Ecosystem Observations

for the Monterey Bay National Marine Sanctuary

2005

National Marine Sanctuaries
Monterey Bay

Photo by Robert Schwemmer/NOAA

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Welcome

On an island and at a time not so far away, I once had the pleasure of doing field biology work. On and off for several years in graduate school, I studied black abalone (*Haliotis cracherodii*) on Santa Cruz Island off Santa Barbara. For years, I also participated in many other research projects conducted by colleagues. I've never lost a personal interest in field biology and still find it one of the most rewarding activities I've done.

This edition of *Ecosystem Observations* provides me, personally – and you too, I hope – with the opportunity to experience the rewards of field biology work vicariously. That's not to say field work is easy, because it's not. It means climbing over stinky dead whales; queasy hours spent offshore in rough, windy conditions; or pulling on a cold wetsuit to wade into tidepools with the evening fog rolling in.

My personal curiosity of all things abalone is whetted a bit in the article inside about human impacts in the rocky intertidal. While kayaking in Monterey Bay several years ago, I began to wonder many things about the plethora of jellies in the bay: Where do they come from? How do they all get here together? Some answers to this, too, are inside. If I ever win the lottery, I'd volunteer to be a field biologist and join Scott Benson to study, and I hope save, leatherback turtles. There's hopeful news in this edition about this reptile, one of the most impressive large organisms on this planet.

I get so much out of these and all the other stories from our field biologist colleagues. Their contributions to *Ecosystem Observations* – the fruits of the many challenges involved in conducting field work – are inspiring to us all.

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

2005 Program Activities for the Monterey Bay National Marine Sanctuary

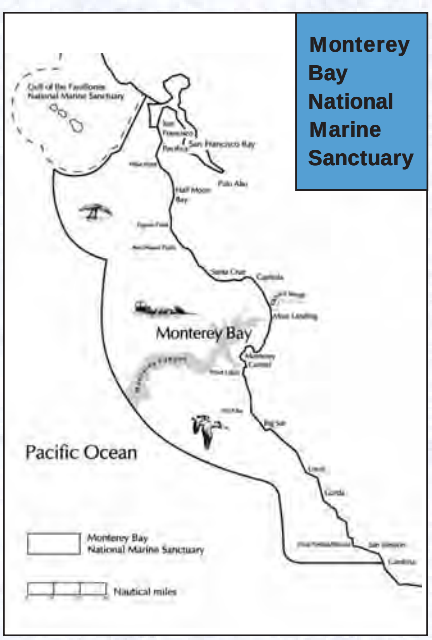
Dedicated in 1992, the Monterey Bay National Marine Sanctuary is the largest of 13 sanctuaries nationwide managed by the National Oceanic and Atmospheric Administration (NOAA). Encompassing more than 13,725 square kilometers (5,300 square miles) of water, its boundaries stretch along the central California 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 2005 follows. This year's report also includes a review of activities surrounding the Joint Management Plan Review (JMPR).

Resource protection involves a complex array of issues, habitats and human impacts, including consideration of water quality, coastal development, harvesting or disturbance of marine life as well as protection of the ecosystem as a whole. Addressing these issues in the sanctuary is particularly challenging given the long stretch of adjacent populated coastline and the need to protect resources while recognizing the many uses of the marine environment. The resource protection team works closely with a variety of partners to initiate and carry out strategies to reduce or prevent detrimental human impacts on sanctuary resources.

Staff continued to evaluate the potential need for marine protected areas (MPAs) that would limit harvest of marine resources in order to conserve habitats and ecological functions within the sanctuary. They are coordinating ongoing efforts of a working group composed of agencies, scientists, environmental organizations, fishermen and other ocean users who are evaluating the potential utility and design of MPAs in federal waters of the sanctuary, generally beyond three miles of shore. Efforts have included the development of detailed goals and objectives; collection and evaluation of biological, geological and socioeconomic data layers; and development of a decision-support tool that can be used to map and evaluate alternative MPA locations. Staff also participated extensively with the state's Marine Life Protection Act Initiative to develop proposals for MPAs in the state waters of the sanctuary, generally within three miles of shore.

The Water Quality Protection Program (WQPP) and its many partners continued efforts in the watersheds to reduce contaminated runoff to the sanctuary. The Agriculture Water Quality Alliance (AWQA), a coalition of groups that are working to carry out the sanctuary's Agriculture and Rural Lands Plan, has collaborated with local farmers and ranchers in 24 watershed working groups. These joint efforts, which included water quality training courses in six counties and targeted efforts to improve sediment, nitrate and pesticide management, received statewide recognition in 2005 in the form of a Governor's Environmental and Economic Leadership Award to the AWQA committee. To address the issue of contaminated runoff in our local cities, WQPP staff also conducted a technical training workshop for plumbers in Santa Cruz County, co-sponsored a workshop on low-impact development in San Luis Obispo County and performed technical outreach to 11 restaurants on best management practices.



Efforts to use trained volunteers to monitor water quality continued under the Sanctuary Citizen Watershed Monitoring Network, in partnership with the Coastal Watershed Council. First Flush, a volunteer event that monitors contaminants flushed off streets by the first heavy rains, held its sixth annual event in the fall. More than 80 trained volunteers in Pacific Grove, Monterey, Seaside, Capitola, Live Oak, Scotts Valley, Santa Cruz, Half Moon Bay and El Granada monitored 32 different sites. Staff continued to coordinate with local cities to use these data to identify and reduce sources of contaminants, improve permit programs and target public education.

Vessel Incidents with Sanctuary Response Dec. 2004 – Nov. 2005

Incident Type	Incident Date	Location	NOAA Costs
Sinking (P/C)	1/1/2005	1/2 nm W of Marina State Beach	$2,000
Grounding (P/C)	1/7/2005	Arroyo Laguna, San Simeon	$5,000
Sinking (P/C)	1/31/2005	2 nm NNE of Monterey Harbor	$20,000
Sinking (C/V)	2/19/2005	3 nm WNW of Point Pinos	$1,000
Sinking (C/V)	3/27/2005	6 nm WNW of Piedras Blancas	$1,000
Grounding (P/C)	3/28/2005	Seabright State Beach	$500
Grounding (P/C)	3/28/2005	Seabright State Beach	$500
Sinking (P/C)	3/30/2005	Mouth of the Pajaro River, Santa Cruz County	$500
Grounding (P/C)	4/8/2005	Santa Cruz Main Beach	$500
Grounding (C/V)	5/2/2005	Moss Landing Harbor entrance	$500
Grounding (P/C)	5/14/2005	Offshore of Davenport	$1,500
Sinking (P/C)	5/22/2005	1 mile W of Moss Landing Harbor	$3,000
Grounding (P/C)	5/24/2005	San Simeon Cove	$2,500
Grounding (P/C)	6/26/2005	Foot of Bay Avenue, Sand City	$500
Grounding (C/V)	7/10/2005	Venice Beach, Half Moon Bay	$1,000
Grounding (P/C)	7/11/2005	1/2 mile N of Pajaro River Mouth	$500
Sinking (P/C)	7/12/2005	100 yards seaward of Monterey Harbor Wharf II	$500
Grounding (P/C)	9/10/2005	Del Monte Beach, Monterey	$500
Grounding (P/C)	10/1/2005	Northern Muir Beach, Marin County	$10,000
Grounding (P/C)	10/24/2005	1/2 mile S of Salinas River mouth	$750
Sinking (P/C)	11/15/2005	1 nm N of Monterey Harbor	$500
Sinking (P/C)	11/24/2005	15 nm SW of Santa Cruz	2,500
TOTAL			$55,250

C/V-Commercial vessel P/C-Pleasure Craft Source: Monterey Bay National Marine Sanctuary

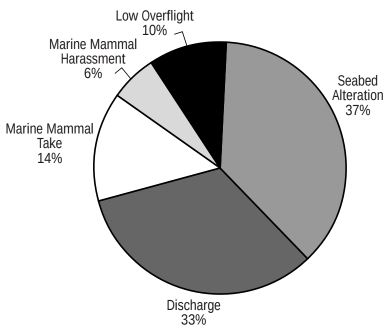
Staff continued to implement two management plans that address issues related to coastal development: desalination and coastal armoring (*see p. 6*). Because of a proliferation of desalination proposals in the region, staff are coordinating with scientists and local and state agencies to develop guidelines for the siting, construction and operation of desalination plants within the sanctuary in order to minimize impacts to natural resources. To address and reduce the spread of coastal armoring such as seawalls and riprap along the sanctuary's beaches, staff are coordinating a regional approach to the issue of coastal erosion and armoring in the sanctuary's Southern Monterey Bay sub-region, from the Salinas River to Wharf 2 in Monterey. In 2005, the sanctuary hosted five meetings of the Southern Monterey Bay Coastal Erosion and Armoring Workgroup, which is comprised of local experts, regulatory agency and local government representatives, conservation interests, and elected officials. The working group compiled and analyzed information on erosion rates and corresponding threats to private and public structures within this region and has identified and begun assessing a range of options available for responding to erosion while minimizing impacts to sanctuary resources.

Enforcement staff received several hundred notifications of potential violations in 2005 and investigated a wide variety of incidents. (*See chart, page 3.*) Discharges and wildlife disturbance are the most frequently reported violations in the sanctuary. Twenty-two vessel groundings/sinkings – often involving debris and fuel spills – were also reported. (*See chart, above.*) Sewage spills from land also continue to be a frequent source of water quality contamination. Staff completed an extensive investigation and settlement discussions regarding the discharge of 15 large shipping containers into the sanctuary.

We also received several reports of large commercial vessels operating inshore of the shipping lanes established by the International Maritime Organization to reduce the risk of oil spills. The sanctuary's enforcement officer, state peace officers and resource protection staff investigated these violations, followed up with responsible parties for

Profile of Documented Enforcement Cases Dec. 2004 – Nov. 2005

These data represent only 51 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. They simply provide a relative comparison of the types of violations occurring within the sanctuary.



•Marine mammal take cases were processed as actions under the Marine Mammal Protection Act instead of the National Marine Sanctuaries Act.

•Vessel groundings and sinkings are counted as seabed alteration cases, though most also involved discharges.

corrective action and identified ways to prevent them in the future, in coordination with a variety of state, federal and local agencies.

We reviewed approximately 50 permit requests this year, issuing permits or authorizations for activities such as seabed disturbance, discharges or overflights below 1,000 feet in restricted zones. Various conditions are imposed on these types of activity to reduce or eliminate threats. Staff coordinated with the California State Lands Commission to oversee completion of an Environmental Impact Statement and permit for the Monterey Accelerated Research System Cabled Observatory (MARS), a 51-kilometer cable that will help collect scientific data offshore of Monterey Bay. Numerous conditions related to laying, monitoring, maintaining and retrieving the cable were added to the permit to reduce impacts to sanctuary resources. Staff also reviewed and commented on a variety of projects and plans under development by others, to ensure that they adequately protected sanctuary resources.

As we head into 2006, the resource protection team looks forward to continuing our partnership efforts with federal, state and local agencies; industries such as agriculture and fishing; environmental groups; scientists; and citizens throughout the region to protect sanctuary resources.

Education and Outreach

The education and outreach team operates under the mission: *To promote understanding, support and participation in the protection and conservation of the Monterey Bay National Marine Sanctuary*. This year, following our mission, we initiated new facility planning, programs and products for our sanctuary as well as participating in international efforts.

We have three interpretive facility efforts underway, with two (Pigeon Point and San Simeon) ready to open this summer. The Pigeon Point facility has been planned in partnership with the Gulf of the Farallones National Marine Sanctuary. The San Simeon facility has been developed in close collaboration with California State Parks (San Luis Obispo Coast District). Named the Coastal Discovery Center at San Simeon Bay, it also serves as the new southern region field office, which opened this past spring. The Pigeon Point facility has a distinctly maritime flavor, while the Coastal Discovery Center has a natural history theme.

Twelfth Annual Sanctuary Reflections Awards

Presented at the 2005 Sanctuary Currents Symposium:

Ruth Vreeland Public Official Award: *Emily Reilly, City of Santa Cruz*

Citizen: *Carol Maehr*

Conservation: *Monterey Bay Sanctuary Citizen Watershed Monitoring Networks Volunteers*

Education: *Kelly Miller, Monterey Academy of Oceanographic Sciences (MAOS)*

Science/Research: *Dr. Bob Lea, California Department of Fish & Game*

Business: *Monterey Bay Kayaks*

Organization/Institution: *California Department of Parks and Recreation*

Special Recognition: *John Laird, Assembly Member, 27th District*

Photo by Cristy Cassel/MBNMS

Students in the MERITO Watershed Academy afterschool program participate in storm drain stenciling in Salinas.

Planning for a Santa Cruz facility also progressed. In partnership with the City of Santa Cruz, the architectural planning was initiated, with designs for the building and grounds enthusiastically received by Santa Cruz residents. Several budget options have been explored, and the city is working with the sanctuary to identify a variety of fundraising vehicles. Concurrent to the architectural planning, the center's interpretive plan is also taking shape.

Sanctuary programming continues to grow and evolve. Our multicultural education program, MERITO (Multicultural Education for Resource Issues Threatening Oceans) served more than 10,200 teachers, students and community members in the cities of Watsonville, Pajaro and Salinas this past year. MERITO is key to bringing the sanctuary messages of ocean issues and conservation to community members we would not otherwise serve through our traditional programs.

The TeamOCEAN (Ocean Conservation Education Action Network) kayak naturalist program continued to grow this year, recruiting 20 additional volunteers. This program puts knowledgeable naturalists on the water in kayaks to greet and interact with fellow day kayakers. The naturalists serve as docents for the sanctuary, promoting respectful wildlife viewing and protecting marine mammals from disturbance. The program reached 5,957 visitors on Monterey Bay, and volunteers donated 1,716 hours. Its greatest benefit is its interpretive nature, teaching wildlife viewing etiquette rather than using a punitive approach: people remember a positive interaction and learn about sanctuary resources at the same time. This program is the largest outreach program the sanctuary currently offers and will continue to explore expansion to address the many other ways people enjoy the sanctuary.

Our team continues to prepare for the draft management plan's release. This year, we developed 20 different fact sheets to accompany the draft management plan. We have addressed each of the major issues and created four-page pamphlets to outline the basics for those not ready to tackle the 400+ page document. Please look for these anywhere you find other sanctuary print materials or access them online in the management plan section of our web site: http://montereybay.noaa.gov.

Two education staff were selected for international visits in 2005. Michelle Templeton, manager of our multicultural program, was asked to join a contingent from Washington to visit the Galapagos Islands; and Dawn Hayes, education and outreach coordinator, was invited to the Great Barrier Reef Marine Park in Australia. The Galapagos trip's purpose was to identify how NOAA and the sanctuary program could assist the Ecuadorian government in developing local environmental programming. The visit to Australia was to learn from that country's highly successful marine zoning process and to share each agency's approach to education, outreach, communications and constituency building.

We all look forward to 2006, as we debut many of the products and facilities we've spent this past year planning, and we encourage readers to participate in the final stages of our management plan review process.

RESEARCH

The purpose of the sanctuary research program is to address resource management needs for scientific information. Our research is now more focused, with a new draft management plan, as we are addressing priority action plans within this document. Our Research Activity Panel of advisors also reorganized this year, enhancing expertise and procedures to address new management needs, rather than providing the more general advice that was needed when the sanctuary was designated in 1992. The research program has grown to a level at which it is impossible to comment on all of our activities over the last year, but more complete information can be found at the sanctuary and Sanctuary Integrated Monitoring Network (SIMoN) web sites (www.montereybay.noaa.gov; www.mbnms-simon.org).

Research staff are agency scientists with many duties, but they enjoy directing their expertise in some field research. To address the issue of invasive species, we have been monitoring and removing the Asian kelp, *Undaria*, in and around sanctuary harbors. With help from dive groups, school groups and the Young Women in Science program, hundreds of pounds of this invasive kelp have been removed. The project was featured at the California Harbor Masters and Port Captains annual meeting to provide information on invasive species management to a broad audience. In addition, invasive species and tidal erosion are being monitored in collaboration with the Elkhorn Slough National Estuarine Research Reserve to support decision making about management structures to modify tidal flow in this critical estuary. Offshore, the Channel Islands National Marine Sanctuary vessel, R/V *Shearwater*, was used to deploy temperature-measuring arrays to feed into a national observatory system, characterizing kelp beds and associated sensitive species related to highway maintenance activities along the Big Sur coast and describing seafloor habitats with a towed camera system. The Beach COMBERS surveys of beach-cast organisms detected unusually high mortality of some seabird species from January through May. (*See page 18.*) As disparate monitoring programs provide updates to the SIMoN program, we are now able to understand events such as these through the integration of information. This year, unusually weak upwelling resulted in warm, nutrient-poor water, which limited food for fishes such as juvenile rockfishes, and so rookeries of fish-eating birds suffered, and we noted increased mortality of adults along sanctuary beaches.

The SIMoN program continues to fund and track numerous monitoring programs. The Collaborative Survey of Cetacean Abundance and Pelagic Ecosystem was supported to conduct marine mammal assessments out to a distance of 300 nautical miles along the U.S. West Coast, with fine-scale sampling within three sanctuaries. This will put the abundance of these species in sanctuaries, including some that are highly migratory, in context with their entire habitat. On a much more local scale, SIMoN supported surveys and analyses to attempt detection of the source of chronically high copper concentrations in the storm drain of Steinbeck Plaza in Monterey. Within the state's MPA designation process, we supported staff and funding to develop an environmental assessment and decision support tool. This map-based software integrates geological, biological, oceanographic and socioeconomic data and allows for customized queries to assist in the analysis of alternative locations and networks of MPAs.


Photo by Andrew DeVogelaere/MBNMS

Sanctuary staff head out to Point Pinos in Pacific Grove to conduct a survey of black abalone.

The SIMoN web site has added information, now totaling almost 100 monitoring program summaries, and offers additional tools. We have new interactive maps on water quality, habitats and ocean observatories so users can visualize and print this information from the Internet. We also have new online data entry tools for the First Flush and Beach COMBERS citizen monitoring programs as well as a search tool for those interested in finding information on specific water quality parameters from the many central coast monitoring efforts.

Submerged cultural resources and maritime heritage are also part of the research program. (See http://montereybay.noaa.gov/resourcepro/resmanissues/culturalres.html.) This aspect of the sanctuary program, while often overlooked, is fascinating. We now provide information on the *Montebello* oil tanker, which was sunk by a Japanese submarine during Word War II (*and see p. 25*). The rigid airship *USS Macon*, large enough to hold 100 men and serve as an aircraft carrier for four planes, is resting on the seafloor off the Big Sur coast. The wreck was originally identified when a fisherman gave pieces of the wreck for decoration in a local restaurant; this year, we completed detailed mapping of the debris field using the NOAA Ship *McArthur II*, which will guide a complete photo mosaic of the site next year.

Finally, we produced publications on topics including deep-sea corals of the Davidson Seamount, regional ocean observing systems, impacts of coastal armoring, ecological assessments, our *SIMoN Says* report and more. For more complete information on research and monitoring, ecosystem updates and new web offerings, check out the SIMoN web site periodically.

Photo by Chad King/MBNMS

The white-spotted rose anemone (Urticina loftonesis) is found in subtidal monitoring surveys.

Joint Management Plan Review

An update of the sanctuary management plan continued in coordination with the Cordell Bank and Gulf of the Farallones National Marine Sanctuaries as part of the Joint Management Plan Review (JMPR). With significant public input, this review of the three management plans examines and updates the priorities, programs, regulations and boundaries of each sanctuary. Staff have worked with the public and the Sanctuary Advisory Council (SAC) since 2001 to determine which programs and priority issues to address and implement over the next five to ten years. Although the release of a draft management plan with proposed regulations and draft environmental impact statement has been delayed until 2006, staff began implementing many of the programs and action plans that were recommended by the SAC in 2003.

Much of the work on the management plan review over the past year focused on producing proposed rule or draft regulations associated with the update. These proposed regulations stem from recommendations made by the public and the SAC during the scoping and action plan development phases of the JMPR. Staff moved forward with a significant recommendation to provide potential protection of the Davidson Seamount by incorporating the area into the sanctuary and adopting specific regulations to address fragile coral and sponge communities that could be harmed by scientific collection, fishing or other disturbances. For much of 2005, we worked with the Pacific Fishery Management Council (PFMC) and NOAA Fisheries to draft regulations under multiple authorities that, if adopted, will provide protection to the Davidson Seamount from various threats. The PFMC unanimously supported the sanctuary's goals and objectives to protect the seamount and designated it both an Essential Fish Habitat and Habitat Area of Particular Concern, while recommending fishing restrictions for the seafloor and water column around the seamount. These draft regulations should be available for public comment in early 2006.

Program Operations

The program operations team continued to provide day-to-day administrative support to the education and outreach, research and monitoring, and resource protection teams while also working on a number of special projects. At the top of the list has been the construction of the 65-foot research vessel, *Fulmar*, due for completion in May 2006. The design of the state-of-the-art vessel is based on the Channel Islands National Marine Sanctuary's R/V *Shearwater*, with the addition of some new equipment features and additional deck space. The new vessel will service the West Coast region by providing a much-needed field research platform for the Gulf of the Farallones, Cordell Bank and Monterey Bay Sanctuaries as well as partner research institutions. A floating dock is also being built to berth the *Fulmar* in conjunction with the U.S. Coast Guard. A NOAA Corps officer has joined the sanctuary staff (January 2006) to manage operations for both the R/V *Fulmar* and the 29-foot *Shark Cat*.

In 2005, an agreement was completed with NOAA Fisheries at its Southwest Fisheries Science Center in Santa Cruz to build offices to house sanctuary staff. The goals are to enhance collaborations with NOAA Fisheries and increase sanctuary presence in the Santa Cruz region. Once completed in April 2006, the space will provide work stations for six to eight staff.

After returning from his six-month detail in Italy, Superintendent William Douros produced a report titled, *The Italian System of Marine Protected Areas*. This report provides information on the differences and similarities between U.S. and Italian MPAs and suggestions on how we can learn from each other. In September 2005, Douros returned to Italy with the director of the National Marine Sanctuary Program and the chief of the Conservation Policy and Planning Branch to review joint science accomplishments and future activities between Italy and the United States. The meeting culminated in the signing of a cooperative agreement between NOAA and Italy's Ministry of Environments to collaborate on science, outreach and exchanges to improve each agency's responsibility for MPA management. NOAA and the Ministry of Environment agreed to several exchanges of staff and expertise to further expand the partnership.

In 2005, the SAC swore in the following new members: Kris Reyes (Tourism alternate), LTJG Jacob Gustafson (USCG alternate), Randy Herz (Diving alternate), Libby Downey (AMBAG alternate), Steve Moore (Research alternate), Tracey Weiss (Education primary) and Cindy Walter (At-large alternate). David Crabbe was also selected as the Commercial Fishing seat alternate. Kaitilin Gaffney, Conservation primary, was elected as the new secretary. For more information on the SAC, please visit http://montereybay.noaa.gov/intro/advisory/advisory.html.

Photo by Robert Schwemmer/NOAA

Contributed Ecosystem Observations

Beach and Coastal Systems

Coastal Erosion and Armoring in Southern Monterey Bay

Eighty-six percent of California's 1,770-kilometer (1,100-mile) coastline is eroding, yet now more than ever people want an ocean view. Coastal erosion has been occurring for the past 18,000 years, when the last glacial period ended and sea level began to rise. Extreme variability in the rates and severity of coastal erosion, particularly in relation to El Niño storm patterns and local geologic conditions, complicates property protection decisions. The Monterey Bay National Marine Sanctuary, which includes 444 kilometers (275 miles) of coastline, has recognized that human responses to coastal erosion may impact sanctuary resources and has set up a working group of regional scientists, planners and consultants to determine the most effective way to minimize those impacts.

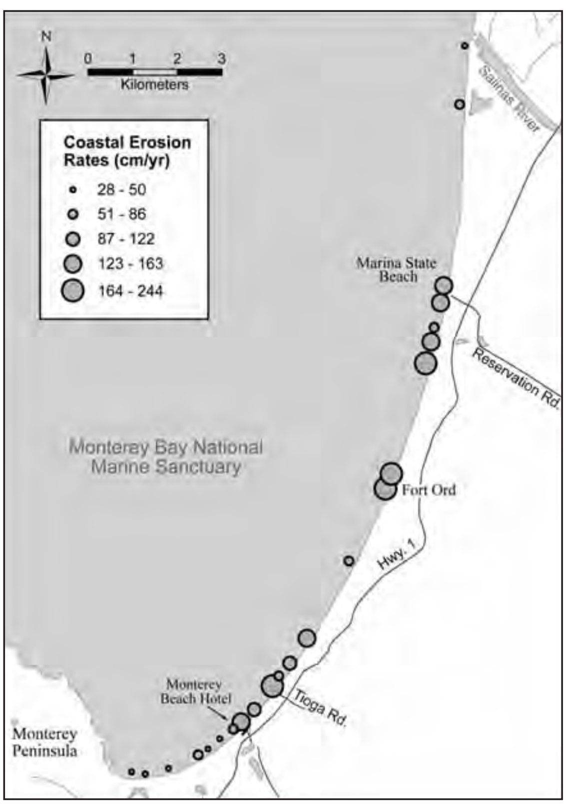


Figure 1. Variability of coastal erosion rates along southern Monterey Bay

An 18-kilometer stretch of relatively undeveloped, dune-backed coast in southern Monterey Bay was selected as the pilot region to begin a comprehensive analysis of erosion rates and management alternatives. By compiling data from scientific studies and consulting reports, the working group estimated that coastal erosion in this region varies from 28 to as much as 244 centimeters per year. (*See Figure 1*.) In general, erosion rates are highest near Fort Ord and decrease to the north and south, a pattern that is likely dictated by variability in the concentration and incident angle of wave energy.

Coastal erosion is a natural process that becomes problematic for people when buildings or infrastructure are threatened by wave action that erodes cliffs and other back-beach landforms. There are numerous responses to deal with coastal erosion, however these are not always acceptable alternatives, since they have varying levels of impact to the environment, economic costs and effectiveness in combating erosion; and they may conflict with policies and regulations of permitting agencies. The most logical alternative is avoiding the hazard in the first place by establishing setbacks for new development – based on local erosion rates – to ensure that structures will not be threatened within their projected lifespan. When existing development is endangered by a retreating shoreline, property owners can sometimes relocate their structures landward or demolish them. (*See Figure 2, p. 7*.) Other ways sometimes considered to slow erosion include increasing the sand supply to beaches by importing sand, referred to as beach nourishment; constructing groin fields, a series of linear, shore-perpendicular barriers; or removing coastal dams, which can trap sand upstream. These methods seek to widen beaches and thereby reduce wave attack on coastal cliffs and dunes. Alternatively, structures such as artificial reefs can be constructed offshore to decrease wave energy reaching the coastline. These erosion mitigation measures are generally very costly, and because the long-term benefits and impacts will vary greatly depending on local conditions, they should be evaluated on a case-by-case basis.

By far the most common method of protecting coastal property and mitigating erosion in California has been the construction of coastal protection structures, such as riprap revetments or seawalls (collectively referred to as "armoring"). More than 24 kilometers of the sanctuary's coastline have been armored, and this figure continues to grow. Various physical and biological impacts of coastal armoring may affect sanctuary resources both directly and indirectly. For example, armoring can restrict vertical and lateral access to

Figure 2.
(a) August 2003 photograph of Stillwell Hall on Fort Ord in Marina
(b) October 2004 photograph of the same site, after the building and riprap were removed because attempts to save the structure from collapsing into the ocean proved to be too costly and ineffective

beaches, cover up a significant portion of recreational beach area and depreciate the coast's aesthetic value. Armoring cliffs with cement or rock piles may reduce the amount of sand on local beaches, because a portion of the natural sand supply comes from the breakdown of cliff and dune material by erosion. In addition, there are potential impacts to biological communities through smothering or changes in benthic habitat.

Another potential effect from coastal armoring in an actively eroding area, such as southern Monterey Bay, is the narrowing of beaches. When armor is placed in front of a building to halt erosion, the shoreline is essentially fixed at that location. Adjacent landforms will continue to retreat landward due to coastal erosion, creating an artificial headland out of the armored segment of coast. The beach will remain the same width on either side of the armored area but will narrow or disappear in front of the armor; this is illustrated in the 'before' image of Stillwell Hall. (*See Figure 2a.*) A little more than one year after Stillwell Hall and the riprap were removed, wave action started to erase the artificial headland, and the beach returned. (*See Figure 2b.*)

The lack of development along much of southern Monterey Bay provides the sanctuary and its partners with an ideal, and increasingly rare, opportunity to be proactive in terms of coastal development. Combining scientific knowledge of the region's dynamic coastline with sound management will undoubtedly help to conserve the natural beauty and value of this resource.

– Rebecca Stamski
Monterey Bay National Marine Sanctuary

Rocky Intertidal and Subtidal Systems

Ecological Impacts of Human Visitation to Rocky Shores

Rocky shores offer a window into the diversity of marine life that is accessible to all. As the tide recedes, rocks covered with algae and invertebrates and tidepools hosting natural aquaria can be explored easily by simply walking along the shore. Easy access provides a tremendous opportunity for visitors to experience nature and learn about the diversity of solutions to life in this unique and challenging environment, but it may also pose threats to the marine life that the visitors come to observe. We have been investigating the possible ecological impacts of human visitation of rocky shores by comparing locations with varying amounts of public access and restrictions on use and by conducting experiments that simulate human disturbance on a small scale.

We compared abundance and diversity of algae and invertebrates across eight locations that span a gradient in possible human disturbance, taking advantage of existing marine reserves and other areas that represent different levels of access and legal or de facto restriction of human activities. Field sites included two no-take marine reserves (the Hopkins Marine Life Refuge and the Point Lobos Ecological Reserve); two 'de facto reserves,' where access to the shore is prevented by the presence of fenced estates (Pescadero Point in Pebble Beach and Mal Paso, south of Point Lobos); two sites, within the Point Pinos Marine Gardens Fish Refuge and the Carmel Bay Ecological Reserve, where marine invertebrate collection is prohibited by law but where public access is unrestricted; and two sites that are not within any marine protected area and are easily accessed from the shore (the rocky shores east of the Monterey Bay Aquarium, accessible from Cannery Row in Monterey, and Soberanes Point, south of Point Lobos). Thus, the eight field sites fall into four categories, each

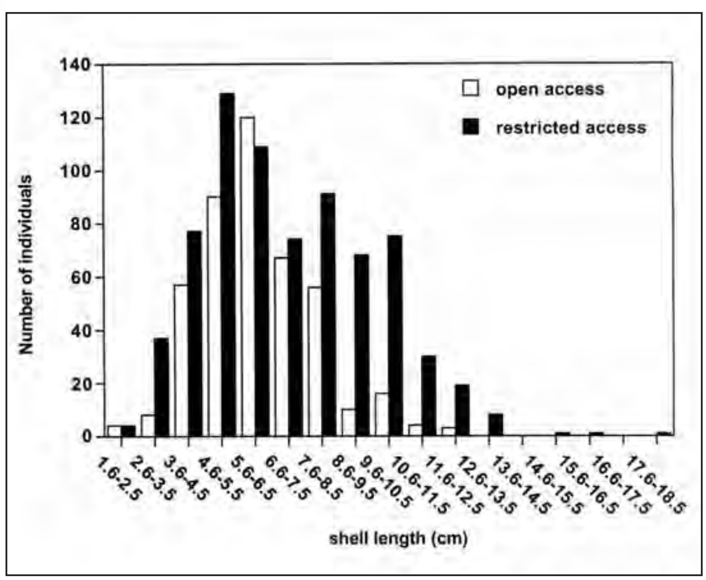


Figure 1. Size frequency distribution of black abalone at open-access and restricted-access sites (e.g., no-take and de facto reserves)

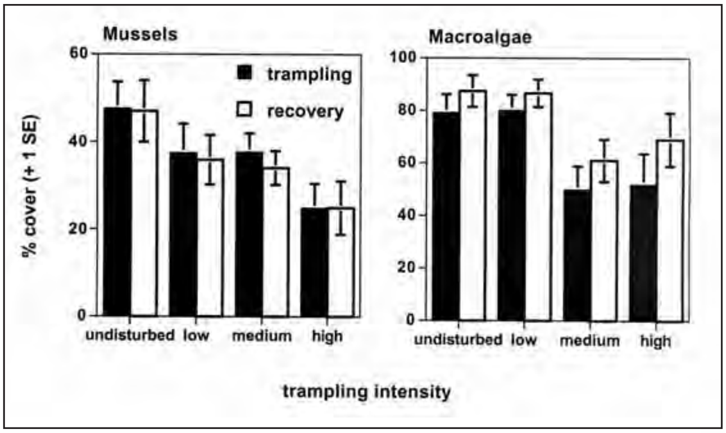


Figure 2. Changes in mussel and algal cover caused by simulated trampling disturbance of 1-meter-square plots. Low-, medium- and high-trampling intensity corresponded to 20, 100 and 400 steps per month. Percent mussel and algal cover after one year of trampling (black bars) and after a subsequent year of recovery (white bars) are reported.

represented by two distinct locations: (1) closed access, no-take reserve, restrictions enforced by on-site personnel; (2) closed access because of coastline morphology and private property along the shore (de facto reserves); (3) open access, restrictions of take because of ecological reserve status but no enforcement by on-site personnel; and (4) open access, no restrictions to collecting other than state-wide regulations.

In the winter and summer of 2002 and 2003, we estimated percent cover of algae and sessile invertebrates (those attached to the rocks, including mussels, barnacles and anemones) within quarter-square-meter plots along transects stretched at different heights along the shore. Small mobile invertebrates, such as limpets and snails, were counted within the same plots. In total, 220 invertebrate and algal taxa were surveyed within 2,304 plots over the course of the two years. Large invertebrates – the black abalone, *Haliotis cracherodii*, and the purple sea urchin, *Strongylocentrotus purpuratus* – were counted within 30-meter-long, 2-meter-wide band transects. One might expect that rocky intertidal assemblages subject to periodic natural disturbance from wave impacts during storms may suffer little additional damage from people trampling and removing organisms from the rocks. To test the prediction that the effects of human visitation might be apparent at wave-protected locations but may be small compared to natural wave impacts on exposed shores, we conducted surveys on both wave-exposed rocky headlands and along stretches of the shore protected by offshore rocks.

These comparisons revealed large amounts of natural variability, unrelated to the intensity of human visitation, at these different locations but also significant differences in the abundance and size of particular species and in the overall structure of the rocky-shore assemblages between open-access sites and restricted-access sites (no-take and de facto reserves). Within these broader categories, differences in legal restrictions on take among sites did not explain any additional amount of variation.

Black abalone were larger at restricted-access sites, with individuals larger than 8 centimeters in length accounting for 14 to 37 percent of all individuals versus 2 to 11 percent of individuals at open-access sites. (*See Figure 1, p. 7.*) Animals larger than 12 centimeters were found only within restricted-access sites. These size differences, evident despite the fact that a statewide ban on black abalone collecting has been in place since 1993, suggest that poaching may be occurring at open-access locations. Another conspicuous member of California rocky-shore communities, the purple sea urchin, had average densities five times greater at restricted-access (1.7 to 4.9 individuals per square meter) than open-access sites (0.2 to 1.0 individuals per square meter). Finally, preliminary analyses indicate that the overall structure of intertidal assemblages, in terms of the identities and relative abundances of rocky shore species, differed between open-access and restricted-access sites. Contrary to predictions, these differences were apparent only on wave-exposed headlands, not on wave-sheltered shores, and appeared to be associated with a smaller extent of mussel (*Mytilus californianus*) beds at open-access sites (ranging 3.7 to 15 percent cover across the four locations, 9 percent on average) compared to reserves (8.7 to 29.5 percent cover, 22.6 percent on average). Possible disturbance associated with human uses appeared to add to or interact with natural wave disturbance to cause observable impacts on these communities.

The locations we compared differ in a variety of ways beyond just differences in human access and use. Therefore, these population- and community-level differences might not be directly associated with human visitation *per se*. However, the above results, which suggest possible direct impacts from human visitation on rocky shore communities, were corroborated by experimental results on the effect of one particular type of human disturbance. We simulated trampling disturbance to 1-square-meter intertidal plots on wave-exposed rocky headlands dominated by mussel beds and at sheltered shores dominated by algal beds located along the Soberanes Point shores. Experimental treatments included trampling levels representative of what we have observed along the Pacific Grove shores (low-trampling intensity); higher disturbance levels documented on rocky shores elsewhere (medium- and high-trampling intensity); and control, undisturbed plots. Treatments were maintained for one year, and recovery was monitored for an additional year, leaving the plots undisturbed during this time. Experimental trampling caused significant reductions in algal cover on wave-protected shores, but only at medium- and high-trampling intensities. (*See Figure 2, above.*) One year after cessation of disturbance, algal cover in the high-intensity trampling

Photo by Steve Lonhart/MBNMS

Easy access to the sanctuary's rocky shores provides a tremendous opportunity for visitors to experience nature, but it may also pose threats to the very marine life that these visitors come to observe.

treatments was still lower but statistically indistinguishable from undisturbed controls. In contrast, mussel beds on wave-exposed headlands were significantly reduced, even at the lowest-trampling intensity, and showed no trends towards recovery.

The rocky shores of the Monterey Bay National Marine Sanctuary provide invaluable opportunities for recreation, education and research. In light of the likely increase of human population densities along these shores, it is crucial to continue to manage and monitor uses of this environment carefully. Species assemblages on exposed shores and long-lived species, including black abalone, sea urchins and mussels, appear to be especially vulnerable to collecting and trampling disturbance and thus are priorities for continued research, education and conservation efforts.

– Fiorenza Micheli, Kimberly Heiman, Carrie Kappel, Peggy Lynch, Jacqueline Martin and Rebecca Martone
Hopkins Marine Station, Stanford University

Coastal Biodiversity Surveys

Rocky intertidal reef habitats make up an important part of the coastal ecosystem. Learning more about the community of algae and invertebrates that lives in this habitat is key to understanding and assessing the health of coastal habitats and results in better management and conservation of our coastal oceans.

The Coastal Biodiversity Survey (CBS; http://cbsurveys.ucsc.edu) is a large-scale research project designed to measure diversity and abundance of algae and invertebrates in rocky intertidal communities on the West Coast of temperate North America. This study combines extraordinary precision at the local scale across an expansive spatial scale to create an unprecedented data set for investigating intertidal community structure patterns. With more than 90 sites ranging from Glacier Bay, Alaska to Baja California Sur, Mexico, this study has established a baseline of knowledge that will enable scientists to detect future ecological shifts within and among sites.

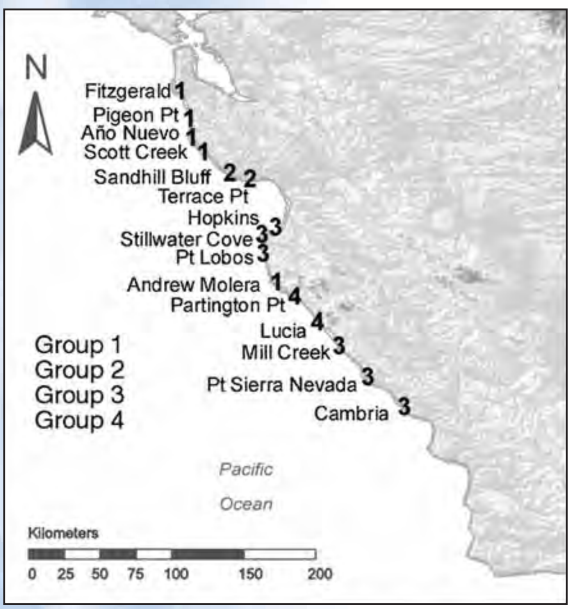


Figure 1. Coastal Biodiversity Survey sites in the sanctuary, grouped by abundance and diversity patterns of algae and invertebrates

The CBS was established to complement both the Partnership for the Interdisciplinary Study of Coastal Oceans (PISCO) monitoring program and the Multi-Agency Rocky Intertidal Monitoring Network (MARINe). A combination of sampling techniques – including point contact, quadrat and swath bands along transect lines – is used to determine the abundance of invertebrates and algae, mobile invertebrates and sea stars, respectively. These data are further linked to the elevation of the substrate in relation to tide levels in order to describe species' vertical distribution.

Results from the CBS have shown that rocky intertidal communities vary with respect to latitude, creating distinct biogeographic regions. Major geographic features such as points and bays along with oceanic currents create boundaries among these regions, which are defined as distinct more by differences in relative abundance of the same species than by differences in species presence.

The Monterey Bay National Marine Sanctuary lies within the biogeographic region bound by San Francisco Bay to the north and Point Conception to the south. Within the sanctuary, sites can be further divided into four groups with a similar suite of species but different species abundances. These differences may be driven by a number of variables, such as the slope of the intertidal bench, topographic complexity, type of bedrock, variable ocean currents, water temperatures, sand scouring, human activity and/or runoff. Interestingly, not all groups are contiguous along the coast. (*See Figure 1.*)

Group 1 contains four sites north of Monterey Bay and one site in Big Sur. Sites within this group all have large, gently sloping benches dominated by algae. Group 2 is made up of two sites at the northern edge of Monterey Bay. This group is less affected by upwelling due to circulation in the bay, which concentrates warm water in this area. Large mussel beds and barnacles dominate these sites. Seasonal sand inundations and sand scour may also affect the assemblage of species in Group 2.

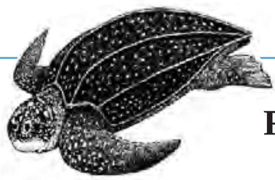
Sites found in Group 3 are located south of Monterey Bay. These sites are topographically complex and dominated by algae and mussels. The dominant algae species in Group 3 are similar to Group 1 but differ in relative abundances. Group 3 sites have an extensive low zone, creating a perfect habitat for many species that cannot withstand long periods of exposure to the air. Group 4 contains two very steep and exposed sites along the Big Sur coast. Mussels, barnacles and coralline algae are the dominant species cover in this group.

Rocky intertidal communities are both diverse and complex. Species must adapt to endure both the sea's crashing waves and the sun's desiccating heat. The CBS addresses fundamental questions relating to biogeography, effects of human use, management of coastal resources and conservation at a relevant spatial scale.

Ongoing research will continue to survey these sites every four years as a long-term monitoring project. Future research may explore the relationship between physical and environmental variables and the structure of the intertidal community.

– Kristen Kusic, Haven Livingston and Peter Raimondi
Department of Ecology and Evolutionary Biology,
University of California Santa Cruz

This project is funded by the David and Lucile Packard Foundation, Gordon and Betty Moore Foundation, Minerals Management Service and Monterey Bay National Marine Sanctuary. Additional support supplied by California State Parks, Fitzgerald Marine Reserve, Gulf of the Farallones National Marine Sanctuary, Hearst Corporation, National Park Service, Pt. Reyes National Seashore and University of California Reserves.



From Monterey Bay to Papua, Indonesia – Partnerships in Leatherback Conservation Inspire Hope

The Pacific leatherback turtle, *Dermochelys coriacea*, a seasonal visitor to the Monterey Bay National Marine Sanctuary, is listed as a critically endangered species on the World Conservation Union (IUCN) Red List. Leatherback sightings occur within the sanctuary primarily during late summer and fall, when these sea turtles arrive at our coastal waters to exploit large aggregations of their jellyfish (*Scyphomedusae*) prey. Although the leatherback is the largest living reptile, it is cryptic at sea and sighted mainly by those who work on the water (fishermen, marine scientists and whale-watch operators).

Leatherbacks nest at beaches in tropical latitudes, and it was long thought that the local visitors originated from nearby colonies in Mexico and Costa Rica. In the late 1990s, however, DNA analysis of skin samples from stranded turtles and those caught incidentally in U.S. fisheries revealed that West Coast leatherbacks were in fact nesting at beaches in the western Pacific (Indonesia, Papua New Guinea [PNG] and Solomon Islands). In September 2000, collaborating with Dr. Scott Eckert, who pioneered satellite-tag attachment methods, we successfully captured two free-swimming leatherbacks in Monterey Bay and released them with satellite-linked transmitters. The telemetry data confirmed the results of our genetic studies: leatherbacks encountered off central California originate from western Pacific nesting beaches. (*See Figure 1.)*

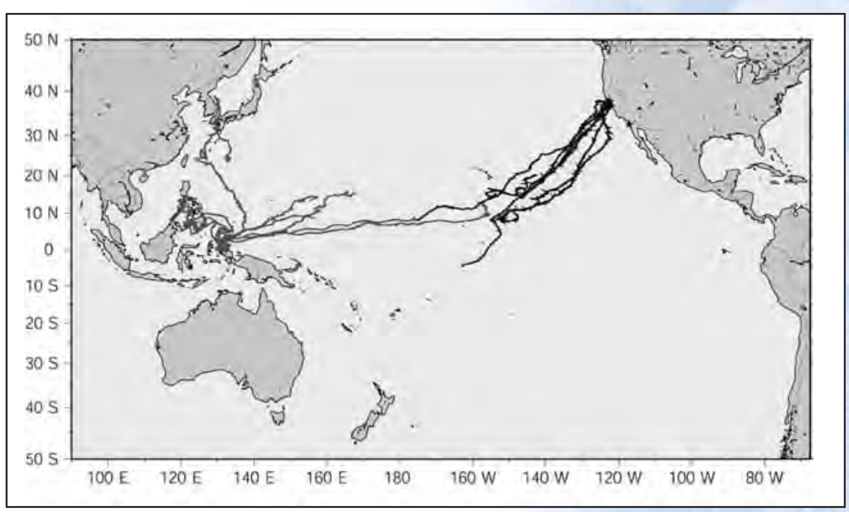
Since 2000, we have tagged 29 additional leatherbacks within the Monterey Bay and Gulf of the Farallones National Marine Sanctuaries and 43 at western Pacific nesting beaches. The results of these efforts have revealed that leatherbacks in the western Pacific region, although considered a single genetic stock, comprise multiple foraging populations. Turtles that nest during the winter months undertake migrations to the south, while those that nest during summer months move to northern foraging grounds, including the North American West Coast. The combined results have fundamentally changed the scope of conservation efforts for leatherback turtles found off the U.S. West Coast.

The Recovery Plan (by NOAA Fisheries and the U.S. Fish and Wildlife Service) for the Pacific leatherback identifies key areas of research and conservation that will be necessary to ensure its survival, including 1) identifying stock ranges, 2) determining movement patterns and foraging habitat and 3) censusing and protecting nesting populations. In particular, protecting nesting beaches has been proven to work well in restoring sea turtle populations. In the Gulf of Mexico, this tactic was effective at halting the extinction of the Kemp's ridley, one of the most critically endangered sea turtles in the world during the 1970s. The huge effort, combined with additional measures to protect ridleys from coastal fishery mortality, resulted in the gradual recovery of the species during the 1990s. Long-term nesting beach protection has also resulted in increases of once-depleted leatherback populations in the Caribbean. However, egg protection alone may be insufficient to reverse the severe declines in the eastern Pacific leatherback rookeries in Mexico and Costa Rica, and it did not prevent the extinction of the Malaysian rookery at Terengganu. It is clear that a holistic approach will be required that also addresses at-sea threats.

Photo courtesy of John Douglas, Moss Landing Marine Laboratories

World Wildlife Fund-Indonesia partners Julius Lawalata, Creusa Hitipeuw and Yulianus Thebu prepare to release a leatherback outfitted with a satellite transmitter in Monterey Bay.

In 2003, a landmark meeting in Bellagio, Italy brought together a group of biologists, economists, legal scholars, conservationists and fishermen from around the Pacific to develop a new multidisciplinary approach to dealing with declining sea turtle populations. The Bellagio Blueprint for Action on Pacific Sea Turtles (*see www.worldfishcenter.org/news/Press/Jan04/seaturtles_6Jan04.htm*) calls for a massive mobilization to protect all remaining nesting sites around the Pacific from unsustainable human harvest,



GMT map by Denise Parker

Figure 1. Satellite-tracked leatherback movements from nesting beaches in Papua, Indonesia and from foraging areas off the California coast in 2003-2004 (Dutton et al., unpublished)

predation and habitat destruction. In addition, threats at sea must be reduced by strengthening and coordinating existing Pacific conservation and fisheries treaties as well as facilitating transfer of new turtle-friendly fishing technologies to multinational fishing fleets.

To meet these goals, we have expanded our work to include not only local research on leatherbacks off central California but also a variety of conservation and research initiatives in western Pacific island nations. We recently conducted aerial surveys in Papua (eastern Indonesia) and PNG that showed large numbers of nesting leatherbacks remaining only on a few beaches in Papua. This underscores the need to protect these last remaining rookeries in the Pacific before it is too late. Efforts to establish coordinated and sustained nesting beach conservation are now getting underway in Papua and throughout the western Pacific. With the help of local community-based organizations, government and university biologists, and Word Wildlife Fund researchers, we are training local villagers to monitor the nesting beaches, evaluate hatching success and attach satellite-linked transmitters to nesting turtles. A cooperative international program involving local villages and non-governmental, governmental and fishery management organizations has recently been established and is gaining momentum. These new developments have inspired cautious optimism about the future of the western Pacific leatherback.

Known by different names throughout beaches in the western Pacific – *trousel, penyu-belimbing, leddebak, tabob* – the leatherback has long been an important part of local cultures and traditions. With new awareness that ‘their’ turtles travel to other locations near and far across the Pacific, our colleagues in PNG and Papua are now working with a broad international community to ensure the survival of the leatherback for future generations.

Within the coastal central California ecosystem, including the sanctuary, foraging populations of leatherback turtles are relatively safe; however, ‘our’ turtles will remain at risk unless we are able to expand our understanding of the entire ecosystem inhabited by these highly mobile marine reptiles. Leatherbacks inhabit an ecosystem that includes not only the sanctuary but extends across the Pacific Ocean, nearly one third of the way around the globe. In this case, ecosystem-based management requires a broad scope to achieve successful conservation of this species at all foraging grounds, nesting beaches and on the migratory routes that connect them.

As they say in Papua New Guinea, *Yumi mas lukautimi gud, trousel blong ol pikinini i kam behain*: “We must take care of the turtles, for they belong to the children of the future.”

– Scott R. Benson and Peter H. Dutton
NOAA Fisheries – Southwest Fisheries Science Center

Jellyfish Population Trends in Southern Monterey Bay from 2000 to 2005

Jellyfish are important in their ecosystems as predators, prey and hosts of symbiotic organisms. Most jellies eat small animals, including copepods, larval invertebrates and fish eggs. In turn, they are preyed upon by ocean sunfish, *Mola mola*, and leatherback sea turtles, *Dermochelys coriacea*. Moribund jellies are eaten by a benthic army of crabs, sea stars and anemones. Jellies are also hosts of symbiotic fishes and crabs. Young fishes use jellies as safe havens from predators, darting under jellyfish bells when danger approaches. Swimming larvae of slender crabs, *Cancer gracilis*, land on jellies and eat some of their parasites while the crabs are transported to new habitats.

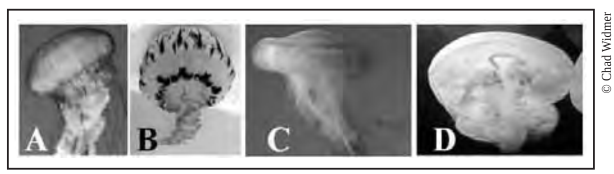


Figure 2. (A) Pacific sea nettle, Chrysaora fuscescens; (B) purple stripe jelly, Chrysaora colorata; (C) egg yolk jelly, Phacellophora camtschatica; (D) Pacific moon jelly, Aurelia labiata

	Pacific sea nettle *Chrysaora fuscescens*	Purple stripe jelly *Chrysaora colorata*	Pacific moon Jelly *Aurelia labiata*	Egg yolk jelly *Phacellophora camtschatica*	Giant bell jelly *Scrippsia pacifica*	Comb jelly *Beroe cucumis*	Lobed comb jelly *Bolinopsis infundibulum*	Sea gooseberry *Pleurobrachia bachei*
2000-2004								
January	XX		X			XX	X	X
February	X	X	X					
March			XX			X	X	XX
April			XX		X	X	X	XXX
May		X	XX		XX	X	X	XX
June	X	X	XX	XXXX	XX	XX	X	X
July	X	XX	XXX	XXXX		X	X	X
August	X	XX	XXX	XX		X	X	XX
September	XXX	XXX	XXX	XX		X		X
October	XXX	X	XXX					X
November	X		XX			X		X
December		X	XX			X		
2005								
January								
February								
March								
April				XXX				X
May				XXX				
June		X		XXX				
July		X		XXXX				
August		X		XXXX				
September		X		XXX				
October		X	X	XX				
November		X	XX	X				
December				X				

Figure 1. Seasonal population abundance of studied Monterey Bay jellies for the years 2000-2004 versus 2005. The number of Xs indicates relative abundance.

Factors affecting seasonal abundance of northeast Pacific jellies are poorly understood. The animals tend to aggregate in locations with particular physical properties. For example, jellies may often be found at the boundary between two different water masses. They may also be found at the surface in the “slicks,” or calm water trails, seen on the surface of the bay on flat days. Annual seasonal population abundance patterns for local jellyfish species have been clearly observed by Monterey Bay Aquarium (MBA) staff while collecting animals for display and research. (*See Figure 1.*)

From 2000 to 2004, jellies were abundant in Monterey Bay. Pacific sea nettles, *Chrysaora fuscescens* (*Figure 2A*), typically arrived during summer and fall. Purple stripe jellies, *Chrysaora colorata* (*Figure 2B*), were usually present in large numbers during the summer and sporadically throughout the year. Egg yolk jellies, *Phacellophora camtschatica* (*Figure 2C*), were typically present for only the summer months. Moon jellies, *Aurelia labiata* (*Figure

2D), were common year-round from 2000 to 2004. Moon jellies are food for *C. fuscescens, C. colorata* and *P. camtschatica*. There were also a number of other smaller jellies, ordinarily arriving in the spring and carrying on through the summer.

In contrast, 2005 was a barren jelly-hunting season, with two exceptions. Egg yolk jellies arrived two months early, stayed three months late and were exceedingly abundant. (*See Figure 1.*) Purple stripe jellies were punctual and more abundant than in years past. However, moon jellies, Pacific sea nettles and the smaller jellies were not present at survey sites from January through September. One possible explanation for the lack of smaller jellies was the early arrival of large numbers of jellyfish-eating egg yolk jellies, capable of clearing most gelatinous prey from large volumes of water. Purple stripe jellies may have survived the onslaught because they are strong, active swimmers and are large enough to escape predation from egg yolk jellies.

In October 2005, the number of egg yolk jellies gradually decreased, and in the last week of the month, large moon jellies (that were record-breaking in size) appeared. In the late 1990s, the largest Pacific moon jellies collected by the aquarium had maximum bell diameters of about 40 centimeters. In 2002, MBA staff collected moon jellies measuring 44 centimeters in diameter, in 2004 some were 44.5 centimeters wide and in October 2005, we collected specimens with bell diameters of 45 centimeters. Within physiological tolerances, growth of Pacific moon jellies increases with temperature. In 2005, unusual summer jelly population patterns were also observed in southern California. Countless egg yolk jellies and black sea nettles, *Chrysaora achlyos*, arrived unexpectedly in southern California waters. Black sea nettles live in warmer water and do not normally occur in Monterey Bay. However, this summer a large black sea nettle was observed under the floating fuel dock in Monterey Harbor.

This year was an unusual one all around the United States. In Monterey Bay the squid, salmon and jelly fishing seasons were lackluster. Southern California saw huge red tides and unusual jelly blooms. Midwest states reported more summer rain than normal, and there were two category-five hurricanes in the Gulf of Mexico. It leaves one to wonder if a poor jelly-hunting season and the rest are linked to global warming or part of normal, large-scale temperature oscillations. Population studies for jellies of southern Monterey Bay will continue at MBA in order to understand better how global climate change and local jellyfish abundance patterns may be related.

– Chad L. Widmer
Monterey Bay Aquarium

The Physical Environment

Satellite Observations

Satellites provide a unique perspective for viewing and understanding the Monterey Bay National Marine Sanctuary. They provide a regional view, showing patterns that are difficult to see from shipboard observations, and they provide a context in time, showing details of changes since the satellites were launched. Using satellite data allows analysis of patterns, trends and variability at resolutions not possible from ship and over areas not captured by moored instruments. This permits evaluation of events such as El Niño and clearer identification of unusual events.

Satellites collect different types of data of use for the Monterey Bay area. The Advanced Very High Resolution Radiometer (AVHRR), which has operated on National Oceanic and Atmospheric Administration (NOAA) weather satellites for more than 20 years, measures thermal infrared radiation, which allows sea-surface temperature to be determined. Ocean color sensors, such as the Sea-Viewing Wide Field-of-View Sensor (SeaWiFS), launched in 1997, measure the amount of light at different wavelengths (colors). Color analysis allows estimation of the amount of chlorophyll (i.e., algae) and the amount of turbidity produced by sediment in the water. The satellites collect data nearly every day, with samples (pixels) every 1 to 4 kilometers where there are no clouds. As a result, the satellites collect hundreds to thousands of samples over the sanctuary on every clear day – and during cloud breaks on cloudy days.

Upwelling is one of the most important factors influencing the region. From March to October, steady winds from the northwest cause surface water to move offshore and be replaced by nutrient-rich sub-surface water from offshore. The sub-surface

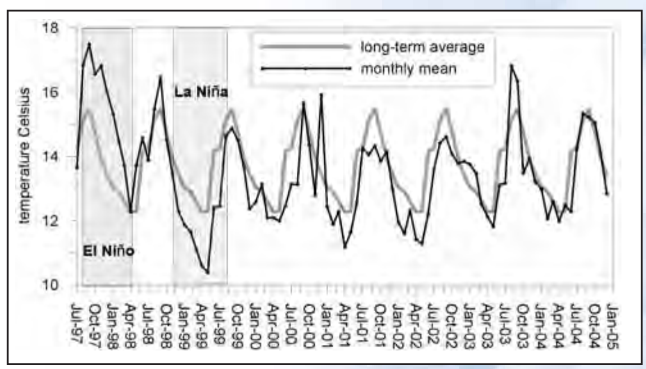


Figure 1. Sea-surface temperature from satellite for the entire sanctuary, showing the long-term monthly averages from 1985 to 2004 and the monthly means

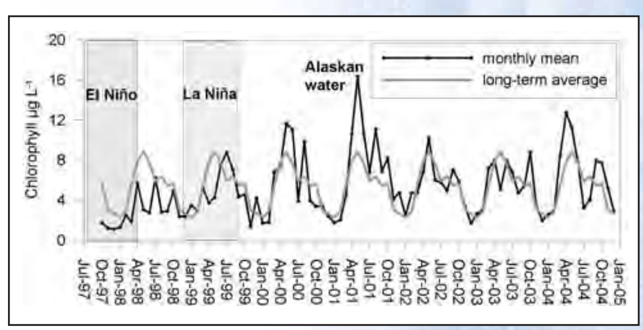


Figure 2. Mean chlorophyll concentration by month for sanctuary areas less than 200 meters deep. Chlorophyll concentration on average follows the upwelling season of March to October, with highest chlorophyll concentration in the spring. The El Niño led to depressed chlorophyll through 1998. The highest chlorophyll, in 2001, resulted from nutrients coming in from Alaskan water.

water is cooler, so upwelling causes the coldest water temperatures to be delayed until April and May rather than mid-winter. (*See Figure 1, p. 12.*) An El Niño event significantly reduces the winds that cause upwelling, while its opposite, La Niña, strengthens them. The 1997-1998 El Niño was severe and significantly reduced upwelling, resulting in warmer sea-surface temperatures. The lack of upwelled nutrients reduced chlorophyll concentrations through 1998 (*see Figure 2, p. 12*), potentially altering the entire food chain. In contrast, the strong 1999 La Niña, which might have been expected to intensify upwelling, had little influence on chlorophyll. In 2001, a much different event occurred: sub-surface, nutrient-rich water that is normally found near Alaska moved much further south. Through upwelling, this water produced an infusion of nutrients into the California coastal system, resulting in much higher chlorophyll concentrations than normal.

Winter is, of course, the wettest time of the year in California. While El Niño is known for reducing upwelling, it also causes wetter winters, and the rainfall has a dramatic effect on sediment flowing into the sanctuary. (*See Figure 3.*) The 1998 El Niño produced a 500 percent increase in turbidity due to sediment in the coastal area of the sanctuary. Turbidity indicates areas of levels of nutrients and pollutants, which ran off the land, increased sedimentation and decreased light for kelps, other algae and sea grasses. The additional nutrients did not appear to offset the lack of upwelled nutrients in the coastal part of the sanctuary. Between the El Niño impact and the Alaskan water impact of 2001, the satellite data indicate that offshore sources of nutrients are far more important regionally to the sanctuary than land-based nutrients, although land-based nutrients may influence some parts of Monterey Bay.

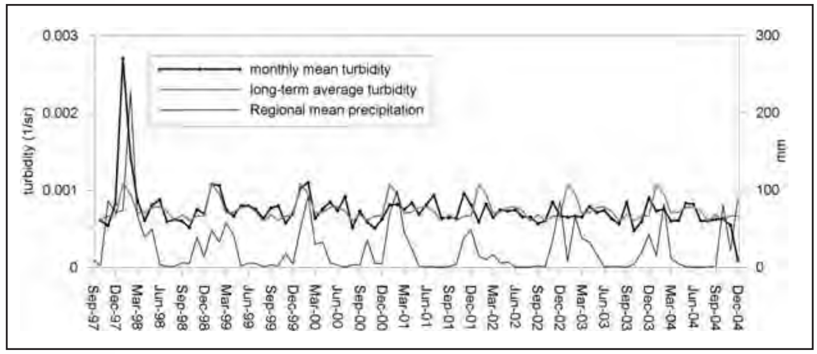
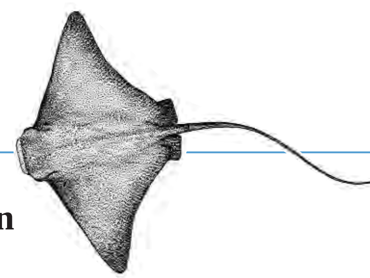


Figure 3. Turbidity and precipitation for sanctuary areas less than 200 meters deep. Turbidity is caused by sediment loading. Normally there is only a slight impact from winter rainfall, and this is localized in parts of Monterey Bay. The wet El Niño winter produced much higher than normal sediment loads through the area.

We are beginning to compare the satellite data with other data sets, including seabirds and marine mammals, in order to identify patterns that can be linked to behavior and mortalities. In addition, ocean color satellites are a potential tool in detecting and monitoring harmful algal blooms, which may permit more rapid response to these events.

– Richard P. Stumpf
National Oceanic and Atmospheric Administration,
National Ocean Service

Wetlands and Watersheds



The Elkhorn Slough Tidal Wetland Plan

Elkhorn Slough, the largest estuary of the Monterey Bay National Marine Sanctuary, joins the Pacific Ocean at the very center of Monterey Bay. The 2,970 acres of Elkhorn Slough tidal habitats include a main subtidal channel flanked by extensive intertidal salt marshes, mudflats, tidal creeks and salt pannes. These areas provide critical habitat for more than 135 aquatic and migratory bird, 550 marine invertebrate and 102 fish species. In addition to providing habitat, Elkhorn Slough offers research, educational and recreational opportunities for kayakers, birdwatchers, hikers, boaters, students and scientists.

The 1999 Elkhorn Slough Watershed Conservation Plan identified human alterations to the tidal influence and hydrology as one of the major threats to Elkhorn Slough's coastal wetlands. Since the 1880s, human actions have caused the loss and degradation of hundreds of acres of tidal wetlands in Elkhorn Slough. Examples of past modifications include railroad, highway, dam and levee construction; upland clearing and cultivation; diking and draining of tidal wetlands; river diversion; intense groundwater pumping; and harbor construction. These changes have greatly disrupted the important balance among tidal influence, geomorphology, and sediment and freshwater supply that sustain Elkhorn Slough's estuarine habitats.

Research studies have confirmed dramatic rates of tidal erosion and marsh loss in the slough. Bathymetric studies conducted by Rikk Kvitek, California State University Monterey Bay, indicate that the mean cross-sectional area of Elkhorn Slough increased by 24 percent in just eight years (1993-2001). Eric Van Dyke and Kerstin Wasson of Elkhorn Slough National Estuarine Research Reserve (ESNERR) analyzed marsh loss, bank erosion and tidal creek changes over time. GIS analysis of Elkhorn Slough tidal habitats demonstrates that the mean percent cover of salt marsh vegetation in undiked marshlands decreased approximately 44 percent between 1931 and 2003. (*See Figure 1, opposite.*) The mean width of 196 tidal creeks increased from 2.5 meters in 1931 to 12.4 meters in 2003. Bank erosion rates along the main channel of Elkhorn Slough are between 0.3 and 0.6 meters per year, with some areas that approach rates of 2.0 meters per year. In light of the significant rates of tidal erosion and marsh loss in Elkhorn Slough, carefully planned management strategies are needed to conserve and restore these critical habitats.

In September 2004, ESNERR and California Department of Fish and Game, with funding from the National Oceanic and Atmospheric Administration, initiated a planning process to develop an Elkhorn Slough Tidal Wetland Plan (TWP) with a wide variety of partners. The purpose of this collaborative process is to conserve, enhance and restore tidal habitats in the Elkhorn Slough watershed by developing strategies to address hydrological management issues. The TWP Strategic Planning Team, the primary decision-making body overseeing the planning process, consists of coastal restoration scientists, managers, and planners; directors of key conservation organizations; and representatives of jurisdictional, regulatory and governmental entities. During the past year, they developed a consensus statement outlining strategic planning principles, a vision, goals and objectives for the TWP. Summarized, the goals are to conserve the existing highest-quality estuarine habitats; restore and enhance degraded estuarine habitats, with a special emphasis on those with the highest loss rates; and restore and enhance natural processes (hydrology and geomorphology) to sustain a more stable estuarine system. The team has also agreed that the current tidal habitat trends are not acceptable and that new management actions are necessary.

A TWP Science Panel, consisting of more than 40 multidisciplinary (biological, hydrogeomorphic, physiochemical, estuarine restoration) experts has met bimonthly over the past year. This group has been instrumental in characterizing what is known about historical changes, tidal habitats, physical processes and causes of tidal erosion and marsh loss. There is now general agreement that the modification of the Elkhorn Slough mouth for the creation of a harbor in 1947, permanently fixing a deeper opening to Monterey Bay, is the main cause of subtidal erosion and more recent marsh loss. Contributing factors include decreases in sediment supply (diversion of the Salinas River), dike/levee failure and removal, the presence of the Monterey Canyon, sea-level rise, wave action and other biogeochemical processes. The panel acknowledges that the process of marsh loss is complex, but the increased tidal range and duration of tidal inundation on the marsh plain (due to the mouth modifications and land subsidence) in combination with the decrease in sediment supply are contributing factors.

The TWP Science Panel and Strategic Planning Team have also agreed that the Elkhorn Slough system is not currently at equilibrium. Their predictions for tidal habitats over the next 50 years, if no actions are taken, include the continued deepening and widening of the channel and tidal creeks, increase in salt marsh conversion to mudflat and tidal creeks, and erosion of sediments in soft-bottom areas.

The next major step in the tidal wetland planning process will be to develop and evaluate potential strategies that achieve the goals to conserve and restore tidal habitats in Elkhorn Slough. Possible strategies to address marsh loss and tidal erosion may include actions to reduce the tidal influence to specific areas or the entire system, to supply sediments to increase the elevations of subsided marsh areas and to restore appropriate levels of tidal exchange to areas behind water-control structures. Key agency and community stakeholders and outside experts will be able to provide input on the draft strategies. The anticipated result of the TWP will be that the partners will be in place to obtain funding, oversee implementation and conduct research and monitoring of the recommended conservation and restoration strategies.

Strategies in the Elkhorn Slough TWP will aim to meet the shared vision of the Strategic Planning Team: "We envision a mosaic of estuarine communities of historic precedence that are sustained by natural tidal, fluvial, sedimentary and biological processes in the Elkhorn Slough Watershed as a legacy for future generations."

For more information, please visit www.elkhornslough.org/tidalwetlandplan.htm.

– Barb Peichel
Elkhorn Slough National Estuarine Research Reserve

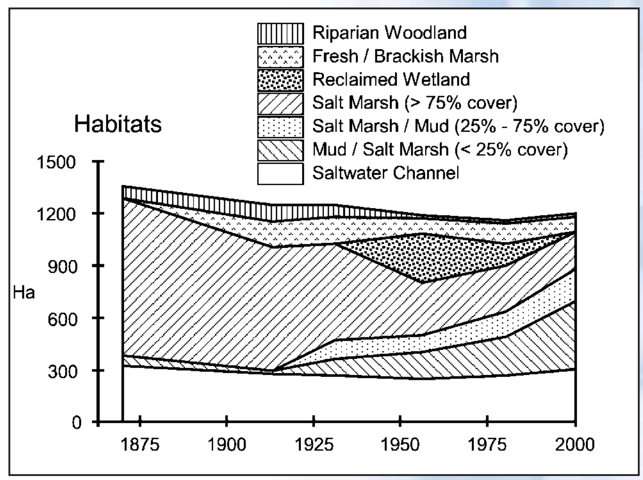
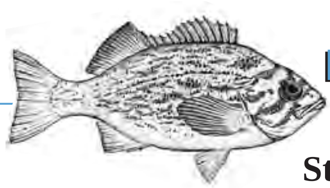


Figure 1. Changes to the extent of acreage (hectares; ha) of tidal habitats in Elkhorn Slough from 1870 to 2000 (Van Dyke and Wasson 2005)



Endangered and Threatened Species

Steelhead are Widespread but Sparse in the Sanctuary

Each winter, hundreds of ocean-going steelhead, *Oncorhynchus mykiss*, return to the Monterey Bay National Marine Sanctuary to ascend local streams and spawn. A century ago, this number was almost certainly in the tens of thousands, but it has undergone a long decline. This is presumably due to the myriad effects of the growing human population on stream habitat; regional climate change; and especially the construction of impassable dams, culverts and other obstructions that block their freshwater migration routes.

The steelhead were listed as threatened (under the Endangered Species Act) in the 1990s, after the California drought put the situation in stark relief: from 1988 to 1992, only 16 adults were observed ascending the fish ladder at San Clemente Dam on the Carmel River. At that time, we knew very little about steelhead abundance in the other two inland systems – the Salinas and Pajaro – but we knew that the human impacts in those systems were at least on par with the Carmel River. We also knew that some modest runs occurred in various coastal basins between San Francisco and Cambria.

Since then, we have learned more about the steelhead – findings both alarming and comforting. Much of the current situation derives from steelhead's dependence on accessible stream reaches with cool, reliable base flows during the summer in which their offspring can successfully 'oversummer' before migrating out to the ocean. Rainbow trout also play a key role, as do estuaries (*see text below*).

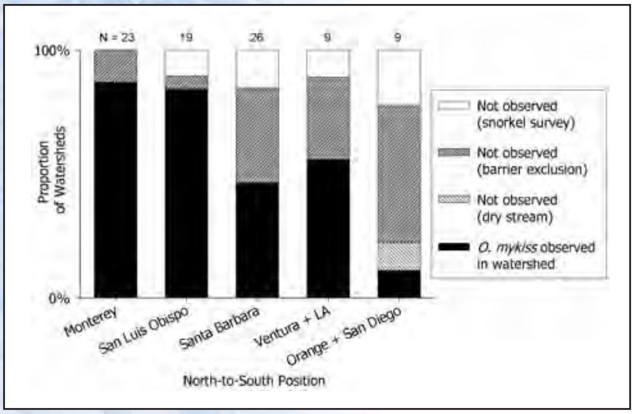


Figure 1. Occurrence (by county) of anadromous Oncorhynchus mykiss as of 2002, in coastal basins (sub-basins for the Pajaro and Salinas systems) in which the species had been recorded historically. 'Barrier exclusions' refer to systems in which impassable dams or other human-made barriers block access to spawning or rearing habitat. Many of these basins have extant non-anadromous populations of O. mykiss above the barrier.

The alarming thing is the climate. Tree-ring data indicate that the climate has become warmer and wetter since the 19th century, when the Little Ice Age ended. Oxygen isotopes in shells at archaeological sites reveal a corresponding rise in sea-surface temperature, by about 2-3˚ C since 1700. The future looks to be warmer still, and possibly drier, according to forecasts by Mark Snyder and others at the University of California Santa Cruz (UCSC).

To a first approximation, stream temperature tracks air temperature; and summer base flow is a function of annual precipitation and watershed size. Matthew Goslin of UCSC, Fred Watson of California State University Monterey Bay and I used these relations to prepare maps of potential steelhead habitat, based on the climate of the past 40 years and the geomorphology of coastal stream networks. We used known occurrences of juvenile fish to estimate the species' tolerance limits along each environmental variable (known as a Bioclim or envelope model). The results advance the idea that oversummering habitat is largely confined to four areas: the immediate coast, the Santa Cruz Mountains, the Carmel River and headwater streams of the east side of the Santa Lucia Mountains.

As of 2002, the species was still widespread in coastal creeks from San Francisco to Cambria (and beyond), according to surveys we conducted in that year. (*See Figure 1.*) In Big Sur we found the species in all the coastal basins in which it had been recorded historically, even the tiniest systems such as Partington and Plaskett Creeks. This fact hints at the idea that small populations, usually thought to be extinction-prone, may be unusually resilient in Big Sur. Meanwhile, steelhead numbers have rebounded in the Carmel River, believed to be partly a result of changes in water and fisheries management and partly a result of the Pacific Decadal Oscillation, which has apparently improved ocean survival of salmonids throughout the West Coast. Clearly, the species is quite resilient under the right conditions. Nevertheless, nowhere is there evidence for the steelhead numbers of a century ago.

Rainbow trout, which stay in fresh water their entire lives, have steelhead as progeny and vice versa. We suspect that environmental cues may influence which of the two strategies a juvenile fish adopts – a hypothesis currently being tested experimentally by Sue Sogard of the National Oceanic and Atmospheric Administration (NOAA), Rob Titus of California Department of Fish and Game and Marc Mangel of UCSC. The rainbow trout 'option' clearly confers resilience on steelhead populations, allowing, for example, the species to persist above impassable dams such as those on the San Antonio and Nacimiento Rivers near Camp Roberts. Genetic studies we conducted in collaboration with Anthony Clemento and Eric Anderson of NOAA and Derek Girman of Sonoma State University indicate that the fish above these dams are not descendents of hatchery fish but are as closely related to existing steelhead populations as the latter are to each other.

Coastal estuaries also appear to confer resilience. Some years ago, Jerry Smith of San Jose State University showed that oversummering juveniles grew very fast in certain lagoon estuaries. In a recent study of Scott Creek steelhead, Sean Hayes of NOAA confirmed this result and suggested that it confers improved ocean survival. By analyzing scales, Hayes found that 'early fast growers' were disproportionately over-represented in the adult steelhead returning to Scott Creek during his four-year study.

These results suggest that the species has the capacity to respond rapidly and positively to the appropriate recovery actions, such as improvements in lagoon condition and restoration of migration corridors. Still, the climate trends are quite worrisome, because they are so overarching. Further south, geologists Lee Harrison and Ed Keller of the University of California Santa Barbara have begun to find that juvenile steelhead are often limited to stream reaches where geologic faulting forces cool, reliable underground base flows to the surface. These are stream reaches that defy climate, so to speak, and we do not yet know if they are widespread or common.

– David Boughton
NOAA Fisheries, Southwest Fisheries Science Center

Marine Mammals

Dolphins of Monterey Bay

Dolphins, with 33 species worldwide, possess a complex brain, social and communication system and are highly adapted physiologically for life at sea. Dolphin schools are composed of subgroups that include closely related individuals, with the strongest bonds among related females. Although subgroups generally remain intact, the overall school size fluctuates. In contrast to baleen whales, which migrate seasonally to specific feeding and breeding areas, most small cetaceans exhibit more subtle seasonal changes in distribution, abundance and behavior. Factors such as

Southwest Fisheries Science Center/NOAA

Northern right whale dolphins

the availability of food resources, predation pressure, physical characteristics of the environment, sex and age class segregation, and reproductive status influence the ecology of small cetaceans.

Six species occur in Monterey Bay either year-round or seasonally. With a submarine canyon and its location within a major upwelling zone, the bay is an extremely rich and productive area, which provides food for thousands of dolphins. These include the near-shore and pelagic bottlenose dolphins (*Tursiops truncatus*), Pacific white-sided dolphins (*Lagenorhynchus obliquidens*), Risso's dolphins (*Grampus griseus*), northern right whale dolphins (*Lissodelphis borealis*), long-beaked common dolphins (*Delphinus capensis*), and short-beaked common dolphins (*Delphinus delphis*).

Central California is characterized by three oceanographic seasons: the upwelling season (March to July), when winds drive cold, nutrient-rich water to the surface creating blooms of plankton; the oceanic season (August to October), when winds relax and warmer offshore water moves in, forming coastal fronts; and the Davidson Current season (November to February), when this northward-bound warmer current surfaces. The onset of each season is variable from year to year.

The frequency of occurrence (*Figure 1*) and the relative abundance (*Figure 2, p. 17*) was compiled for the pelagic dolphin species over the past eight years (1998 to 2005; 2,924 effort trips) to look at recent trends. However, data extend back to 1987, when I began my master's thesis on Pacific white-sided dolphins.

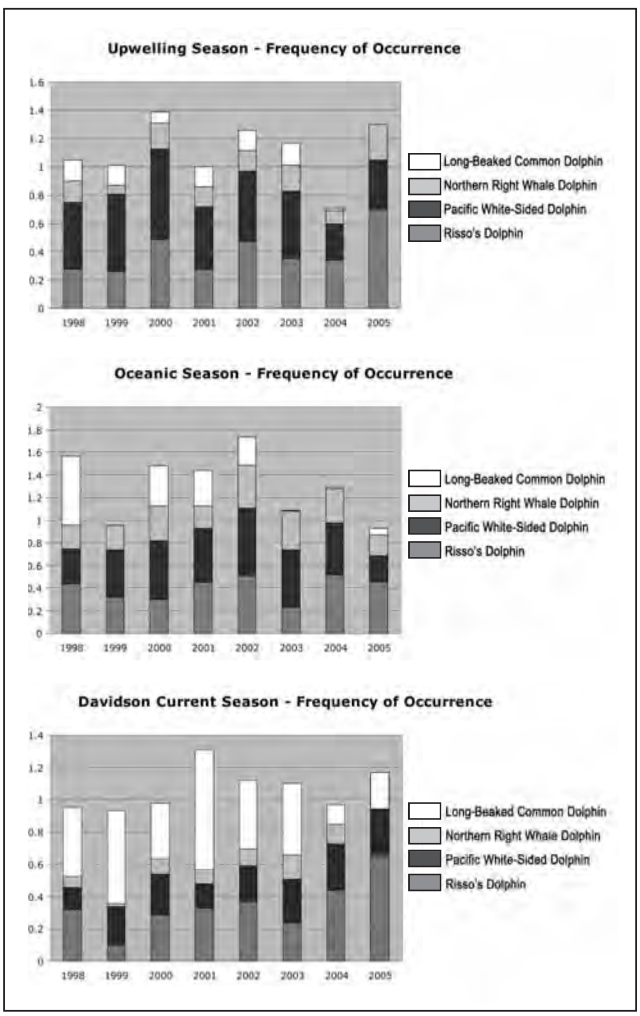


Figure 1. The frequency of occurrence by oceanographic season

Pacific white-sided dolphins are one of the most abundant dolphins endemic to the temperate North Pacific. In Monterey Bay they are frequently sighted near the canyon edge – although somewhat less in the past few years. In recent years (1997 to 2005), they were found on 40 percent of days, and their mean group size was 285. This is in contrast to the 1987-1991 study period, when they were sighted on 63 percent of days, with a mean group size of 203 (range 2,000-4,000), and 51 percent of the time they were found in small groups of one to 50 dolphins. Their low abundance

Photo by Southwest Fisheries Science Center/NOAA

Pacific white-sided dolphins

during the spring of 2004 was likely related to the nearly daily presence of killer whales. They were also infrequently sighted and in low numbers during the 1997-1998 El Niño, a time when the warmer-water species, long- and short-beaked common dolphins, were most prevalent. By analyzing stomach contents of stranded dolphins in Monterey Bay, I found that they contained 12 species of fish and squid and that the animals commonly fed on northern anchovy, Pacific whiting and a variety of pelagic small squid.

Risso's dolphins are also frequently sighted and highly abundant in the Monterey Bay region and are also known to frequent high-relief, heterogeneous and shelf-edge habitats. Their presence and group sizes have generally increased since the 1987-1991 period (with a mean group size of 113), compared to an average of 298 in recent years. During the winter of 2004-2005, Risso's dolphins were sighted nearly every day, often in groups exceeding 500 animals – with the largest group estimated at 6,000. This corresponded to the known presence of large numbers of Humboldt (jumbo) squid. The squid were in the 4-foot to 6-foot range and are a known prey for Risso's dolphins. It's not unusual for groups of Risso's dolphins to occur in the shallower shelf waters of the bay. Since the deep canyon is so close here, the Risso's may venture near shore on occasion to rest or feed on spawning market squid. I analyzed the stomach of a stranded Risso's in the area and found that it was full (unusual for most Risso's dolphin strandings) and contained 13 different species of squid.

Northern right whale dolphins, an unusual torpedo-shaped dolphin with no dorsal fin, have a similar distribution to Pacific white-sided dolphins, and in Monterey Bay they are frequently sighted (84 percent of the time) in association with Pacific white-sided dolphins and/or Risso's dolphins. These three species often form mixed-species groups, especially when the total group size of all three exceeds several hundred individuals. Multi-species groups of dolphins, a common phenomenon in Monterey Bay, could provide more options in feeding strategies (e.g., to herd and capture fishes) and a protective function (e.g., to defend against killer whales) similar to large, single-species herds.

Both species of common dolphins (long- and short-beaked) are associated with warmer waters. Long-beaked commons are found most often during late fall and winter in groups of 500 or more. Short-beaked commons are infrequently sighted and were most abundant during the 1997-1998 El Niño period. The long-beaked type is often sighted from shore, as they tend to travel in circuits throughout the area – often approaching the inner bay waters in the mornings. They may stay for several days or weeks before moving on. They first appeared during the 1982-1983 El Niño, then sporadically after that until the 1990s, when they were often a seasonal visitor. Long-beaked common dolphins feed predominantly on anchovies and market squid. With a similar diet to Pacific white-sided dolphins, these two species may alternate abundance.

Bottlenose dolphins are the only species that inhabits the shallow waters of Monterey Bay, usually just outside the surf line. They were first noticed in Monterey Bay during the 1982-1983 El Niño, and some of the dolphins were known individuals that had previously lived in warmer southern California waters. They are currently year-round residents (200-300 in population, with some moving in and out of the area) that travel in small groups (fewer than 15) and are often observed from shore throughout the inner bay.

Monterey Bay is clearly an important area for dolphins. Their frequent occurrence and high abundance suggests that this rich region provides a predictable and abundant food source throughout the year.

– Nancy Black
Monterey Bay Cetacean Project

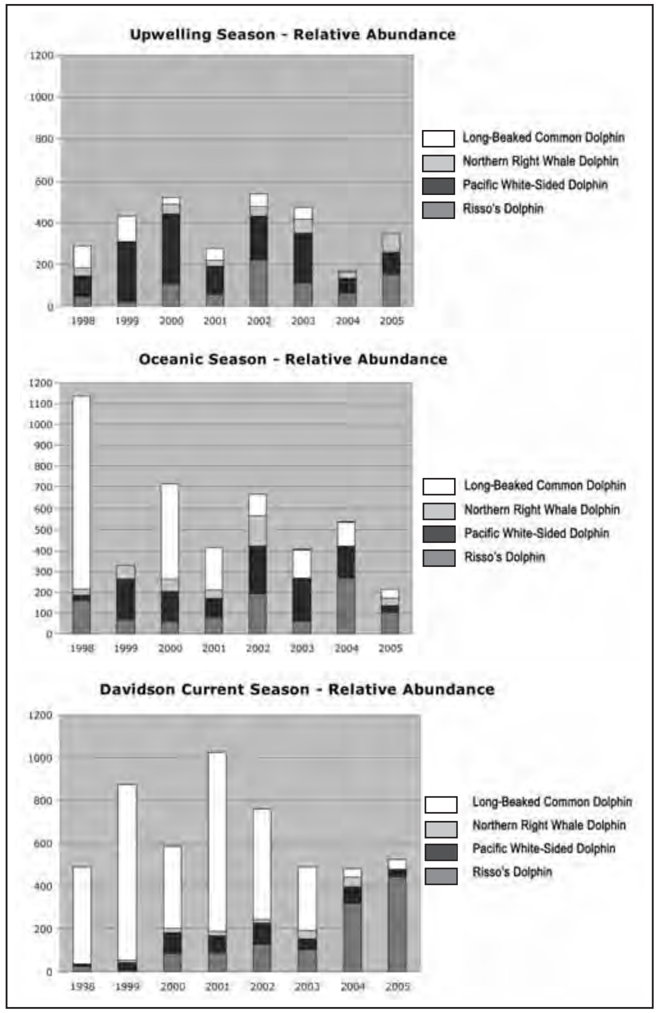


Figure 2. The relative abundance by oceanographic season

Gray Whale Populations

Thousands of gray whales, *Eschrichtium robustus*, regularly traverse the waters of the Monterey Bay National Marine Sanctuary. Their twice-annual migration between feeding areas off Alaska and breeding and calving grounds in Baja California – a round trip of 12,000 miles – is the longest of any mammal. The regular passage of these baleen whales along the coast provides an important opportunity to conduct population assessments.

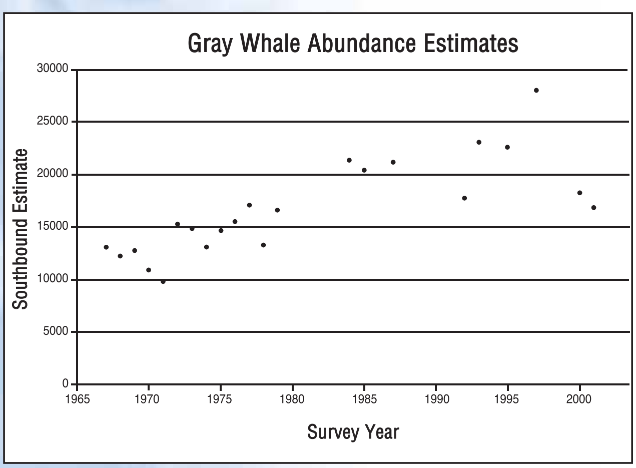


Figure 1. Abundance estimates for the eastern North Pacific population of gray whales. These data are from a working document (Rugh et al. 2004) presented to the International Whaling Commission and should not be cited without the author's permission.

In 1999, five years after the eastern North Pacific population of gray whales was removed from the federal list of endangered and threatened species (under the Endangered Species Act), a team of scientists met at the National Marine Mammal Lab (NMML) in Seattle to review this decision and to evaluate its current status. All of the available information at that time indicated that the decision had been a sound one and that the population was continuing smoothly along the road to recovery. However, during that same year (spring of 1999) stranding rates for gray whales increased ten-fold and calf production plummeted. Stranding rates were even higher in 2000, and calf counts remained at very low levels through 2001.

These observations led to speculation that the gray whale population had already exceeded the carrying capacity of its environment and that gray whales were starving. The most recent census of southbound gray whales was conducted by scientists from the NMML (2000-2001 and 2001-2002), and the count analysis revealed what some considered at the time to be an alarming trend because the abundance estimates were declining. (*See Figure 1.*)

Now, with some time behind us and additional years of information, things don't look nearly as grim.

Stranding rates have returned to the normal levels (about 30 per year), and calf production has recovered to or exceeded levels seen before the events of 1999 and 2000. (*See Figure 2.*) There is a possibility that the abundance estimate in 1997-1998 (27,958 whales) may have been too high, if missing counts were overestimated when access to the research station was lost due to the washout of Highway 1 south of Carmel. That year, the census ended with some counts from Point Lobos, but there are concerns about interpreting the data because the counts were not conducted from the standard site at Granite Canyon. The low estimates of 2000-2001 and 2001-2002 (about 18,000 whales) probably reflect a drop in abundance (as evidenced by high stranding rates and low calf recruitment) but also may be biased downward if not all members of the population migrated as far south as the survey site in those years. A careful look at Figure 1 reveals that there are several instances in which increases in estimated abundance between years (1971 to 1972 and 1992 to 1993) are larger than can be explained by reproductive output of this population over a single season. It is likely that the root cause of the 1999 and 2000 events were related to climate-driven oceanographic factors, but the exact link still evades us.

However, the relationship between calf production and climate is becoming clearer. We have an excellent time series of calf estimates (1994 to 2005), and the link between the timing of sea-ice retreat in the Bering and Chukchi Seas and calf production the following winter is statistically solid. We think that late-retreating sea ice may act as a physical barrier that keeps pregnant females, the first wave of the population to return north, from reaching prime feeding sites. We feel that the nutritive condition of these females between when they arrive on the feeding grounds and early July has a direct impact on the probability that their pregnancies will be carried to term.

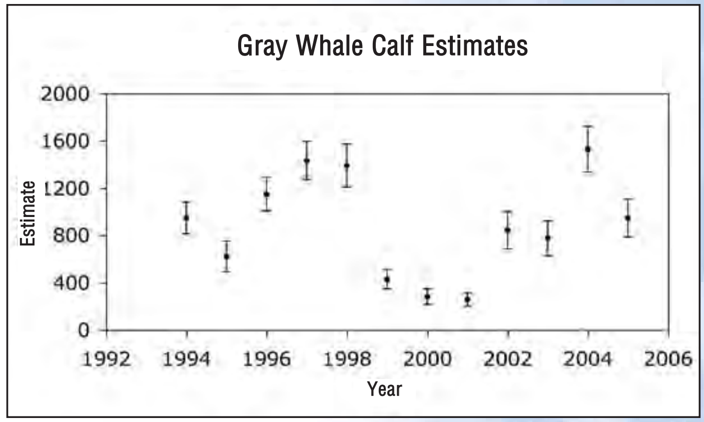
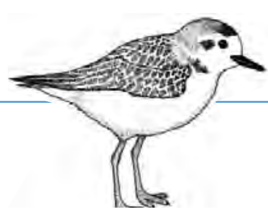


Figure 2. Estimates of northbound gray whale calves based on counts made from the Piedras Blancas Light Station. Data from 2001-2005 are preliminary and should not be cited without the author's permission.

The broader question is how the steady warming trend in the Arctic, and subsequent reduction in the extent of seasonal ice, will affect gray whales in the long term. Frankly, we don't know. Primary feeding grounds and primary prey have changed since the surveys that Sue Moore at NMML conducted in the 1980s. Her most recent surveys indicate that the Chirikov Basin, between St. Lawrence Island and the Bering Strait, no longer supports dense aggregations of feeding gray whales as it did two decades ago. We don't know how the shift in diet will impact gray whales or how prey populations will respond to increased grazing. It is clear that the Arctic is experiencing a warming trend, and we don't know how this change will impact the ecosystem of which gray whales are a significant part.

– Wayne Perryman
NOAA Fisheries – Southwest Fisheries Science Center



Bird Populations

Beach COMBERS Update

Volunteers with the Monterey Bay National Marine Sanctuary's Coastal Ocean Marine Bird and Mammal Education and Research Surveys (Beach COMBERS) sample selected beach sections on a monthly basis to record the incidence of dead wildlife. Established in 1997, the program is an important resource for obtaining information – and detecting trends – on mortality rates for all marine bird and mammal species in Monterey Bay.

Ocean conditions off California during the spring of 2005 appeared similar to what we might expect during a warm El Niño event, with sea-surface temperatures about 2°C greater than usual. A reduction in the frequency of upwelling-driven winds typical in April to June had significant effects on the seabird community in central California. Beach COMBERS volunteers were the first to record a pulse of unusual mortality for five seabird species (four alcids and one cormorant), compared with baseline data collected during the past eight years.

In January and February, the first unusual pattern was detected in two pelagic species: planktivorous (plankton-eating) Cassin's Auklet, *Ptychorhamphus aleuticus*, and the piscivorous (fish-eating) Rhinoceros Auklet, *Cerorhinca monocerata*. (*See Figure 1, p. 19.*) Cassin's are small alcids (approximately 160 grams) that feed primarily on krill and larval fishes. In general, because of their small size and pelagic habitat, auklets are not well represented in Beach COMBERS surveys (usually <0.5 birds per kilometer). During a typical year, we find two to 10 Cassin's, with the exception of the 1997-1998 El Niño, when 163 were recorded. In 2005, we documented 82, including 16 freshly deposited birds on Sunset State Beach alone. Rhinoceros Auklet (approximately 800 grams) followed Cassin's and showed the highest number of deaths in May, June and July (0.15 to 0.8 birds per kilometer).

In May, a wide deposition of unusual numbers of dead Brandt's Cormorants, *Phalacrocorax penicillatus*, on beaches from central California and Oregon prompted many reports from the public, rehabilitation centers, state agencies and other beach survey programs. Indeed, our up-to-date beach survey data revealed a significant increase in the number of cormorants (5.4 birds per kilometer), many of which were adults in breeding plumage.

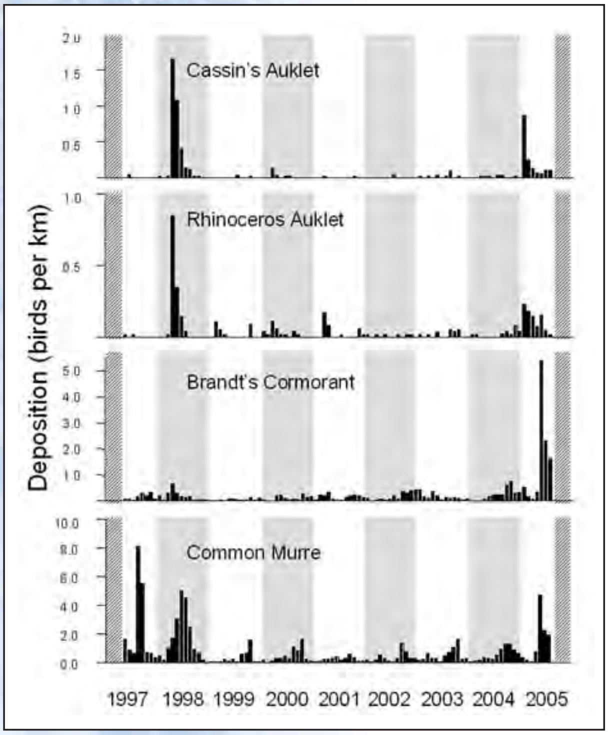


Figure 1. Long-term trend in deposition of four resident seabirds showing increased monthly mean deposition (birds per kilometer) in 2005 relative to baseline reported by Beach COMBERS in the Monterey Bay area (beaches 1 to 11, 51 kilometers; May 1997 to July 2005). Significant mortality of several species was similar to that of the 1997-1998 El Niño; however ocean conditions were unlike a true El Niño. Alternating bars indicate years and line hatching indicates no survey data. Note difference in scale of y-axis among species.

By July, other fish-eating species, such as the Common Murre, *Uria aalge*, and the Pigeon Guillemot, *Cepphus columba*, appeared dead in greater numbers than usual on sanctuary beaches. Based on necropsies performed at the Marine Wildlife Veterinary Care and Research Center (California Department of Fish and Game, Santa Cruz), it became obvious that an entire community of seabirds off California were dying of starvation. Interestingly, the timing of mortality among species differed – a pattern likely related to differing trophic levels and foraging habitats among the affected species: pelagic species had the earliest mortalities, followed by mid-water piscivores and lastly by nearshore benthic-feeding species.

Was this an El Niño event? Although we did find higher numbers of dead birds among several resident species, migratory Sooty Shearwater, *Puffinus griseus*, from the southern hemisphere did not show elevated deposition in 2005. Sooty Shearwater deposition typically increases significantly during El Niño events (e.g., 1997-1998 and 2000). Francisco Chavez and other oceanographers at the Monterey Bay Aquarium Research Institute who are working to understand this year's conditions recognize that despite certain similarities, this was not an El Niño but rather a more localized event caused by regional (i.e., north-eastern Pacific) atmospheric anomalies. Although normal upwelling conditions appeared to return by July, it was too late for the seabirds that depend upon a food web that is initiated prior to the spring-summer breeding season. Without the pulse of cold, nutrient-rich waters into the system in early spring, forage fish abundances likely were reduced. The NOAA Fisheries laboratory in Santa Cruz reported dismal returns during its annual survey for juvenile rockfishes (*Sebastes* spp.); it also documented reduced hake, krill, anchovies and larval flatfishes, according to Steve Ralston at the lab. As a result, many seabirds likely faced a severe food shortage. Many resident seabirds, including murres, auklets, guillemots and cormorants, failed to nest successfully. Reproductive rates for Cassin's Auklet were the lowest ever recorded in 30 years of monitoring at the Farallon Islands off San Francisco, according to William J. Sydeman at PRBO Conservation Science. Food stress also appeared to result in a significant increase in sub-adult to adult mortality, as evidenced from beached bird deposition. We hypothesized that reduced larval/juvenile recruitment among rockfishes, a key prey shared by all affected species, was ultimately responsible for this food stress event. The timing and duration of upwelling winds, the dominant physical forcing influencing the Monterey Bay ecosystem, can ultimately make the difference between a successful breeding season and a failed one, and dramatic changes likely affect the survival of resident seabirds.

Understanding how changing ocean conditions affect seabirds can provide important indicators of the dynamics of forage fishes. Not only seabirds, but commercial and recreational fishermen and local economies, depend on ocean conditions that foster abundant forage fishes. We will continue collecting systematic information on beached bird deposition to understand what seabirds can tell us about the ecosystem within our sanctuary. This example from the Beach COMBERS highlights how information about seabirds can contribute toward a better understanding of food-web dynamics, trophic interactions, marine productivity and forage fish availability – essential aspects required for a complete understanding of the effects of fluctuations in the marine ecosystem.

– Hannah Nevins And Jim Harvey
Beach COMBERS, Moss Landing Marine Laboratories

This work was supported in part through a grant from the Monterey Bay Sanctuary Foundation, Sanctuary Integrated Monitoring Network (SIMoN). Substantial in-kind support was provided by Moss Landing Marine Laboratories and California Department of Fish and Game, Marine Wildlife Veterinary Care and Research Center. This work was made possible by the dedicated volunteer beach surveyors of Beach COMBERS and Beach Watch programs.

Winter Mortality of Surf Scoters

Since its inception in 1997, the Coastal Ocean Marine Bird and Mammal Education and Research Surveys (Beach COMBERS) project has documented some interesting trends in deposition of dead birds and mammals on beaches within the Monterey Bay National Marine Sanctuary. (*See previous article.*) The growing long-term data set allows researchers to identify unusually large mortality events, or die-offs. For example, during the winter of 2003-2004, Beach COMBERS documented a die-off of Northern Fulmars, *Fulmarus glacialis*, an order of magnitude greater than usual. (*See Ecosystem Observations 2004, p. 18.*) Another notable die-off involved unusually high numbers of dead Surf Scoters, *Melanitta perspicillata*, during the winter and spring of 1998.

Surf Scoters are sea ducks that breed in Alaska and northern Canada and winter in coastal areas as far south as Baja, Mexico. They are common in Monterey Bay nearshore waters from November through April. In April 1998, Surf Scoter deposition

Surf Scoters are sea ducks that breed in Alaska and northern Canada and winter in coastal areas as far south as Baja, Mexico.

on Monterey Bay beaches spiked to 3.6 birds per linear kilometer, more than 20 times the five-year mean for this species. While the Beach COMBER data are excellent for identifying these unusual mortality events, without information on natural population fluctuations, it can be difficult to determine if these die-offs are related to an acute event, such as an oil spill or disease, or if they are the natural result of higher-than-normal numbers of live birds occurring locally.

In the case of the 1998 Surf Scoter die-off, we were fortunate to have data on the concurrent abundance of Surf Scoters in Monterey Bay. Surveys were conducted from a small open skiff in a 100-meter strip transect 500 meters offshore, from Capitola to Monterey. These surveys were conducted during the early spring of 1998 and then from February 1999 through March 2001. With these data, we were able to investigate the relationship between numbers of dead scoters found on local beaches and densities of live scoters in Monterey Bay. Deposition rate (number of birds per linear kilometer) was exponentially related to at-sea density during the previous month. (*See Figure 1.*) These data indicate that winter mortality of Surf Scoters in central California may be density-dependent: as the number of Surf Scoters in the bay increases, the mortality rate (number found dead per number found alive the previous month) also increases. This relationship is weak, and more data would be useful to determine whether the relationship truly is density-dependent. If density dependence is occurring, it could be a result of increased competition for food, which would affect baseline health, or an increased transmission rate of parasites.

So what caused this unusual mortality event in 1998? We examined the gastrointestinal tracts of more than 30 Surf Scoters collected on Monterey beaches in 1998 and found remarkable densities of acanthocephalan parasites in their intestines. (Most had 15-20 parasites per centimeter of intestine.) Stomach contents and observations of live scoters indicated that, in Monterey Bay sandy beaches, they feed primarily on sand crabs (*Emerita analoga*), which carry cysts of acanthocephalan parasites. These small worms often infect Surf Scoters and have also been implicated in sea otter (*Enhydra lutris*) deaths. Although Surf Scoters are a natural host of these parasites, which are ingested as cysts in sand crabs, death may have been due to perforation of intestinal walls and peritonitis as a result of these infections. Increased Surf Scoter numbers in Monterey Bay may have allowed easier transmission of parasites.

These preliminary data illustrate the usefulness of concurrent monitoring programs in the sanctuary. Although this study focused on data from 1998 through 2001, the Beach COMBERS project continues to collect data that could be used for similar assessments in the future. Further use of at-sea surveys conducted concurrently with beached-bird monitoring projects can help determine if observed die-offs represent unusual mortality events or are simply proportional to fluctuating local population levels. In addition, further research on the baseline health of animals such as Surf Scoters will be useful in determining causes of death during mortality events.

– Laird Henkel, Hannah Nevins, Jim Harvey and Scott Benson
Moss Landing Marine Laboratories

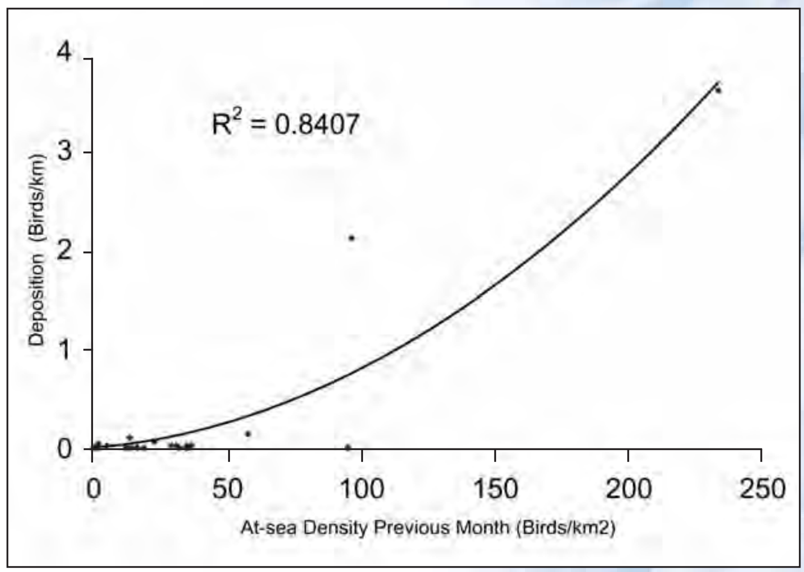
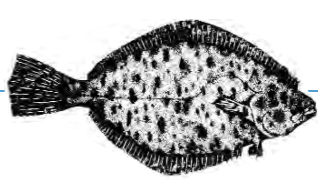


Figure 1. Relationship of deposition of beach-cast Surf Scoters to at-sea density in the previous month, from 26 surveys between March 1998 and January 2001



Harvested Species

Spreading and Stranding of Humboldt Squid

Dosidicus gigas (Humboldt, or jumbo squid) is endemic to the California and Peru currents and their equatorial convergence. (*See Figure 1A, p. 21.*) Within this zone, the biomass of *Dosidicus* is immense. High abundance, an extremely flexible diet and high daily consumption rate combine to make the species an ecologically important predator.

Monterey Bay witnessed *Dosidicus* in 2002, when a warm-water anomaly off southern Baja California was followed by a wave of mass strandings that swept northward from La Jolla to Mendocino. Local strandings were modest, but 2003 brought another wave and more media attention. Yet such events were not new: Monterey strandings were reported as early as 1912, and a similar northward wave occurred

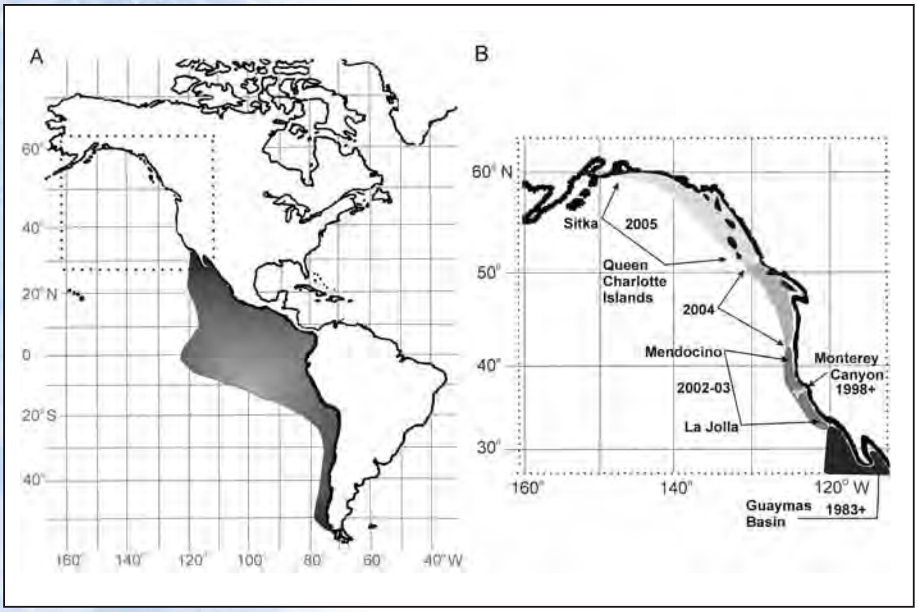


Figure 1. Distribution and recent range extensions of Dosidicus gigas.
A. Distribution of Dosidicus as given in a 1984 FAO report is shown as shaded.
B. Detail of Pacific Northwest from panel A showing approximate areas and dates of recent northward range expansions

in 1934-1935, with the ravenous squid disturbing Monterey commercial and sport fishermen. In January 1936, Ed Ricketts purchased 400 pounds of *Dosidicus* caught by a purse seiner in southern Monterey Bay for Pacific Biological Laboratories. (*See photo.*)

Causes of these invasions and associated strandings are unknown. During strandings, squid typically swim actively onto the beach, suggesting some neurological defect. In 2003, I hypothesized intoxication by domoic acid, a toxin produced in harmful algal blooms that causes abnormal behavior and brain lesions in sea lions. Carl Elliger at Hopkins Marine Station and I have now analyzed stomach contents of beached *Dosidicus* from La Jolla and Monterey, and although the guts contained organisms known to harbor domoic acid (anchovies, sardines, pelagic red crabs), we detected no toxin.

In reality, the number of squid stranded is probably a minute fraction of the invading horde, and factors behind the invasions may be key to understanding the strandings. Because *Dosidicus* is large (up to 40 kilograms) and locally abundant, an area must be highly productive to support a stable population. One such area may be the Monterey canyon system, where *Dosidicus* has been regularly seen during ROV operations by the Monterey Bay Aquarium Research Institute (MBARI) since 1998, according to MBARI scientists Bruce Robison and Louis Zeidberg. It now appears to be a year-round resident. Another area of permanent residence, at least since the 1970s, is the Guaymas Basin in the Sea of Cortez, where *Dosidicus* circulates seasonally between feeding grounds off Baja California Sur and Sonora. Why these particular areas were apparently successfully colonized at these particular times remains mysterious.

Few areas may be rich enough to satisfy the appetite of this species, and ephemeral appearances and strandings of Humboldt squid elsewhere may reflect this. As depicted in Figure 1B, *Dosidicus* appeared in 2004 from Oregon to British Columbia following a warm-water anomaly off that coast (*See www.thecephalopodpage.org/Dosidicusgigas.html.*) In 2005, the range expanded further, past the Queen Charlotte Islands to Sitka, Alaska. How long *Dosidicus* remains in this northern area remains to be seen, but the reason it is there revolves around productivity. Temperature *per se* is not likely to be a critical factor, because (unpublished) electronic tagging studies with Mexican colleagues in the Sea of Cortez reveal that the squid tolerates large temperature swings as part of its daily vertical migrations.

Molecular genetic analysis by Carl Elliger and Zora Lebaric in my lab indicates that many Pacific Northwest *Dosidicus* are indistinguishable from specimens captured as far away as Chile. This suggests that *Dosidicus* is highly nomadic – an amoeboid species that sends invading fingers into any area where productivity is high, regardless of the cause. If productivity persists, the squid remain and flourish. If the productivity burst is transient, the invading squid cannot be sustained. They must either depart or starve; perhaps some of these latter animals end up in strandings.

In order to understand the waxing and waning of *Dosidicus* on a global scale, we may paradoxically have to study individual animals. Electronic tagging of adults is being used to monitor long-distance migrations. Thus far, we have recorded migrations of up to 100 miles in three days, so sizeable

Photo by Ralph Buchsbaum, courtesy of John and Vicky Pearse

Edward F. Ricketts of Pacific Biological Laboratories in Monterey (1936) with an apparently preserved specimen of Dosidicus gigas migrations are possible. We are also locating spawning grounds by identifying hatchlings in plankton samples. One such area lies in the Sea of Cortez, but others remain undiscovered.

In 1945, Ed Ricketts wrote in unpublished notes: *"If you know the natural history,…especially the complete life history of the beasts chiefly involved, you can… understand just how and even why it occurs in a certain place at a given period…"* (provided by K.A. Rodger, UC Davis). Old truths still have much to teach us.

– William F. Gilly
Hopkins Marine Station of Stanford University

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Dosidicus gigas in hunting mode

Human Interactions

Human Impacts on Marine Mammal Health

Marine mammals along the California coastline and within our marine sanctuaries are vulnerable to the effects of human activities. The impact on marine mammal health may be direct and obvious, such as mortality due to gunshot wounds and entanglements, or indirect and harder to detect. These influences have been seen in marine mammals within the marine sanctuaries off the California coast through thorough examination of stranded animals as well as monitoring the health of animals handled during management activities.

Stranded animals are more likely to be the sickest animals of a wild population and thus are useful to sample in order to identify and detect diseases. Surveys of stranded California sea lions' genetics have revealed that those dying with infectious diseases are more likely to be inbred than sea lions dying from trauma. Mortality is easy to detect, but subtle effects on the immune system and reproduction require specialized diagnostic tests adapted for use in marine mammals.

Direct disturbances include wounds and mortality due to gunshot (8 percent of stranded California sea lions examined by The Marine Mammal Center are shot); entanglements in marine debris such as packing straps and fishing gear; vessel strikes; contamination from oil spills; and ingestion of fish hooks and sinkers. The latter may cause perforation of the esophagus or stomach that can result in infection and death: unusually, this year a harbor seal from San Francisco Bay died due to lead poisoning after ingesting a lead sinker. This animal had previously been observed rearing a pup on rocks under the Richmond Bridge in San Francisco Bay, and it stranded with neurological signs weeks later. A large salmon flasher and lead sinker were found in its stomach, and lead levels in the seal's blood were extremely high.

Vessel interactions vary from propeller cuts that seriously injure or kill smaller marine mammals such as otters, seals and sea lions to blunt trauma from ship hulls that fracture the skulls of large humpback whales. The largest victim of a ship strike in recent years was an 80-foot-long female blue whale found floating off the Golden Gate with four large gashes along its back and flank due to propeller cuts. The most obscure entanglement in recent years was the strangulation of an elephant seal by a toilet seat around its neck: this animal was saved by University of California researchers who managed to remove the seat.

Photo by Robert Schwemmer/NOAA

Marine mammals are susceptible to infection by agents in terrestrial runoff or sewage.

People's acts affect marine mammal health indirectly, also. This can occur in a number of ways, such as through infection by agents in terrestrial runoff or sewage including bacteria and protozoa; persistent organochlorines and heavy metals accumulating in the marine ecosystem due to industrialization; and disturbance due to increased noise generated by maritime shipping, offshore drilling, seismic surveys and military activities.

Recently identified parasites in marine mammals include *Giardia lamblia*, *Sarcocystis neurona* and *Toxoplasma gondii*, which are all capable of infecting humans and are likely of terrestrial origin. *Toxoplasma gondii* relies upon a cat (wild or domestic felid) to maintain its life cycle, so its presence in sea otters, dolphins, seals and sea lions is unusual and raises questions about how it has reached these marine mammal hosts, which have no direct contact with cats. Bacteria such as *Salmonella* and *Campylobacter,* known causes of diarrhea in humans and terrestrial livestock, have been cultured from seals and sea lions. Many of the bacteria show antibiotic resistance, suggesting that they have been exposed to these drugs before infecting marine mammals.

The incidence of harmful algal blooms, such as those producing domoic acid, appears to be increasing in recent years. Although the reasons for this increase in toxin-producing blooms are unclear, human activities that alter terrestrial runoff and increase global warming may be important. These indirect effects may increase nutrients for phytoplankton blooms or change the types of nutrients available, which may determine whether or not the blooms become toxic. Biotoxins produced by these blooms can have dramatic effects on marine mammals, resulting in mass mortality events, as well as less obvious effects on reproduction and physiology. Domoic acid was first detected as causing California sea lion deaths in 1998, when seizuring and dying animals were found to have eaten anchovies and sardines containing it. Since then, there have been repeated sea lion die-offs associated with exposure to this toxin, as well as abortions and death of prematurely born pups following pregnant female sea lions' exposure to this toxin.

Other toxins detected in California sea lions include PCBs and DDTs, contaminants that accumulate up the food chain and are regularly detected in marine mammal tissues. High PCB levels in California sea lions have been associated with an increased risk of cancer as well as altered hormonal levels in harbor seals and sea lions.

Disturbances to marine mammal health from human action are thus varied, ranging from the obvious to those requiring thorough examination and sampling of affected animals to detect. These effects will require continued monitoring as well as continued collaboration among ecosystem managers, researchers and veterinarians to understand better the relative importance of these various threats to the long-term health of the marine mammal population.

– Frances Gulland
The Marine Mammal Center

Marine Protected Areas: Gaining Attention

Anyone who listens to the latest news on ocean issues is bound to hear about marine protected areas (MPAs), which are discussed with conviction and enthusiasm by some, wariness and disdain by others. What exactly is an MPA, who's talking about them and why the rise in conversation over this often-misunderstood subject?

"Marine protected area" is an umbrella term for a managed area in the marine environment that provides some degree of resource protection. MPAs can be established by different authorities (e.g., municipal, state) and involve a range of protection strategies. Most restrict or prohibit one or more human activities, such as disturbing or harvesting marine life, ocean dumping, oil drilling and the like. Besides having different goals or levels of protection and use, MPAs can vary dramatically in size and shape and safeguard an array of natural or cultural resources.

Related terms – including marine park, marine preserve, marine reserve, national seashore and others – may also be used to describe MPAs. For example, the Monterey Bay National Marine Sanctuary is a large, federally designated MPA that encompasses diverse habitats and shipwrecks off central California. To help protect the sanctuary, the National Oceanic and Atmospheric Administration (NOAA), the agency responsible for its management) conducts research, monitoring, education and outreach programs while restricting or prohibiting some recreational and commercial uses.

A common misconception is that all MPAs are 'no-take' areas, closed to public use. But most MPAs, like the sanctuary, are managed for a variety of uses. Approximately 1 percent of the world's oceans and only .01 percent of U.S. waters are encompassed by no-take areas. Locally, three small, no-take state reserves cover less than .01 percent of sanctuary waters.

Scientific research has shown that properly designed MPAs – particularly those that restrict or prohibit the removal of marine life – can effectively conserve a diversity of marine life and habitats. In fact, these types of MPA generally contain a greater abundance and higher diversity of species as well as larger fishes within their boundaries than similar habitats outside the protected areas. Larger fishes often produce more young than smaller fishes (*see Figure 1*), and in some cases, their young may be healthier and more likely to survive. MPAs can prevent, slow or reverse the destruction of ocean habitats and help maintain a diversity and abundance of species.

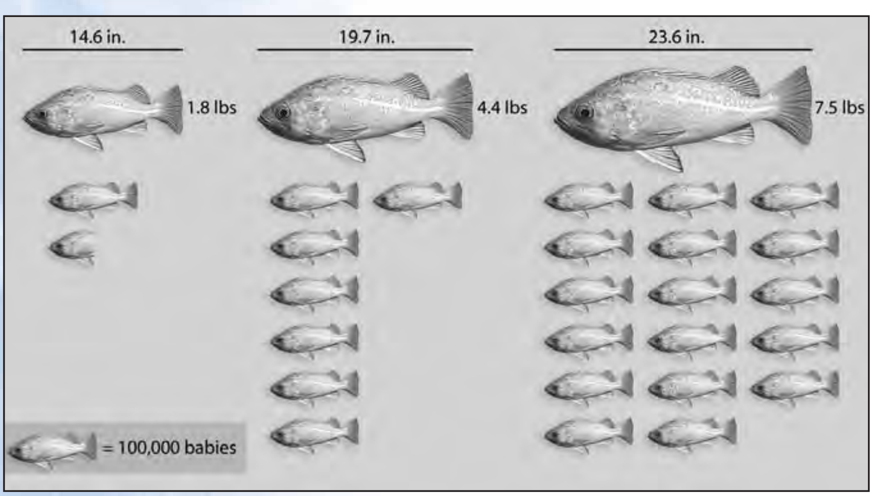


Figure courtesy of PISCO and Donna Schroeder

Figure 1. Larger fishes produce more young, as is the case for these vermillion rockfish.

Because pollution, overfishing and habitat destruction threaten oceans today, many groups, including governments, scientists, fishermen, concerned citizens and others, are discussing the need for new MPAs to complement existing ocean protection measures. MPA are gaining momentum as a marine conservation tool throughout the world. Countries such as South Africa, Italy, Canada and New Zealand have all established 'no-take' marine areas. In July 2004, Australia designated one-third of the Great Barrier Reef as one.

Recently, both the U.S. Commission on Ocean Policy and the Pew Oceans Commission called for a new system of MPAs to support ecosystem-based ocean management in the United States. In 1999, the Marine Life Protection Act (MLPA) mandated that the State of California implement and manage an improved network of MPAs to protect marine life, habitats, ecosystems and natural heritage. Currently, the California Resources Agency and California Department of Fish and Game are partnering with others to achieve the goals of the MLPA.

In 2002, a review of the sanctuary management plan resulted in significant public comment on this issue – most urging the establishment of new MPAs with restricted harvest in some areas of the sanctuary to provide for greater ecosystem protection. As a result, NOAA convened a diverse group of stakeholders to design potential new MPAs in federal waters within the sanctuary (generally beyond three nautical miles of shore) and evaluate their utility. As new MPAs are proposed and considered, their design and location will also reflect the desire to support sustainable fisheries, since fishing is an important cultural and economic activity in the sanctuary. Designation of new MPAs in state waters of the sanctuary (generally within three nautical miles of shore) will be accomplished through the MLPA process and the California Fish and Game Commission. The sanctuary and MLPA staff are working closely to coordinate efforts and share resources to design the new system of MPAs.

Not everyone agrees that new MPAs are needed, and their potential costs – including socioeconomic impacts to fishermen and potential for fishing effort to shift into other areas – should be considered. One thing is certain, however: the discussion about MPAs will continue as new networks are established in California, and likely, in other parts of our nation and the world. Most critical to the success of new MPAs, and all ocean protection measures for that matter, is for those who care about the ocean – managers, fishermen, scientists, conservationists, divers, business leaders, citizens and others – to share their knowledge and ideas and work together to help resolve environmental issues. Only by coming together can we ensure that our oceans are healthy in the future.

To get involved with the designation of new MPAs or submit your comments on this matter, visit www.dfg.ca.gov/mrd/mlpa/ or www.sanctuaries.nos.noaa.gov/jointplan/.

– Liz Love
Monterey Bay National Marine Sanctuary

Sanctuary Volunteers Are Priceless!

Volunteers are integral to the success of Monterey Bay National Marine Sanctuary programs. Local citizens participate in advisory groups – such as the Sanctuary Advisory Council and its four working groups – or in the field with the Coastal Ocean Marine Bird and Mammal Education and Research Surveys (Beach COMBERS) or as interpretive kayakers, intertidal surveyors and water monitors. The volunteers are as diverse as the jobs they implement: they range in age from 10 to 85 and include students, professionals and retired citizens. Last year, more than 500 volunteers donated 10,300 hours to sanctuary programs.

Sanctuary volunteers are enthusiastic and can be easily trained to perform work that staff don't have time to accomplish. Our large ratio of volunteers to staff clearly demonstrates their ability to be more places more often and to collect more information throughout the sanctuary than staff could ever hope to accomplish alone. These individuals are also valuable stewards of the environment and are able to share their understanding and concern for the environment through their actions and contacts in the community.

Several sanctuary programs that monitor and protect our coastal resources would not be possible without community volunteers. These include TeamOCEAN, Beach COMBERS, LiMPETs and the Citizen Watershed Monitoring Network.

TeamOCEAN (Ocean Conservation Education Action Network), an outreach program initiated in 2000, provides face-to-face interpretation of sanctuary natural history to kayakers on the bay. Knowledgeable volunteers greet and interact with visitors on the water and promote respectful wildlife viewing by explaining how to enjoy marine wildlife without disturbing the animals' daily activities. In 2005, 48 TeamOCEAN volunteers interacted with more than 5,500 people on the water, and they have reached more than 22,000 visitors during the past four years.

Beach COMBERS, a beach survey program, relies on more than 80 trained volunteers to achieve its goal of monitoring the status of stranded birds and mammals as an indicator of the sanctuary's health. (*See article, p. 18.*) Since 1997, volunteers have collected information on stranding rates for a variety of bird and mammal species that inhabit or visit the sanctuary. Pairs of volunteers monitor more than 20 beaches throughout the sanctuary, surveying selected beach segments monthly during low tide.


Photo by Art Eyjen

Volunteer training and "dry run" for First Flush 2005

LiMPETs (Long-term Monitoring Program and Experiential Training) is yet another beach monitoring and data gathering program; it is conducted primarily by high school students. In 2005, 1,390 students surveyed rocky intertidal or sandy beaches to document the population density and diversity of marine organisms living in these habitats. Data from the program can be used to assess environmental health, and the students involved gain understanding of the value of scientific monitoring and the importance of intertidal and sandy beach ecosystems.

The Monterey Bay Sanctuary Citizen Watershed Monitoring Network (Network) also relies heavily on volunteer participation. The Network partners with the Coastal Watershed Council and

Maris Sidenstecker and Enid Irwin measure transparency at the Snapshot Day monitoring event.

local cities to implement several volunteer-based water quality monitoring programs, including Snapshot Day, Urban Watch and First Flush. These programs continue to grow each year, both in geographic scope and number of participants. Last year, more than 280 Network volunteers donated 4,075 hours.

Snapshot Day began in 2000 as a one-day event in which the majority of rivers and streams along the coast were monitored to assess the quality of the water and surrounding habitat. This event began as an educational activity and has grown into a valuable source for water quality data. In 2000, more than 120 volunteers monitored 108 sampling sites. In 2005, Snapshot Day involved 163 sampling sites throughout the sanctuary, monitored by 161 volunteers.

Urban Watch is a dry-weather monitoring program in which volunteers collect and analyze urban runoff for common urban pollutants approximately 20 times throughout the dry weather season. Urban Watch has also grown from just one city (Monterey) in 1998 to five cities (Monterey, Pacific Grove, Capitola, Live Oak and Scotts Valley) in 2005, with the participation of 55 volunteers.

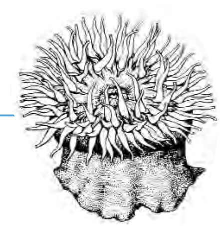
First Flush has also expanded over the past five years. In this program, volunteers collect water samples during the first major storm of the season at any time of the day or night. In 2005, 83 volunteers sampled 32 storm drain outfalls in nine cities, as compared to just 25 volunteers who sampled 14 outfalls in three cities during 2000.

Each of these programs provides information on the quality of water flowing into the sanctuary. Results have been used to acquire grant funding for additional monitoring or to support restoration projects. Results have also been used to determine the most appropriate management practices and educational programs to implement. In addition, they have spawned monitoring in areas where it was warranted. For example, high copper and zinc concentrations detected during First Flush in a Monterey drainage led to additional upstream monitoring to attempt to track the source of metals. Further, Snapshot Day results led to a grant-funded "Clean Streams" monitoring program in two Salinas watersheds in which monitoring is attempting to determine land use impacts on the waterways that lead to the sanctuary. In all of these programs, sanctuary staff and partners work together to address water quality issues.

No matter what activity they are involved in, volunteers are a tremendous asset to the sanctuary and its programs. An abundance of energy, enthusiasm, dedication and concern for the sanctuary make them a priceless collection.

– Bridget Hoover
Monterey Bay Sanctuary Citizen Watershed Monitoring Network

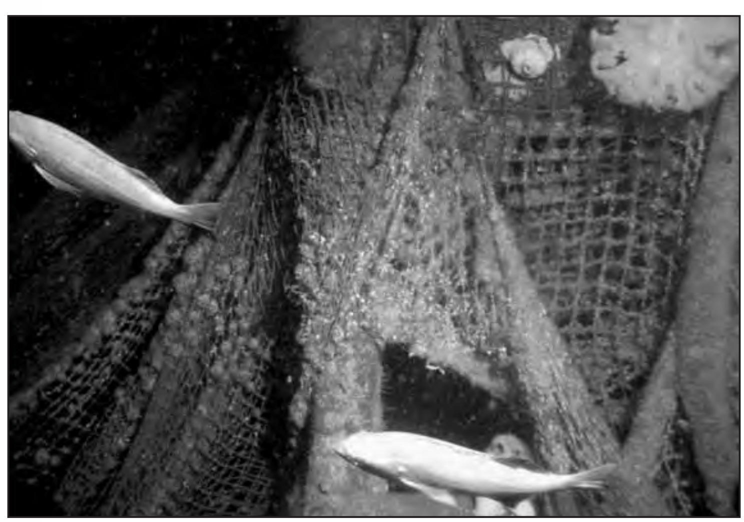
Site Profile



Expeditions to the Shipwreck *Montebello*

Located just south of the Monterey Bay National Marine Sanctuary boundary are the remains of the Union Oil tanker *Montebello*. On December 22, 1941, the tanker loaded a cargo of 73,571 barrels (3,089,982 gallons) of Santa Maria crude oil at Port San Luis, California destined for Vancouver, British Columbia. With the outbreak of World War II just three weeks earlier, there were reports of Japanese submarines attacking merchant ships along the California coast. On December 23 at 1:30 a.m., the tanker, now loaded with the cargo of oil, cleared the port proceeding on a northbound course.

Ordinary seaman Richard Quincy, then 22 years of age, recalled the events of the early morning. At 5:30 a.m. it was still dark, the *Montebello*'s lights were blacked out and the vessel's position was nearing Piedras Blancas Point. Quincy, who was on watch, could make out an object on the water running in the tanker's wake but discounted it as a northbound coastal



The starboard side of the tanker's bridge structure is partially obscured by fishing nets and presents a challenge when navigating the shipwreck in a submersible.

vessel. As the rising sun silhouetted the trailing vessel off the port quarter, Quincy realized it was a Japanese submarine low in the water. The submarine *I-21* then repositioned to the starboard quarter between the tanker and mainland and fired a single torpedo into the *Montebello*.

At 5:55 a.m., the captain gave the order to abandon ship, and all 38 crewmen left the tanker in four lifeboats. They cleared the sinking tanker as the submarine descended below the surface to avoid detection from responding aircraft. The crew watched their ship settle in the bow, submerging below the surface at 6:45 a.m. As the bow started downward, the crew witnessed the stern clearing the ocean surface by 45 meters (150 feet).

Photo courtesy of the Vancouver Maritime Museum

The Montebello carried petroleum products to the Hawaiian Islands, Siberia, British Columbia and other ports in the Pacific.

For years, the *Montebello* was largely forgotten, except for local fishermen who found the site to be a productive fishing spot. It was not until members of the Central Coast Maritime Museum Association (CCMMA) considered nominating the shipwreck to the National Register, to properly memorialize the historic event and raise public awareness in the local community, that the tanker gained attention again. There was also growing concern about whether the shipwreck still contained its toxic cargo of crude oil, which was potentially threatening the nearby sanctuary waters.

On November 7, 1996, working aboard the R/V *Cavalier*, Jack Hunter, president of the CCMMA, and his science team conducted four dives using the two-person *Delta* submersible. Based on their observations, it was determined that during the sinking, *Montebello* hit the ocean floor with enough force to drive the bow deep into the bottom sediment, separating at the torpedo impact zone. The aft 90 percent of the hull then recoiled back and settled squarely on its keel. More importantly, the investigation concluded that the torpedo had not penetrated the region of the tanker's oil cargo storage holds, but instead had actually struck forward in the pump room and dry storage cargo hold. It is Hunter's opinion that the crude oil cargo is still entombed in the tanker.

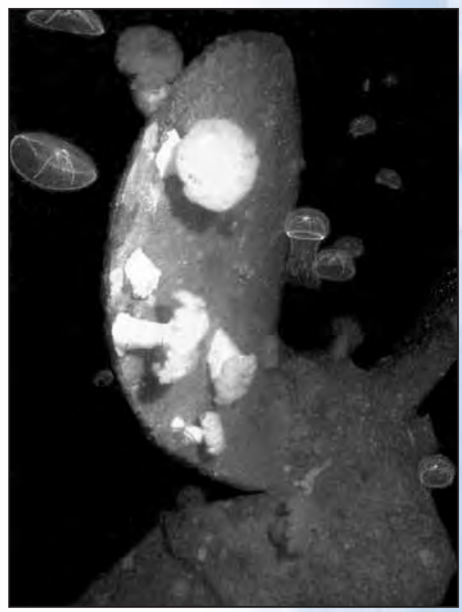


Photo by Robert Schwemmer/NOAA

The Montebello's 18-foot diameter bronze propeller, now idle, has been colonized by white plume anemones.

In September 2003, the Monterey Bay National Marine Sanctuary led an expedition to the shipwreck as part of its shipwreck-monitoring and site-characterization program. The expedition once again used the *Delta* submersible, launched from the R/V *Velero IV*.

The goals of the science team, which was led by the author, were to record the structural integrity of the hull and note signs of degradation since the 1996 reconnaissance and to investigate tanker areas not recorded during the 1996 expedition. The team would also investigate and record signs of oil discharge as well as *Beggiatoa* bacteria feeding on hydrocarbons and would document the extensive marine life that has colonized at the shipwreck site.

Over the course of two days, eight successful dives revealed greater details of the tanker, with no observations of oil discharging into the water column. Further, no observations of *Beggiatoa* bacteria were reported. Observations made in the region of the starboard stern quarter suggest that steel corrosion may have advanced since the 1996 expedition. Sixteen fish species and 29 invertebrate species were recorded during two one-hour submersible dives. These numbers are conservative, since there are probably many more species, especially smaller and cryptic species. The sanctuary plans to continue monitoring the site of the *Montebello* in the future – for signs of oil discharge or hull degradation.

For further information, please visit www.channelislands.noaa.gov/shipwreck/dbase/montebello.html (for Montebello data) and www.channelislands.noaa.gov/shipwreck/dbase/montebello_2.html (for the 1996 Montebello expedition).

– Robert V. Schwemmer
National Marine Sanctuaries West Coast Regional Maritime Heritage Program

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