Johnson**

Illustrations © Monterey Bay Aquarium

National Oceanic and Atmospheric Administration

Monterey Bay National Marine Sanctuary

299 Foam Street
Monterey, CA 93940
(831) 647-4201

http://www.montereybay.noaa.gov

We welcome comments, which should be sent to Dawn Hayes, Education Coordinator, at the address above.

PRINTED ON RECYCLED PAPER.

The sanctuary thanks the following individuals and organizations for contributing their time and effort to this publication – as writers, reviewers, and advisors:

Daniel W. Anderson, Department of Wildlife, Fish, and Conservation Biology, University of California Davis

Julie Barrow, Monterey Bay National Marine Sanctuary

Lydia Bergen, Partnership for Interdisciplinary Studies of Coastal Oceans, University of California Santa Cruz

Nancy Black, Monterey Bay Cetacean Project

John Calambokidis, Cascadia Research

Nicole Capps, Monterey Bay National Marine Sanctuary

Francisco P. Chavez, Monterey Bay Aquarium Research Institute

Chris Coburn, Monterey Bay National Marine Sanctuary

Jason Cope, University of Washington

Marilyn Dahlheim, National Marine Mammal Laboratory, National Marine Fisheries Service

Michael Dalton, Institute for Earth Systems Science & Policy, California State University Monterey Bay

Edward F. DeLong, Monterey Bay Aquarium Research Institute

Andrew DeVogelaere, Monterey Bay National Marine Sanctuary

William J. Douros, Monterey Bay National Marine Sanctuary

Lisa Emanuelson, Monterey Bay National Marine Sanctuary

Franklin Gress, Department of Wildlife, Fish, and Conservation Biology, University of California Davis

Cheryl Hapke, United States Geological Survey

Jim Harvey, Moss Landing Marine Laboratories

Dawn Hayes, Monterey Bay National Marine Sanctuary

Laird Henkel, Moss Landing Marine Laboratories and H.T. Harvey & Associates

Scott Kathey, Monterey Bay National Marine Sanctuary

Lisa Kerr, Moss Landing Marine Laboratories

Scott Kimura, TENERA Environmental

Irina Kogan, Monterey Bay National Marine Sanctuary and Monterey Bay Aquarium Research Institute

Steve Lonhart, Monterey Bay National Marine Sanctuary and Sanctuary Integrated Monitoring Network (SIMoN)

Liz Love, Monterey Bay National Marine Sanctuary

George Matsumoto, Monterey Bay Aquarium Research Institute

Reiko Michisaki, Monterey Bay Aquarium Research Institute

Sean Morton, Monterey Bay National Marine Sanctuary

Charlie Paull, Monterey Bay Aquarium Research Institute

J. Timothy Pennington, Monterey Bay Aquarium Research Institute

Caroline Pomeroy, Institute of Marine Sciences, University of California Santa Cruz

Holly Price, Monterey Bay National Marine Sanctuary

Peter Raimondi, Department of Ecology and Evolutionary Biology, University of California Santa Cruz

Michele Roest, Monterey Bay National Marine Sanctuary

John P. Ryan, Monterey Bay Aquarium Research Institute

JoAnn Semones

Richard Starr, University of California Sea Grant Extension Program

Richard Ternullo, Monterey Bay Cetacean Project

Andrew Thurber, Moss Landing Marine Laboratories

Tierney Thys, Sea Studios Foundation

Gala Wagner, Moss Landing Marine Laboratories

Mike Weise, University of California Santa Cruz

Nick Welschmeyer, Moss Landing Marine Laboratories

Lawrence Younan, Moss Landing Marine Laboratories